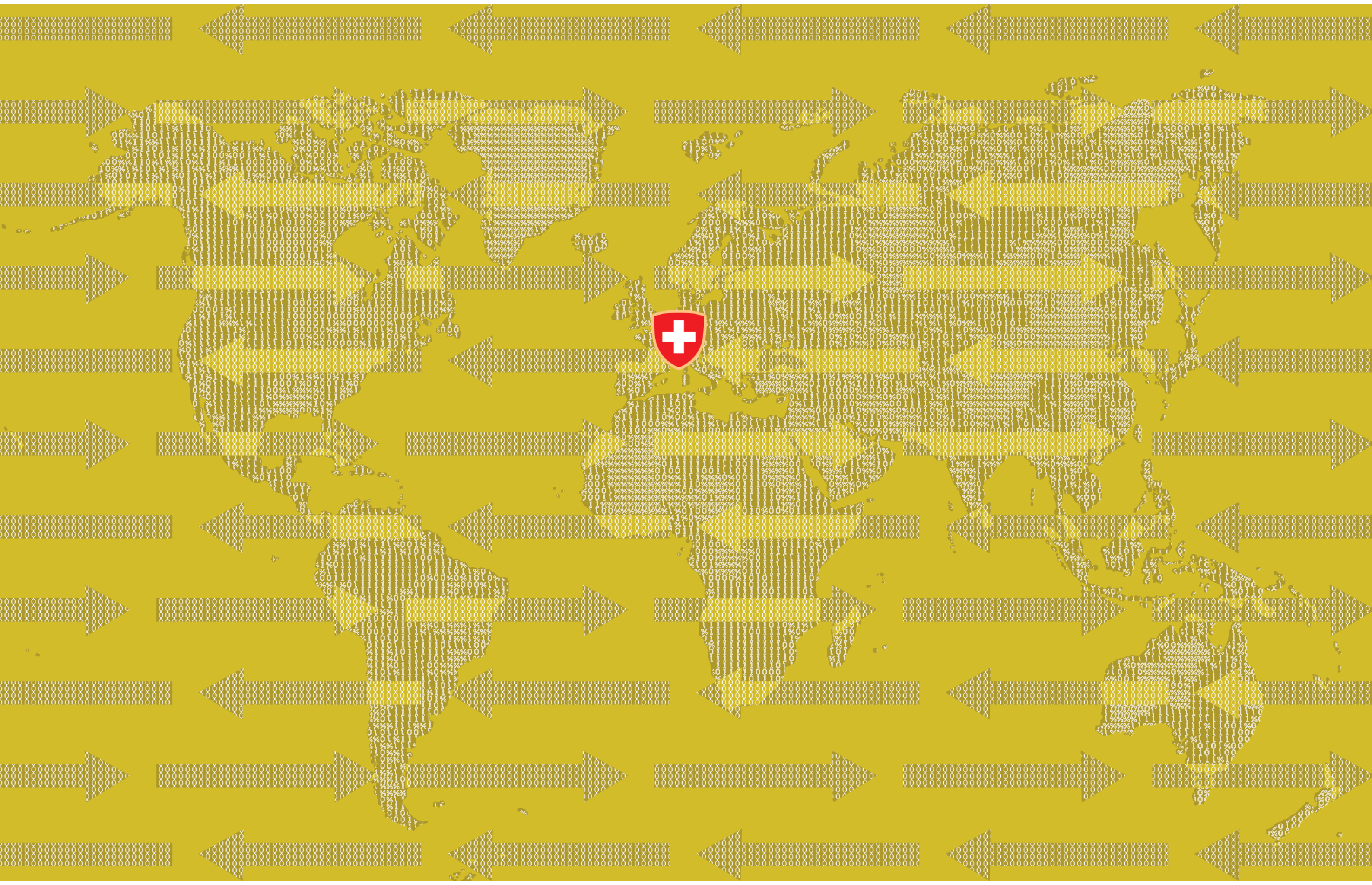
Switzerland's Seventh National Communication and Third Biennial Report under the UNFCCC

Fourth National Communication under the Kyoto Protocol to the UNFCCC

1 January 2018



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Annex C Responses to recommendations and encouragements: Authors of the respective sections in the main text.

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Foreword

Four years after the submission of Switzerland's sixth national communication, considerable progress in the development and implementation of climate policy has been made at the national as well as at the international level. While the Paris Agreement represents an important milestone in our collective effort to curb climate change, Switzerland's greenhouse gas emissions – in spite of continued economic and population growth – have shown a clearly declining trend in recent years. It is reassuring to see that the measures put in place over the last two decades proof to be effective and that they are compatible with the prosperous development of society.

At present, the process for establishing the legal basis for the implementation of the Paris Agreement at the national level is well under way. The third CO_2 Act will build upon proven instruments. It will contain the necessary modifications to meet the mitigation target Switzerland has committed to for the 2030 time horizon. Projections indicate that, beyond 2030, further action will be required to honour the ultimate goals set by 'Paris'.

The Paris Agreement is truly visionary in stipulating that, in order to limit global warming to a level well below the critical threshold of two degrees Celsius, it is our common ambition to achieve a balance between anthropogenic emissions and removals of greenhouse gases in the second half of this century. We must acknowledge that we do not have a clear understanding yet of what it means to live in a 'net zero emissions world'. Winning the battle against climate change will largely depend on our ability to perceive 'net zero' as a code for a desirable, better future. If we manage to see the Paris Agreement as the key that will free us from the dependency on fossil fuels while opening the way to a genuinely balanced, sustainable use of the riches provided by Earth, the battle is already halfway won.

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December 2017

1 Executive summary

1.1 Introduction

Switzerland's seventh national communication under the United Nations Framework Convention on Climate Change (UNFCCC) was prepared based on the UNFCCC reporting guidelines on national communications as provided in document FCCC/SBI/2016/L.22. These guidelines are the outcome of a careful and thorough process of updating of the previous guidelines version that was adopted in 1999. The revised guidelines represent the consensus of Parties with regard to all provisions except the language in which national communications are submitted. Switzerland has decided to apply these guidelines in order to be able to provide up-to-date information that is consistent with the provisions of the UNFCCC biennial reporting guidelines.

Switzerland's third biennial report is presented as an annex to the seventh national communication (Annex B), with detailed reporting of the information on the common topics in the main text of the national communication. The third biennial report was prepared based on the UNFCCC biennial reporting guidelines for developed country Parties (decision 2/CP.17). The accompanying tables were prepared according to the common tabular format (BR CTF tables, decision 19/CP.18). Switzerland took into consideration the methodologies for the reporting of financial information by Parties included in Annex I to the Convention (decision 9/CP.21), also implementing the revisions to the common tabular format. The supplementary information under Article 7, paragraph 2 of the Kyoto Protocol, as requested by decision 22/CP.7, is contained in different chapters and sections of Switzerland's seventh national communication and summarised in Annex A.

In preparation of the seventh national communication and the third biennial report, Switzerland took into account the issues raised by the expert review teams in the course of the reviews of the previous reports. To assist the review process, Annex C provides detailed answers to every recommendation and encouragement from the 'report of the technical review of the sixth national communication of Switzerland' (FCCC/IDR.6/CHE) and the 'report of the technical review of the second biennial report of Switzerland' (FCCC/TRR.2/CHE). The following sections provide a summary of the chapters contained in Switzerland's seventh national communication.

1.2 National circumstances relevant to greenhouse gas emissions and removals

Government structure

Switzerland is a confederation, subdivided into 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, the principle of subsidiarity is of greatest importance. This is reflected in constitutional law, stipulating that unless legislative power is explicitly assigned to the Swiss Confederation, the cantons are sovereign, i.e. entitled to legislate in an area of policy. At the federal level, the following separation of powers is established: (i) the legislative authority at the federal level consists of a bicameral parliament, with the 200 members of the National Council representing the population of the country as a whole and the 46 members of the Council of States representing the cantons (together forming the Federal Assembly, i.e. the Swiss Parliament), (ii) the executive authority at the federal level is the Swiss Federal Council, consisting of seven members with equal power, and (iii) the highest judicative authority of the country is the Federal Supreme Court. However, according to the Federal Constitution of the Swiss Confederation, the Swiss people are sovereign and ultimately the supreme political authority. Consequently, virtually all important decisions have to be approved by the electorate (i.e. adults who are eligible to vote, about 63 per cent of the resident population). The most important formal instruments of Switzerland's direct democracy are (i) the optional referendum which allows citizens to veto decisions made by the Swiss Parliament, (ii) the mandatory referendum on each constitutional amendment passed by the Swiss Parliament, and (iii) the popular initiative by which citizens can propose amendments to the Federal Constitution of the Swiss Confederation.

Due to the very close economic ties of Switzerland with neighbouring States and the European Union, the relationship with the European Union is a high priority of Swiss foreign policy. Bilateral agreements are the legal basis of this close cooperation and most new laws or amendments to existing laws are made compatible with European Union legislation. Switzerland is a member of several international organisations (e.g. the OECD, the World Bank Group and all United Nations specialised agencies). In March 2002, the Swiss population also voted for membership to the United Nations, and since September 2002, Switzerland is a full member of the United Nations.

Population profile

At the end of 2015, Switzerland had a population of 8.327 million permanent residents with an average a density of 201.7 persons per square kilometre. Population is concentrated on the Swiss Plateau, the major alpine valleys and the Ticino, while the density is substantially lower in the hilly and alpine regions of the country. Population growth exceeded one per cent per year for about the last decade and mainly results from immigration and increasing life expectancy. It is expected that population growth will continue, leading to 9.5 million permanent residents by 2030 and 10.2 million permanent residents by 2045. Approximately 25 per cent of the permanent residential population are foreign nationals.

Economic profile

Switzerland's nominal gross domestic product was about 650 billion Swiss francs in 2016, corresponding to about 78 thousand Swiss francs per capita. With just a few exceptions in the early 1990s and in 2009, Switzerland's real gross domestic product increased annually by up to four per cent compared to the previous year over the period 1990 to 2015. Switzerland's economy largely depends on the services sector, which in 2015 not only employed 75.7 per cent of the total workforce, but also contributed 73.8 per cent to the gross value added.

The economy strongly depends on trade with other countries, as Switzerland imports bulk raw materials and exports processed high-quality goods. Switzerland's trade balance (exports minus imports) was about balanced between 1992 and the early 2000s. Since 2002, exports growth has been accelerating as compared to imports growth. By 2015, Switzerland's trade balance (export minus imports) equalled about five per cent of the gross domestic product. Among the most important traded goods in terms of monetary value are chemical and pharmaceutical products, noble metals, jewels and gemstones, machines, instruments and electronics, precision instruments, and watches.

Geographical profile

Switzerland, located in the centre of Europe, covers an area of 41'285 square kilometres, comprising 31.3 per cent forests and grove, 35.9 per cent utilised agricultural area, 7.5 per cent built-up and 25.3 per cent unproductive surface. The topography is determined by the Swiss Plateau, the Jura Mountains and the Alps. Around 50 per cent of Switzerland's surface area is located above 1'000 metres above sea level.

Climate profile

With the Alps acting as climatic divide, meteorological conditions such as average temperature and precipitation vary significantly across Switzerland. About one third of the relatively abundant precipitation occurs as snow. Variable winter temperatures are an important factor influencing energy consumption and leave a strong imprint on annual CO_2 emissions. Long-term measurements indicate a marked shift towards a warmer climate (+2.0 degrees Celsius between 1864 and 2016 compared to +0.9 degrees Celsius globally). Changes in mean precipitation are less clear, although there are robust indications for changes in heavy precipitation.

Energy

Switzerland's energy system largely depends on energy imports. Gross energy consumption of 1'087'820 TJ in 2016 was composed as follows: (i) 259'800 TJ had a domestic origin (50.3 per cent hydropower, 22.7 per cent waste, 15.9 per cent wood, 11.1 per cent other renewable energy sources), (ii) 954'040 TJ were imported (48.3 per cent crude oil and oil products, 13.2 per cent gas, 23.1 per cent nuclear fuel, 14.3 per cent electricity, 0.5 per cent wood and other renewable energy resources, and 0.5 per cent coal), (iii) exports accounted for a total of 142'250 TJ (86.3 per cent electricity, 13.6 per cent oil products, 0.1 per cent wood), and (iv) the remaining 16'230 TJ corresponded to changes in the stocks of crude oil, oil products and coal. Due to the impact of meteorological conditions on heating demand, the final energy consumption shows strong year-to-year variations. However, looking at the last about five years, a decreasing trend in final energy consumption is discernible.

Transport

Switzerland's transport infrastructure provides for extensive road and rail networks serving individual and freight transport needs. This includes comprehensive public transportation services. The number of cars in Switzerland increased from 3.0 million in 1990 to 4.5 million in 2016. Between 1980 and 2015, motorised private transport (total passenger kilometres) increased by 43.9 per cent and public transport on road and rail (total passenger kilometres) increased by 83.4 per cent, as a result of an increase in population as well as in the daily travel distance per person.

Freight transport increased by 40 per cent since 1990, with the share of rail fluctuating around 40 per cent. However, transalpine freight transport in Switzerland is dominated by rail, inter alia, thanks to newly constructed railway tunnels. Given the relatively short distances and the dense and fast road and railway networks, domestic aviation is negligible.

Industry and services

The structure of Switzerland's industry sector clearly reflects the fact that the country is relatively poor in natural resources. Switzerland's industry is specialised in the production of mechanical devices and engines, data processing equipment, and high-precision instruments (watches and goods for medical uses). Of greatest importance are the food processing and chemical industries, in particular the production of pharmaceutical articles. However, Switzerland's economy is largely based on the highly diverse services sector, with the following most important branches (in descending order of gross value added): (i) wholesale trade, (ii) legal advice, architecture and consultancy, (iii) financial service activities, (iv) human health activities, (v) insurance, reinsurance and pension funding, and (vi) retail trade, etc.

Waste

With regard to waste treatment, Switzerland has efficient infrastructure, high standards and clear legal stipulations in place. In concert with increasing prosperity and the steady growth of population, the total amount of municipal solid waste generated in Switzerland increased by 47 per cent between 1990 and 2015 and accounted for 6.03 million tonnes in 2015 (724 kilograms per person). Thereof, 2.85 million tonnes were incinerated and 3.18 million tonnes were recycled (landfilling of combustible waste is banned since the year 2000). In Switzerland, the wastewater of virtually the full population (i.e. of about 97 per cent of the population) is sewered to a wastewater treatment plant.

Building stock and urban structure

In 2015, the building stock in Switzerland consisted of 1.7 million buildings with at least partial residential use, corresponding to an increase of 30 per cent compared to 1990. Between 1990 and 2015, the energy reference area of buildings in the services sector increased by 28 per cent, of buildings in the industry sector by 22 per cent, and of buildings for residential use by 41 per cent. In 2015, 63 per cent of all buildings were heated with fossil fuels. Heat pumps account for about 70 per cent of heating systems installed in newly constructed buildings. Switzerland's urban structure may be best described by the term 'network city', i.e. a large number of interconnected 'nodes' with high densities of population, goods and information which have an extensive and efficient mutual exchange.

Agriculture

Switzerland's utilised agricultural area (excluding alpine pastures) accounts for 25.4 per cent of the total land surface. When alpine pastures are included, the agricultural land surface covers 35.9 per cent of the total land surface. The number of farms decreased by one third between 1996 and 2015. A large share of farms keep ruminants. The number of cattle decreased by 16 per cent between 1990 and 2015 while productivity per animal was on the rise.

Forest

A third of Switzerland is covered by forests, with more than half of the forest being located above 1'000 metres above sea level. Of the 419 million cubic metres wood stocked in Swiss forests, 32 per cent arise from deciduous trees and 68 per cent arise from coniferous trees. Since 1983–1985, the forest area has increased by 9.7 per cent. Forest growth was significant in the Alps, while the forest area in the central lowlands and the Jura remained about stable.

Relationship between national circumstances and greenhouse gas emissions

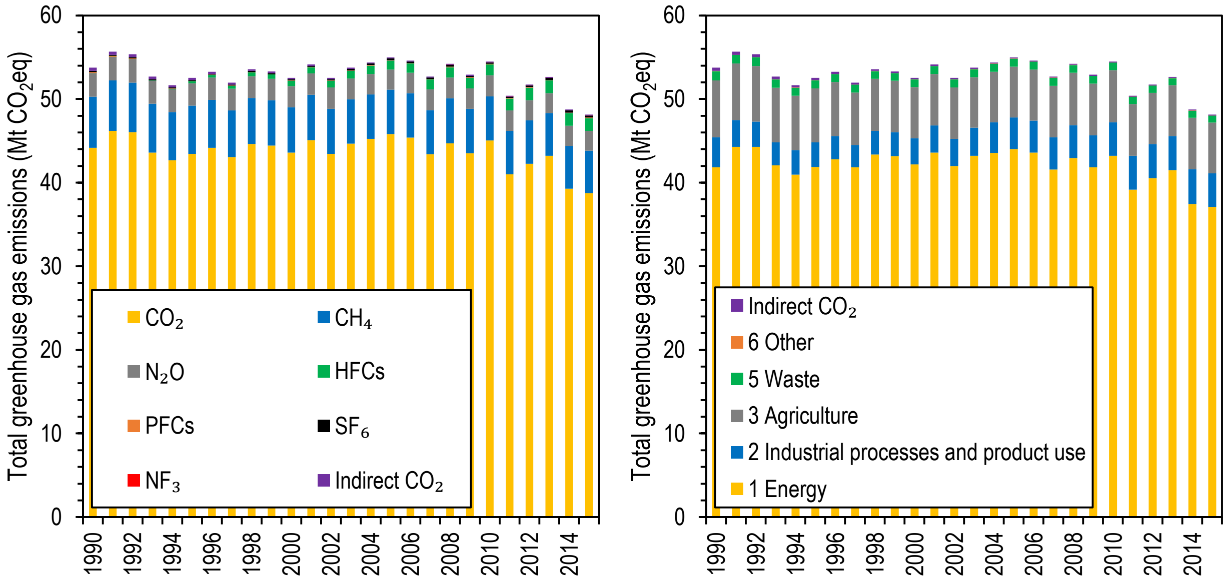
In line with the prospering economy and closely related to the increasing population, numerous key variables – such as the gross domestic product, industrial production, number of buildings, energy reference areas (in the services, industry, and buildings sectors), vehicle stock, passenger and tonne kilometres, foodstuff produced, amount of waste, etc. – evolved, from 1990 to 2015, in a way as to provoke additional greenhouse gas emissions. In contrast, Switzerland's greenhouse gas emissions showed a slightly decreasing trend over the same time interval, indicating a decoupling of greenhouse gas emissions from economic and population growth. Accordingly, Switzerland managed to improve its greenhouse gas intensity substantially. Greenhouse gas emissions per capita and per gross domestic product decreased by 27 and 39 per cent, respectively, between 1990 and 2015.

1.3 Greenhouse gas inventory information

Switzerland's greenhouse gas emissions

Switzerland's total greenhouse gas emissions (excluding LULUCF and international bunkers, including indirect CO_2) were 48.151 million tonnes of CO_2 equivalents in 2015 (Fig. 1), corresponding to 5.8 tonnes of CO_2 equivalents per capita. Between 1990 and 2015, total greenhouse gas emissions (excluding LULUCF) were mostly modulated by year-to-year changes in meteorological conditions which drive the amount of fuel needed for heating purposes. This resulted in minimum emissions of 89.6 per cent in 2015 and maximum emissions of 103.6 per cent in 1991, relative to 1990. For the last 10 years, a slightly decreasing trend superimposed the variations from meteorological conditions.

Fig. 1 > Switzerland's total greenhouse gas emissions (excluding LULUCF and international bunkers, including emissions from the sectors 1, 2, 3, 5, and 6, including indirect CO2), 1990–2015. Left: Subdivided by gas. Right: Subdivided by sector.



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Regarding gases, CO_2 was the dominant contributor gas over the full time period (share of 80.5 per cent in total greenhouse gas emissions in 2015). CO_2 emissions primarily stem from fuel combustion activities, followed by emissions from industrial processes (mainly cement production). CH_4 emissions decreased by 16.7 per cent between 1990 and 2015, and accounted for a share of 10.6 per cent in total greenhouse gas emissions in 2015. The decrease is mainly attributable to reduced emissions from agriculture, but reduced CH_4 emissions from the energy and waste sectors also contributed to the observed trend. N_2O emissions decreased by 16.9 per cent between 1990 and 2015, and accounted for a share of 4.9 per cent in total greenhouse gas emissions in 2015. N_2O emissions from manure management and agricultural soils declined in concert with CH_4 emissions due to decreasing livestock populations and decreasing use of fertiliser. F-gas emissions (HFCs, PFCs, SF_6, and NF_3) increased their share in total greenhouse gas emissions from 0.5 per cent in 1990 to 3.8 per cent in 2015.

Regarding sectors, the major source of greenhouse gases in Switzerland is represented by sector 1 'Energy' (77.1 per cent of total emissions in 2015). In this sector, the overall emissions remained at a relatively constant level since 1990, with some fluctuations mainly caused by year-to-year variations in meteorological conditions. As in Switzerland electric power is mainly generated by hydroelectric and nuclear power plants, the main contributions to the emissions from sector 1 'Energy' stem from the source categories 1A3 'Transport', 1A4 'Other sectors' (residential and commercial buildings), and 1A2 'Manufacturing industries and construction'. Sector 2 'Industrial processes and product use' accounted for a share of 8.3 per cent in total greenhouse gas emissions in 2015. Sector 3 'Agriculture' accounted for a share of 12.6 per cent in total greenhouse gas emissions in 2015. Declining livestock (cattle and swine) and reduced fertiliser use have led to a decrease in CO_2 equivalents emissions from this sector until 2004, subsequently emissions remained relatively stable. In sector 4 'Land use, land-use change and forestry' (LULUCF), a reduction in net CO_2 removals is observed between 1990 and 2015, but wood harvesting is generally exceeded by the growth of the living biomass pool. Sector 5 'Waste' contributed 1.8 per cent to total greenhouse gas emissions in 2015. Emissions are mainly caused by solid waste disposal sites (inputs into solid waste disposal sites ceased in the year 2000, but emissions still occur) and wastewater treatment, and decreased by 25.3 per cent since 1990. Emissions from sector 6 'Other' as well as indirect CO_2 emissions play a minor role.

National inventory arrangements

Switzerland's national greenhouse gas inventory system is developed and managed under the auspices of the Swiss Federal Department of the Environment, Transport, Energy and Communications, with the Swiss Federal Office for the Environment being responsible for the coordination. All institutional arrangements required for ensuring quality and timeliness of national submissions were established with regard to the first commitment period of the Kyoto Protocol, when the national system was becoming fully operational. All arrangements have been maintained and adjusted as required ever since.

National registry

Switzerland's national registry conforms to the technical specifications of data exchange standards (DES) for registry systems under the Kyoto Protocol. It got fully operational with the international transaction log (ITL) on 4 December 2007. The daily reconciliations confirm the integrity of the database.

1.4 Policies and measures

Switzerland has a wide spectrum of policies and measures in place. Many of these have been upheld for a long time and are scheduled to be strengthened in the future or supplemented by additional policies and measures (planned policies and measures). In its seventh national communication, Switzerland presents estimates of the mitigation impact of each policy and measure, discusses – in a more general way – the costs of policies and measures, and provides details regarding monitoring and evaluation. Also discussed are the economic and social consequences of response measures.

Policymaking process

The Federal Constitution of the Swiss Confederation forms the overarching framework for environmental and climate policy in Switzerland, making long-term preservation of natural resources one of the main aims (Article 74 of the Federal Constitution of the Swiss Confederation). The Swiss government has established an Interdepartmental Sustainable Development Committee which defines the priorities for action and oversees implementation and monitoring of progress. The interdepartmental committee on climate of the federal authorities ('IDA-Klima') is responsible for the coordination between different policy areas and assures a coherent climate policy of the Swiss Confederation in compliance with the UNFCCC.

Deduced from the Federal Constitution of the Swiss Confederation, the principles and instruments of Switzerland's environmental policy are stipulated in the Federal Act on the Protection of the Environment, supported by various related acts (such as the CO_2 Act and the Energy Act) which define objectives, instruments, measures and general rules of implementation of climate policy at the needed level of detail.

By ratifying the UNFCCC in 1993, the Kyoto Protocol in 2003, the Doha Amendment to the Kyoto Protocol in 2015, and the Paris Agreement in 2017 Switzerland internationally committed to contribute to the stabilisation of greenhouse gas emissions at a level that prevents dangerous anthropogenic interference with the climate system.

Even if global warming is limited to two degrees Celsius or below, Switzerland will face major impacts (hitherto the warming in Switzerland exceeded the global warming by about a factor of two). Adapting to the effects of climate change is therefore becoming increasingly important. The Swiss government – entrusted to coordinate adaptation efforts – has implemented the Swiss adaptation strategy and the corresponding action plan, as well as various supporting measures.

Cross-sectoral policies and measures

While various policies and measures may have side effects beyond their specific policy domain, some policies and measures are clearly cross-sectoral in nature in that they impact on several sectors at the same time. The CO_2 Act is the most fundamental of these cross-sectoral policies and measures, forming the legal framework for the implementation of Switzerland's wide spectrum of policies and measures tackling climate change. The first CO_2 Act entered into force in

2000 and has been replaced by the second CO_2 Act in 2013. The third CO_2 Act (planned measure) is being drafted and will supersede the current legislation in 2021. The first, second and third CO_2 Act stipulate the domestic reduction targets (aligned with Switzerland's international reduction commitments), set incentives for increasing use of renewable energies and development of innovative technologies, and aim at creating new employment opportunities in future-oriented areas. Other cross-sectoral policies and measures are (i) the CO_2 levy on heating and process fuels which sets an incentive to use fossil fuels more efficiently, to invest in low carbon technologies and to switch to low-carbon or carbon-free energy sources, (ii) Switzerland's emissions trading scheme (cap and trade system) which gives participating companies the flexibility in contributing to CO_2 reduction goals under the same rules as their international competitors, and (iii) the negotiated reduction commitments (for exemption from the CO_2 levy) for companies of certain sectors with substantial CO_2 emissions, which are not participating in the emissions trading scheme; these companies may commit to individual emission reduction targets (taking into account the technological potential and economic viability of measures) in exchange for being exempt from the CO_2 levy on heating and process fuels.

Energy sector

In the energy sector, the Energy Strategy 2050 sets a number of priorities to assure the future energy supply, such as reduction in energy consumption, broadening of the portfolio of energy sources, expansion and restructuring of the electricity transmission grid as well as energy storage. Emphasis is placed on increased energy savings (energy efficiency), the expansion of hydropower and implementation of new renewable energies. With regard to concrete policies and measures in the energy sector, the SwissEnergy programme represents a major policy instrument engaging cantons, municipalities, industry, as well as environmental and consumer associations for awareness raising and the promotion of increased energy efficiency and the enhanced use of renewable energy. The national buildings refurbishment programme increases the energy efficiency of buildings and promotes the use of renewable energies in the buildings sector, financed by one third of the revenues from the CO_2 levy on heating and process fuels. The building codes of the cantons, which were agreed on by the cantonal energy directors, provide a set of common energy and insulation standards (model ordinances) aimed at reducing energy consumption of buildings. Negotiated commitments on energy efficiency entitle energy-intensive companies to receive a full or partial refund of electricity network surcharges (raised for the promotion of renewable energies) if they commit to enhancing energy efficiency in a target agreement with the Swiss government. The obligation to offset emissions from gas-fired combined-cycle power plants ensures that planning permissions for such power plants are only given if operators commit to offset the CO_2 emissions in full. In the framework of the negotiated reduction commitment of municipal solid waste incineration plant operators, the Swiss Association of municipal solid waste incineration plants committed to reduce net CO_2 emissions (e.g. through the effective use of the heat generated or the recuperation of metals) and to establish a monitoring system to track progress towards the goals set in the agreement with the Swiss government.

Transport sector

Within the transport sector, CO_2 emission regulations for newly registered vehicles ensure the steady decrease of specific fuel consumption of passenger cars and light commercial vehicles. The trend to more efficient vehicles is further supported by the energy label for new motor vehicles which informs potential buyers at the point of sale about specific fuel consumption and CO_2 emissions of the vehicles. The partial compensation of CO_2 emissions from motor fuel use replaces the former climate cent. It obliges importers of fossil motor fuels to offset an increasing part of the resulting CO_2 emissions through investments in domestic emission reduction projects, financed by a surcharge on the imported fuels. The heavy vehicle charge is applied to passenger and freight transport vehicles of more than 3.5 tonnes gross weight and aims at reducing tonne kilometres, in particular by shifting transalpine transport from road to rail. The mineral oil tax reduction on biofuels and natural gas sets an incentive to enhance the use of renewable motor fuels but also sets strict ecological and social requirements for their production. Further policies and measures in the transport sector concern aviation: (i) the inclusion of aviation in the emissions trading scheme (planned measure), (ii) the CO_2 emissions standard for aircraft, and (iii) the participation of Switzerland in the carbon offsetting and reduction scheme for international civil aviation (CORSIA) (planned measure).

Industrial processes and product use sector

The main instruments affecting greenhouse gas emissions from industry are the CO_2 levy on heating and process fuels, the emissions trading scheme, and the negotiated reduction commitments (for exemption from the CO_2 levy). For emission of F-gases and precursor gases – such as NMVOC – specific policies and measures have been developed. On the one hand, the provisions relating to substances stable in the atmosphere (HFCs, PFCs, SF_6, NF_3) regulate, inter alia, compressed gas containers, plastic foams, solvents containing HFCs, PFCs or HFEs, refrigerants, extinguishing agents, and SF_6 in electrical distribution equipment. On the other hand, the international exhaust gas regulations (NMVOC), the Ordinance on Air Pollution Control and the NMVOC incentive fee aim at reducing NMVOC emissions by setting emission limits for motor vehicles and stationary installations and by using market-based instruments.

Agriculture sector

In the agriculture sector, the following policies and measures are in place: (i) the proof of ecological performance to receive direct payments, contingent on an appropriate soil nutrient balance, a suitable proportion of ecological compensation areas, a crop rotation system, soil protection measures, selective application of crop protection agents, and animal husbandry in line with legal provisions, (ii) the resource programme (subsidies for a more efficient use of natural resources), (iii) the climate strategy for agriculture, i.e. the declaration of intent to reduce greenhouse gas emissions from agriculture by one third by 2050 compared to 1990 with technical, operational and organisational measures and by another third with measures influencing food production and consumption, and (iv) the further development of the direct payments system (orientation towards targets), in particular with additional funds for environmentally-friendly production systems and for the efficient use of resources.

Land use, land-use change and forestry sector

In the land use, land-use change and forestry sector the climate-related goal of policies and measures is to adapt forests by increasing resilience to climate change and – taking into account the high growing stock – to reduce CO_2 emissions by substituting other materials or fossil fuels rather than enhancing sink capacity. The following policies and measures aim at reaching these goals: (i) the Forest Act (sustainable forest management and forest area conservation), including a ban on clear-cutting and deforestation, (ii) the Wood Action Plan aiming at better use of the wood harvest potential (optimised cascaded use of wood, climate-appropriate building and refurbishment as well as communication, knowledge transfer and cooperation), (iii) the measures within Forest Policy 2020 aiming at improving the conditions for an efficient and innovative forestry and wood industry, and (iv) the Forest Act (most recent changes), a renewal of legal provision aiming at, inter alia, increasing the adaptive capacity of Switzerland’s forests and the promotion of the use of sustainably produced timber (e.g. for the construction of federal buildings).

Waste sector

In the waste sector, two policies and measures are in place. First, the ban on landfilling of combustible waste ensures that all combustible waste is incinerated in waste incineration plants using the combustion heat to generate electricity or to supply district heating networks and industrial facilities. Second, the Ordinance on the Avoidance and Management of Waste enforces the further optimisation of energy recovery by municipal solid waste incineration plants.

1.5 Projections and total effect of policies and measures

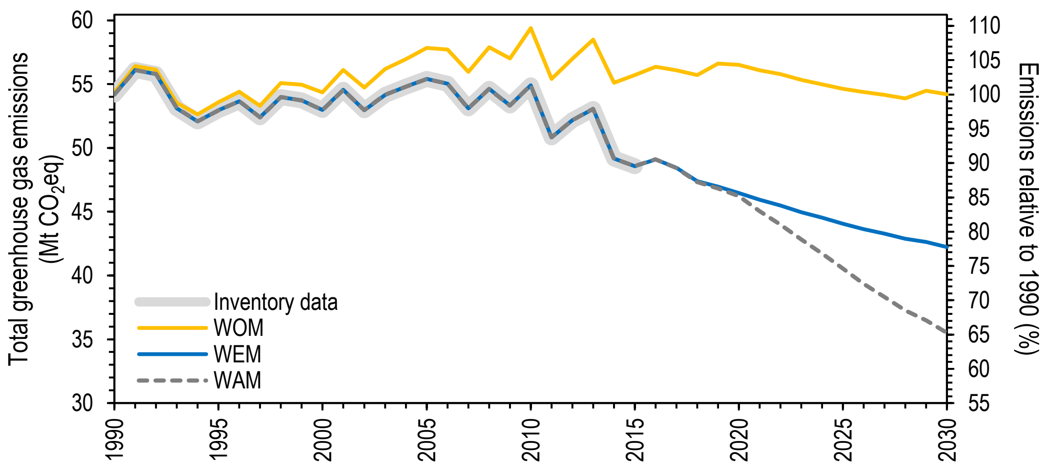
As shown in Fig. 2, Switzerland has developed the three scenarios ‘with existing measures’ (WEM), ‘without measures’ (WOM), and ‘with additional measures’ (WAM) covering the time interval from 1990 to 2030 (the WEM and WAM scenarios correspond to actual inventory data between 1990 and 2015). Regarding the underlying key parameters, population is assumed to increase considerably over the coming decades. This is also reflected in energy reference area and transport growth. Switzerland’s gross domestic product, another parameter strongly influencing energy consumption and greenhouse gas emissions, is also assumed to increase considerably over the coming decades. In brief, the three scenarios are characterised as follows:

- The WEM scenario reflects the current state of legislation and also takes into account the stipulated strengthening of existing policies and measures (i.e. any strengthening foreseen under current legislation). By 2020 and 2030, Switzerland’s total greenhouse gas emissions under the WEM scenario are projected to decrease to 85.6 per cent and 77.7 per cent of the emissions in 1990, respectively. Emission reductions from the source categories covering residential and commercial/institutional buildings (1A4) as well as transport (1A3) dominate the projected evolution of total greenhouse gas emissions under the WEM scenario. Emissions from other source categories remain about stable and/or are of minor importance, with the exception of the F-gases, where projections suggest the peaking of emissions before 2020 and a decline thereafter;
- Under the WOM scenario, climate-relevant policies and measures are excluded as early as 1990 (with a few exceptions). Consequently, emissions under the WOM scenario show an increasing tendency until around 2010,

followed by a slow decrease to 4.0 per cent above the emissions in 1990 by 2020 and to 0.3 per cent below the emissions in 1990 by 2030. This decreasing trend after about 2010 is a result of autonomous technological progress improving the greenhouse gas efficiency also in the absence of policies and measures. Notably, under this scenario greenhouse gas emissions show a stepwise increase at the time when nuclear power plants are decommissioned and assumed to be replaced by gas-fired combined-cycle power plants (2019 and 2029). A continuously increasing trend is also projected for emissions from the industrial processes and product use sector, which, driven by HFC emissions, increase to 29.1 per cent above the emissions in 1990 by 2020 and to 31.9 per cent above the emissions in 1990 by 2030;

- The WAM scenario encompasses implemented, adopted and planned policies and measures. By 2030, Switzerland's total greenhouse gas emissions under the WAM scenario are projected to decrease to 65.2 per cent of the emissions in 1990. Compared to the WEM scenario, emissions decrease faster, as new policies and measures are introduced and existing policies and measures are strengthened beyond the strengthening already stipulated under current legislation (i.e., under the WEM scenario).

Fig. 2 > Total greenhouse gas emissions under the WEM, WOM and WAM scenarios as relevant for Switzerland's emission reduction targets (i.e. including emissions of all greenhouse gases from the sectors 1, 2, 3 and 5, including indirect CO_2 emissions from these sectors, excluding direct and indirect emissions from sector 6, excluding emissions and removals from land use, land-use change and forestry, and excluding emissions from international transport). Also shown are actual inventory data for the years 1990 to 2015. The vertical axis to the right indicates emissions relative to 1990.



Swiss Federal Office for the Environment

The difference between the emissions under the WOM and WEM scenarios indicates that the total effect of currently implemented and adopted policies and measures is estimated at a reduction of 10.0 million tonnes of CO_2 equivalents for 2020 and 12.0 million tonnes of CO_2 equivalents for 2030 (annual reduction, not cumulative). In 2020, CO_2 contributes 83 per cent to the total reduction, and the energy sector accounts for 84 per cent of the total reduction. For 2030, the difference between the emissions under the WEM and WAM scenarios indicates that the total additional effect of planned policies and measures is estimated at 6.7 million tonnes of CO_2 equivalents (annual reduction, not cumulative).

The methodologies applied to calculate Switzerland's greenhouse gas emission scenarios are tailored to the particular characteristics of each sector, ensuring consistency with the actual data of the greenhouse gas inventory. For the energy sector a computable general equilibrium model providing the optimised use of goods including energy – thereby reflecting the effect of policies and measures in place at any time – was applied for the first time. For the industrial processes and product use sector as well as for the waste sector, projections were calculated following exactly the same methodology as used for the greenhouse gas inventory, i.e. bottom-up estimates according to the 2006 IPCC guidelines for national greenhouse gas inventories. For the agriculture sector, scenarios are based on projected activity data, e.g. livestock numbers, crop production data (amount of crops harvested, area of crop cultures, meadows and pastures) and fertiliser use from different agricultural policy evaluation models. To project emissions from the land use, land-use change and forestry sector, a stochastic empirical single tree forest management scenario model (MASSIMO3) was used. Switzerland also performed a sensitivity analysis to investigate the dependency of the projected emissions on the key underlying assumptions.

1.6 Vulnerability assessment, climate change impacts and adaptation measures

State of models, scenarios and knowledge about climate change impacts

The official scenarios on climate change currently used in Switzerland (CH2011 scenarios) were launched in 2011. They were based on a large number of European-scale regional climate model experiments available at that time from international projects. Statistical methods were used to produce multi-model estimates of changes and associated uncertainties in seasonal mean temperature and precipitation changes for three representative Swiss regions and three scenario periods.

The CH2011 scenarios served as a basis for a variety of climate change impact studies in Switzerland. The largest such study, 'CH2014-Impacts', investigated quantitative impacts of climate change focusing on ecologic, economic and social impacts. The CH2011 scenarios, together with their extensions, also constituted the basis of an overview report on climate change in Switzerland published by the Swiss Academy of Sciences in late 2016. In many respects, research findings presented in Switzerland's sixth national communication still correspond to the current state of knowledge on climate change impacts in the various sectors.

With the advancement of new higher-resolved regional climate model projections and with an improving scientific understanding of systems affected by climate change it is desirable to update the national climate scenarios. A new generation of climate change scenarios for Switzerland (CH2018 scenarios), to be launched in 2018, is being developed as a focus area of the National Centre for Climate Services, which was newly established in 2015. Other goals of the National Centre for Climate Services are to bundle the existing climate services of the Swiss federation, to create new, tailor-made solutions for clients, and to act as a network agent and knowledge broker, thus boosting climate literacy, enabling decision-making processes that take climate considerations into account, and contributing to increased resilience.

Assessment of risks and opportunities

An assessment of present and future climate-related risks and opportunities has been performed in a comprehensive project lasting from 2010 until 2017. It included:

- Developing a method to systematically assess and compare risks and opportunities;
- Carrying out eight case studies in different regions of Switzerland;
- Evaluating and prioritizing the risks and opportunities at the national level in a synthesis report.

The main result is a list of all risks and opportunities potentially affecting Switzerland and a shorter list of the key risks and opportunities that are to be addressed as a matter of priority. Most of the identified risks are already part of the Swiss adaptation strategy (see paragraph below). However, three additional challenges were identified in the project which are not dealt with in the Swiss adaptation strategy. These are linked to winter- and hailstorms, the so-called 'wild card risks' as well as risks and opportunities due to climate-related effects abroad. Furthermore, the project highlighted some opportunities, implying that the Swiss adaptation strategy must not only consider negative but also positive effects. The results of the assessment will be an important input to updating the action plan of the Swiss adaptation strategy in 2019.

Implementation of adaptation action

In 2012, the Swiss Federal Council adopted the first part of the Swiss adaptation strategy, determining the goals, challenges and fields of action. The second part of the strategy, adopted on 9 April 2014, is an action plan for the period 2014 to 2019 that comprises 63 adaptation measures. According to a survey amongst the federal offices responsible for policy development and implementation, a large majority of these measures was in different stages of implementation by 2017 (completed, advanced stage, or early phase). Additional activities supporting the implementation of the Swiss adaptation strategy are, inter alia, an information platform on adaptation to climate change, the pilot programme 'Adaptation to climate change' (see below), and the National Centre for Climate Services.

Cantons are obliged to report on the measures they undertake to adapt to climate change on a five-year basis. The first reporting, which took place in 2015, indicated that 14 cantons had analysed the impacts of climate change from a multi-sectoral and cross-sectoral perspective. In eleven cantons a political decision was taken to focus on adaptation at a cross-sectoral level as a measure complementary to mitigation. Eight cantons had developed an adaptation strategy or an adaptation plan. Only five small cantons reported that they did not undertake any adaptation action yet on a cross-sectoral level.

In 2013, in order to incentivise climate change adaptation action on regional and local level, the pilot programme 'Adaptation to climate change' was launched. Under the leadership of the Swiss Federal Office for the Environment and in cooperation with the civil protection, public health, agriculture, spatial development and the food safety and veterinary offices, the programme serves as a national funding initiative to support cantons, regions and municipalities in tackling the challenges related to climate change impacts. Following a call for projects in 2013, more than 100 proposals were submitted of which 31 projects were selected for funding. These were assigned to five thematic clusters:

- Management of local water scarcity (eight projects);
- Management of natural hazards (six projects);
- Management of ecosystem and land-use changes (ten projects);
- Resilient urban development (three projects);
- Knowledge transfer and governance (four projects).

Project implementation took place between 2014 and 2016. The final phase in 2017 comprised a programme evaluation, the synthesis of results as well as dissemination activities. A follow-up programme is in preparation.

1.7 Financial, technological and capacity-building support

The Federal Constitution of the Swiss Confederation stipulates that Switzerland be committed to the long-term preservation of natural resources and to a just and peaceful international order. Furthermore, it states that Switzerland shall in particular promote global sustainable development and protect the natural resource base in view of alleviating poverty in the world. Support for international climate action – through a variety of channels and instruments, such as dedicated multilateral climate funds, specific multilateral and bilateral climate programmes and projects, as well as integrating low-carbon development and climate resilience into Switzerland's development assistance – has thus been a cornerstone of Switzerland's international engagement since the early 1990s. Regarding international climate financing, three government entities – the Swiss Agency for Development and Cooperation, the Swiss State Secretariat for Economic Affairs, and the Swiss Federal Office for the Environment – have specific roles and dedicated budgets. They cooperate closely to ensure the overall effectiveness and coherence of Swiss support for climate change adaptation and mitigation activities in developing countries and countries in transition.

Through its multilateral and bilateral cooperation and as a member of the main multilateral institutions (such as multilateral development banks, the Global Environment Facility, the United Nations Development Programme, the United Nations Industrial Development Organisation, etc.) Switzerland strives to ensure a more coherent implementation of policies and strategies and to promote synergies in the international division of labour. At a bilateral level, Switzerland supports activities in mitigation and adaptation activities in a number of focal countries and/or regions.

Switzerland's public climate finance has seen a steady increase over the past years. Standing at 175 million US dollars in 2012 the respective amount grew to 299 million US dollars in 2014 and to 330 million US dollars in 2016. This increase was partly fuelled by the decision of the Swiss Parliament in 2011 to raise the level of official development assistance to 0.5 per cent of gross national income by 2015. In addition, Switzerland's official development assistance has gradually shifted to place an enhanced focus on climate change, integrating it into development activities. These strategic decisions lead to a remarkable progression compared to previous efforts. Switzerland therefore categorises its provided climate finance as new and additional. It represents furthermore its highest possible effort under budget constraints that currently also affect official development assistance spending and is therefore considered adequate by the Swiss government pursuant to Article 4, paragraph 3, of the Convention.

Switzerland has made financial contributions to the UNFCCC secretariat, to the operating entities of the financial mechanism of the Convention, to other multilateral institutions and to international financial institutions such as the World Bank and other multilateral development banks that fund climate change adaptation, mitigation, disaster risk management, capacity building and technology cooperation programmes in developing countries. Among the international financial institutions, the largest contribution goes to the International Development Association, a substantial share of which is allocated to finance climate change action. Switzerland's total contribution to the 17th replenishment of the International Development Association was 752 million US dollars. Moreover, many international organisations, such as the United Nations Development Programme and the Consultative Group on International Agricultural Research, whose operations are co-funded by Swiss core contributions, are increasingly generating important climate benefits. In total, Switzerland increased its climate-specific contributions (public, grant-based) to multilateral institutions from 97 million US dollars in 2013 to 136 million US dollars in 2016 for mitigation and adaptation activities in developing country Parties.

Next to the important multilateral engagement, bilateral programmes and projects build a key element of Switzerland's climate change cooperation. Switzerland works closely with bilateral partners to deliver both effective global responses and tangible results on the ground. All activities are implemented by one of the two Swiss development agencies – the Swiss Agency for Development and Cooperation or the Swiss State Secretariat for Economic Affairs – in close cooperation with government institutions, non-governmental organisations, private sector entities and research institutions. Switzerland's bilateral and regional climate-relevant activities are (i) generating new and relevant knowledge on climate policy, (ii) technology and implementation, (iii) harness and replicate successful practices, (iv) develop the skills and capacities of partner countries for their engagement in the international debate on climate change issues, and (v) the implementation of climate action. Switzerland was able to increase its public bilateral climate-specific programmes and projects from 184 million US dollars in 2013 to 194 million US dollars in 2016, of which 50.5 per cent were provided for adaptation activities and 49.5 per cent for mitigation activities in developing country Parties. In addition, Switzerland increased its bilateral private sector mobilisation from less than two million US dollars in 2013 to 8.5 million US dollars in 2016 through some of its public co-financing activities.

To foster mutual learning, various success stories for effective technology transfer and development as well as capacity building are highlighted in Switzerland's seventh national communication. Switzerland thereby highlights the integrated character of both technology transfer and capacity building in Swiss mitigation and/or adaptation support projects and programmes for developing country Parties.

1.8 Research and systematic observation

Research

In Switzerland, climate research is spread over many institutions and funded through national and international funding bodies. Climate-related research can be divided into several categories:

- National research centres (Oeschger Centre for Climate Change Research, Centre for Climate Systems Modelling, Centre for Development and Environment);
- Climate-relevant energy research, including eight dedicated competence centres (SCCER);
- Individual research projects (funded by the National Science Foundation or government institutions);
- Participation in international research programmes (European Union, European Cooperation in Science and Technology, World Climate Research Programme, Future Earth) by researchers at various universities, the Swiss Federal Institutes of Technology in Zurich and Lausanne, universities of applied sciences and private and public research organisations;
- Collaborations with international research centres and organisations (European Centre for Medium-Range Weather Forecasts, European Organisation for the Exploitation of Meteorological Satellites, World Meteorological Organisation, Intergovernmental Panel on Climate Change).

In 2017, about 130 climate-relevant projects have received funding from the National Science Foundation, with an average funding of 150 thousand Swiss francs per project and year. The funding provided for 55 European Union research projects and for 86 European Cooperation in Science and Technology projects was about 23 million Swiss francs and about 15 million Swiss francs, respectively (for the whole project duration each).

Switzerland participates in various international research programmes, operates climate monitoring stations and networks (in collaboration with the Global Climate Observing System, GCOS), and maintains calibration and data centres.

A number of ‘Global Research Projects’ of Future Earth (former ‘core projects’ of the International Geosphere Biosphere Programme IGPB) are substantially supported by Switzerland. The international project offices for the Past Global Changes (PAGES) project, the Global Mountain Biodiversity Assessment, the international research programme on biodiversity science (bioDISCOVERY) as well as the Global Land Project are all hosted by Swiss research institutions and at least partly funded by Switzerland. Swiss scientists are involved in many other global research projects within Future Earth. Switzerland also contributes substantially to capacity building in transdisciplinary research methods within Future Earth through its ‘Network of Transdisciplinarity’ (td-net).

Systematic observation

Switzerland has a long-standing tradition of climate observation. Temperature and precipitation records for more than 150 years, the world’s longest total ozone series, glacier measurements dating back to the end of the 19th century and the 30-year anniversary of the World Glacier Monitoring Service form some of the highlights of the Swiss contribution to global climate monitoring.

The national climate observing system (GCOS Switzerland) serves as the observation and monitoring pillar for the national implementation of the Global Framework for Climate Services. The national implementation of the Global Framework for Climate Services is coordinated by the National Centre for Climate Services.

Aligned with the schedule of the international GCOS programme and in close collaboration with its national partner institutions, the Swiss GCOS Office at MeteoSwiss has recently elaborated a new strategy for the GCOS Switzerland programme for the period 2017–2026. While maintaining a priority on securing the most important long measurement series, particular emphasis will be put on promoting, e.g., the integration of new measurement techniques, an integrative monitoring approach across earth system cycles, and enhanced communication with stakeholders.

The strategy update also involved the revision of the national GCOS Switzerland inventory report from 2007. The following essential climate variables were newly included in the inventory report: river temperature, albedo, soil carbon, land surface temperature, and anthropogenic greenhouse gases. Furthermore, a new section on ancillary data (e.g. digital elevation models) was added, and a new overarching chapter on new methods of observation summarises latest developments in climate observations (e.g. satellite observations).

Switzerland actively contributes to the GCOS Cooperation Mechanism to enhance the quality of climate observations globally, in particular in developing and emerging countries. During the period 2011–2017, the project CATCOS (Capacity Building and Twinning for Climate Observing Systems) aimed to improve the capacity to obtain high-quality climate observations in the atmospheric and terrestrial domains, and to submit these to the designated GCOS international data centres. The project was active in ten countries in Africa, South-East Asia, South America, and Central Asia.

1.9 Education, training and public awareness

In Switzerland, over the past decade, recurrent severe weather events that may be related to a changing climate have reinforced the public perception of climate change. Impacts of exceptional weather conditions on agriculture and winter tourism are increasingly seen as potential harbingers of a shifting climate regime. At the same time, in the political debate about more sustainable modes of energy provision as well as about drivers, trends and patterns of energy consumption, greenhouse gas emissions and climate change have become a prominent element.

These developments reflect a general change in public perception of climate change as a reality that needs to be taken into account in politics and business. However, the challenges this poses to present modes of production and consumption may not yet be fully understood. In a world of globalised markets, where flows of raw materials, goods and energy are complex and difficult to track, balance sheets at the national level have lost much of their meaning and the links between local decision making and global implications for the environment are weak. This underlines the importance of continuing efforts in the areas of education, training and public awareness.

Compulsory education

Switzerland has a federal education system in which the education ministries of the 26 cantons have far-reaching competencies to decide about the school system on all levels, including curricula and learning methods. In recent years, efforts to harmonise curricula for compulsory education have been undertaken.

At present, a large majority of German speaking and bilingual cantons have endorsed a common model curriculum, thus aligning their educational frameworks with the related requirements as set out in the Federal Constitution of the Swiss Confederation. This curriculum defines goals at all levels of compulsory education. It serves as a planning tool for schools.

Education for sustainable development is acknowledged as a cross-disciplinary theme relevant to a wide range of subjects. However, there is no systemic approach to the integration of the notion of sustainable development in the formal education system nor are there binding national guidelines concerning its integration into educators' initial training. As regards topics directly related to the core issues of the UNFCCC, in the national model curricula for the lower-secondary level, weather, climate and climate change are explicitly addressed.

Vocational education and training

Education for sustainable development is part of the general studies curriculum for all apprentices in Switzerland. Additionally, in many of the decrees for each profession there is a reference to education for sustainable development. Amongst the main instruments of the SwissEnergy programme are information and awareness raising activities, counselling as well as targeted support for education and training projects. The programme contains measures directed at professionals from various trades, in particular the construction sector. One of its ambitions is to include new developments in energy technologies in vocational education, offering up-to-date training materials and accelerating knowledge transfer. In addition, the 'Climate programme Training and Communication', which is developed based on the second CO_2 Act, will have a special focus on professions with high relevance for Switzerland's greenhouse gas emissions.

Public awareness

In recent years, no public awareness-raising campaigns focussing specifically on climate change and directed at the general public have been conducted by the federal authorities. Climate change is widely recognised as one of the major long-term challenges for Switzerland. This is partly due to a committed scientific community but also to be credited to an active scene of environmental non-governmental organisations, complemented by ecologically-oriented business associations, both involved in raising awareness and stimulating public debate about climate policy. Nevertheless, as emission reduction targets need strengthening and the field of adaptation gains in importance, maintaining public support for related policies and measures remains a challenge.

At the federal level, SwissEnergy is the major programme for conveying information related to energy efficiency and renewable energies to the general public. In 2016, the SwissEnergy programme launched the 'Energy Challenge', a nation-wide awareness raising campaign. In the near future, this programme will be supplemented by the more climate-specific measures of the 'Climate programme Training and Communication', where municipalities will be a target of particular interest.

Participation in international education, training and awareness raising activities

International activities supported by Switzerland with a strong bearing for training and capacity building are documented in the chapter on financial, technological and capacity-building support. Additional activities relevant to education, training and awareness raising at the international level include, inter alia, contributions to the organisation and implementation of regional workshops in the context of the Cluster Francophone of the Partnership on Transparency in the Paris Agreement (formerly known as the International Partnership on Mitigation and MRV).

2 National circumstances relevant to greenhouse gas emissions and removals

Switzerland's national circumstances are presented in section 2.1 to 2.13, followed by a discussion of how the national circumstances affect greenhouse gas emissions and removals, and how the national circumstances and changes therein affect greenhouse gas emissions and removals over time (section 2.14).

2.1 Government structure

This section provides a general overview of Switzerland's government structure and political organisation. Specific information related to the policymaking process in the context of environmental and climate policy is presented in section 4.1

Administrative structures

Switzerland is a confederation, subdivided into 26 cantons (states). The legislative authority consists of a bicameral parliament which, when in joint session, is known as the Federal Assembly, i.e. the Swiss Parliament. One chamber of the Swiss Parliament, the National Council, consists of 200 members, representing the population of the country as a whole. The other chamber, the Council of States, represents the cantons. In proportion to the number of inhabitants of each canton, 20 cantons are represented in the Council of States by two members and six half-cantons by one member (leading to a total of 46 members). The legislative system comprises several hierarchical levels and all legislation must ultimately comply with the Federal Constitution of the Swiss Confederation. Both chambers of the Swiss Parliament have equal power, meaning that federal acts or constitutional amendments can only enter into force once they passed both chambers. However, decisions by the Swiss Parliament are subject to optional referendums (federal acts) or mandatory referendums (constitutional amendments) by the Swiss population (see below). The members of the Swiss Parliament are directly elected by the Swiss population for a four-year term, while the Swiss Parliament then elects the Swiss Federal Council for a four-year term as well.

The executive authority at the federal level, the Swiss Federal Council, consists of seven members with equal power. The Swiss Federal Council is supported by the Swiss Federal Chancellery and seven federal departments (federal administration)[2]. While the Swiss Federal Council has the power to directly implement the contents of federal acts through ordinances, it proposes changes to the Federal Constitution of the Swiss Confederation or federal acts for parliamentary discussion and approval.

The highest judicative authority in Switzerland is the Federal Supreme Court, representing the final arbiter on disputes in the field of civil law (citizen-citizen), in the public arena (citizen-state), as well as in disputes between cantons or between cantons and the Swiss Confederation.

In Switzerland, the principle of subsidiarity is of greatest importance, as ingrained in Article 3 and 5a of the Federal Constitution of the Swiss Confederation, stipulating that unless legislative power is explicitly assigned to the Swiss Confederation, the cantons are sovereign, i.e. entitled to legislate in an area of policy (*Swiss Confederation*, 1999a). This fundamental principle helps to protect minority interests, above all those of the French-, Italian- and Romansh-speaking parts of Switzerland. Accordingly, each canton has its own government, parliament and cantonal court, while responsibilities are shared between the federal authorities and the cantons. Each canton also has its own financial budget and sets its own level of direct taxation (fiscal federalism). Despite a system of fiscal equalisation amongst cantons, substantial differences between cantons remain in the level of taxation of both households and companies.

Relevant inter-ministerial decision-making processes or bodies

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,

[2] For details see https://www.admin.ch/gov/en/start/federal-council/political-system-of-switzerland.html, in particular http://www.bk.admin.ch/dokumentation/02070/index.html?lang=en.

cantons cooperate horizontally and have agreements that facilitate harmonised and effective implementation of policies and measures.

The cantons and other interested parties (e.g. business, trade unions, non-governmental organisations etc.) are included in a consultation process whenever the Swiss Federal Council proposes a significant change to the Federal Constitution of the Swiss Confederation, to a federal act 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 policymaking and of political culture in Switzerland. However, this political participation process also leads to a relatively slow policymaking process, which needs to be taken into account in the context of the policies and measures described in chapter 4.

Within the federal administration, interdepartmental exchange and consultation is an important pillar during the preparation phase of legal provisions or other business requiring a decision by the Swiss Federal Council. The leading federal offices, mandated by the respective member of the Swiss Federal Council, therefore conduct, as a matter of routine, an interdepartmental official consultation. Then, the received feedbacks are, to the extent possible, taken into account. In the forefront of the respective meeting of the Swiss Federal Council leading to the final decision on the business, all departments are invited to provide their agreement or reservations in a so-called joint reporting procedure.

Regarding environmental and climate policies, particular interdepartmental decision-making processes and bodies are established (see section 4.1 for further information).

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 of the Swiss Confederation, 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 5.3 million citizens in 2015, i.e. around 63 per cent of the resident population. Those under the age of 18 years 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 long-standing 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 across Switzerland.

As mentioned above, the people elect the 200 members of the National Council and the 46 members of the Council of States every four years. All Swiss citizens over the age of 18 years may take part in elections, both actively and passively. In other words, they may cast their votes and stand for election themselves.

An important formal instrument of direct democracy is the referendum. The optional referendum allows citizens to veto decisions made by the Swiss Parliament. To request a popular vote on a decision by the Swiss Parliament, the collection of 50 thousand valid signatures within 100 days is needed. There is a mandatory referendum on each constitutional amendment passed by the Swiss Parliament. It is thus possible to have a referendum concerning regulations at the level of the Federal Constitution of the Swiss Confederation, 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.

By means of a popular initiative, which requires the collection of 100 thousand valid signatures within 18 months, citizens can propose amendments to the Federal Constitution of the Swiss Confederation (at the cantonal level also amendments to a law). Popular initiatives may comprise a general proposal or contain detailed regulations. A popular initiative needs to be accepted by a majority of the electorate and of the cantons to become part of the Federal Constitution of the Swiss Confederation. This requirement for a ‘double’ majority (population and cantons) mainly serves to protect the interests of sparsely populated rural cantons.

The ballots needed to implement the direct democracy in Switzerland generally take place four times a year and on average involve three to four proposals – in exceptional cases also up to twice that many – that may be adopted or rejected. Often, cantonal and communal ballots are held at the same time.

International relations

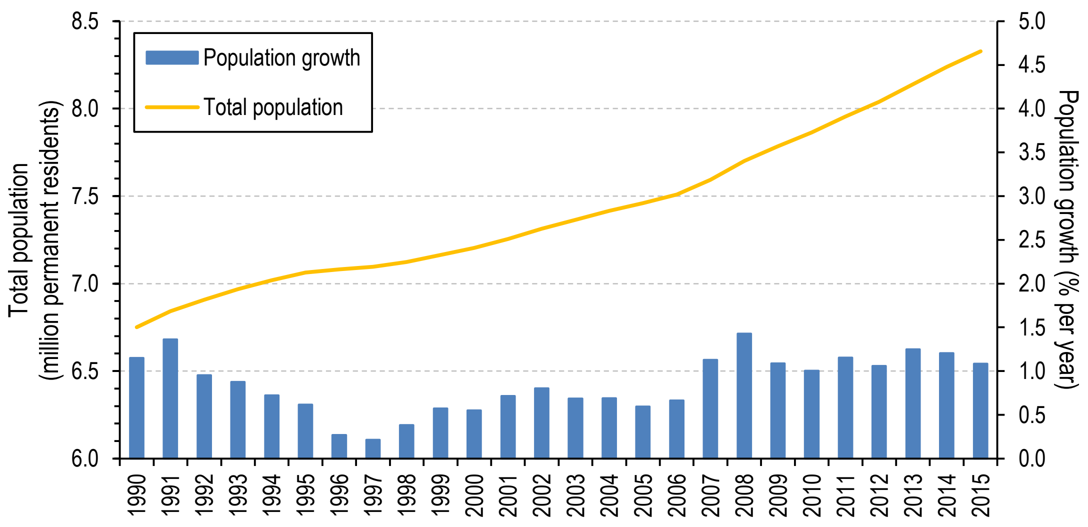
Switzerland is a member of several international organisations (e.g. the OECD, the World Bank Group and all specialised agencies of the United Nations). In March 2002, the Swiss population also voted for membership of the United Nations, and since September 2002, Switzerland has been a full member.

Although not a member state of the European Union, Switzerland has a strong relationship with the European Union and European policy is a high priority of Swiss foreign policy. The legal basis of this close cooperation is formed by bilateral agreements[3], and most Swiss laws have been made compatible with legislation of the European Union. Relations between Switzerland and the European Union have developed over decades. The bilateral agreements have been extended step by step. Important stages of this policy have been assessed and approved by the people in referendums. Since 2006, Switzerland is a member of the European Environmental Agency (EEA), one of the most important agencies for European cooperation in environmental issues. Concerning climate policy measures, Switzerland often adapts instruments of the European Union. Current examples are the CO_2 emission regulations for newly registered vehicles or the emissions trading scheme.

2.2 Population profile

At the end of 2015, Switzerland had a population of 8’327’126 permanent residents (*SFSO*, 2016a). Since the beginning of the 20th century, Switzerland’s population has more than doubled, the increase of population from 1990 to the end of 2015 was 23 per cent, and population growth exceeded one per cent per year for about the last decade (Fig. 3). Population growth mainly results from immigration and increasing life expectancy. It is expected that population growth will continue, leading to 9.5 million permanent residents by 2030 and 10.2 million permanent residents by 2045 (*SFSO*, 2015a).

Fig. 3 > Switzerland’s total population (orange) and population growth (blue) between 1990 and 2015. At the end of 2015, Switzerland had 8.33 million permanent residents, of which 4.12 million men and 4.21 million women.



SFSO (2016a)

Switzerland’s population density at the end of 2015 was 201.7 persons per square kilometre. Population is concentrated on the Swiss Plateau, the major alpine valleys and the Ticino, while the density is substantially lower in the hilly and alpine regions of the country (Fig. 4).

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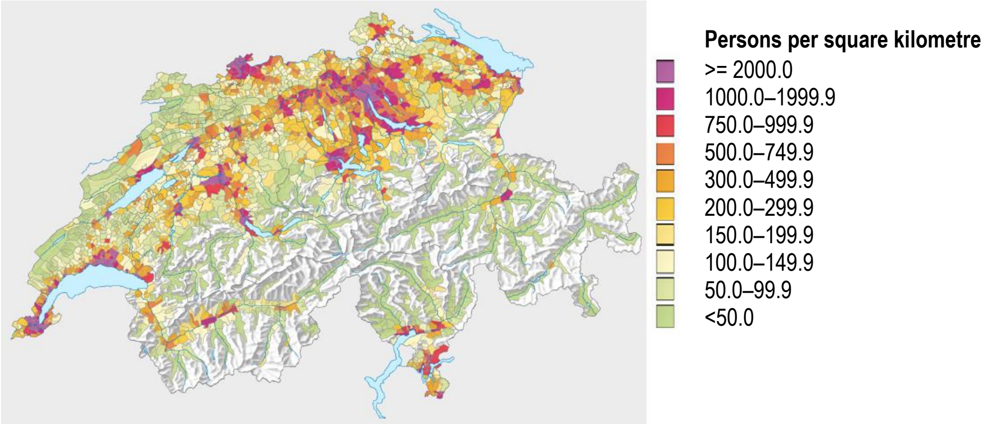
[3] https://www.eda.admin.ch/dea/en/home/bilaterale-abkommen.html

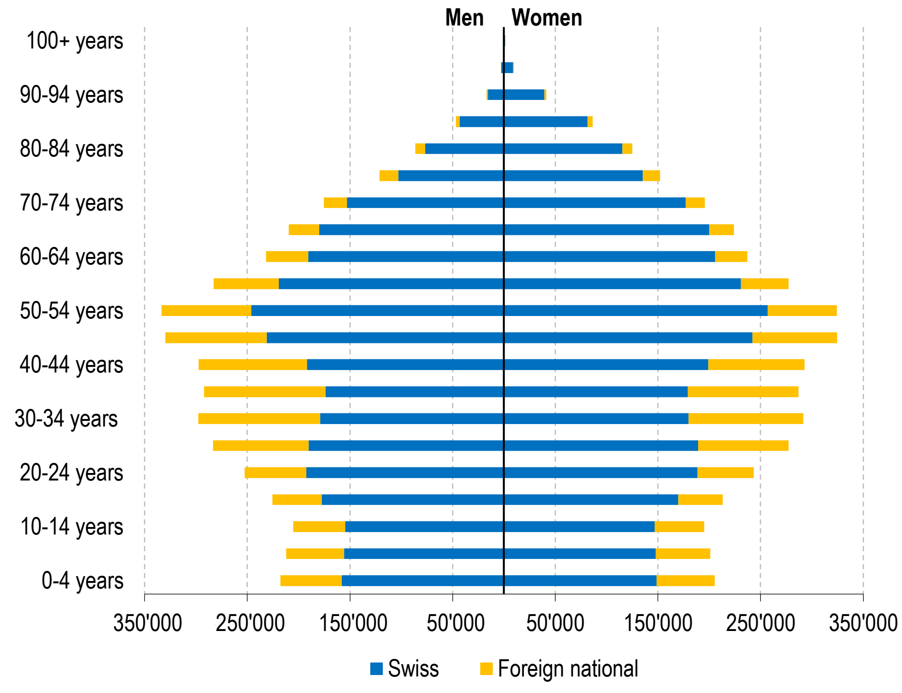
Fig. 4 > Spatial distribution of Switzerland's population in 2014.



SFSO (2016a)

Fig. 5 shows the demographic structure of Switzerland in 2015 by age, sex and nationality. Foreign nationals account for about 25 per cent 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. Switzerland has four official languages (German, French, Italian, and Romansh). In 2014, 63.3 per cent of Switzerland's permanent population indicated German as the main language, 22.7 per cent French, 8.1 per cent Italian, 0.5 per cent Romansh, and 20.9 per cent other languages (the sum exceeds 100 per cent as some persons indicated more than one language; *SFSO*, 2016a).

Fig. 5 > Age distribution by age, sex and nationality in Switzerland in 2015.



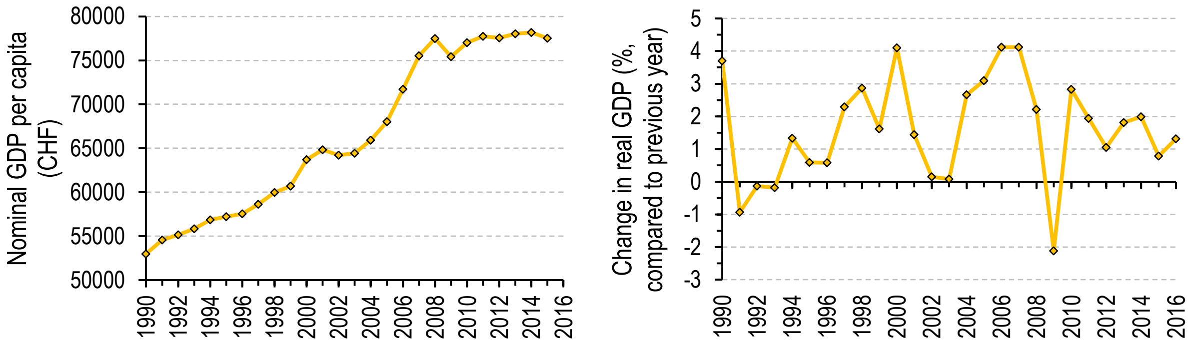
SFSO (2016a)

2.3 Economic profile

Gross domestic product, workforce and gross value added by sectors

Switzerland's nominal gross domestic product was about 650 billion Swiss francs in 2016, corresponding to about 78 thousand Swiss francs per capita (*SECO*, 2017). The nominal gross domestic product per capita increased by 46.6 per cent between 1990 and 2008, and remained about stable thereafter (Fig. 6, left). With just a few exceptions in the early 1990s and in 2009, Switzerland's real gross domestic product increased annually by up to four per cent compared to the previous year over the period 1990 to 2015 (Fig. 6, right).

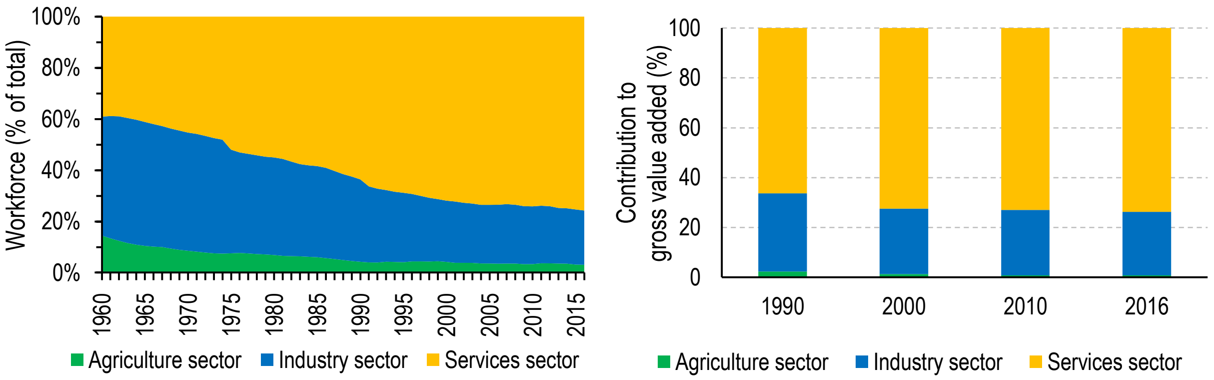
Fig. 6 > Switzerland's nominal gross domestic product (GDP) per capita (left; population of 2015 is used for 2016 as well) and percentage change of real gross domestic product (reference year 2010) compared to previous year (right) between 1990 and 2016.



SECO (2017), *SFSO* (2016a)

Between 1960 and 2015 the proportion of the total workforce employed in the different sectors changed substantially (Fig. 7, left); in the agriculture and industry sectors it has fallen from 14.5 and 46.5 per cent to 3.1 and 21.2 per cent, respectively, leading to a substantial increase in the services sector. Accordingly, Switzerland's economy largely depends on the services sector, which in 2015 not only employed 75.7 per cent of the total workforce, but also contributed 73.8 per cent to the gross value added (Fig. 7, right). The structural change to a 'service society' is thus steadily continuing.

Fig. 7 > Contribution of economic sectors to total workforce (left) and gross value added (right).

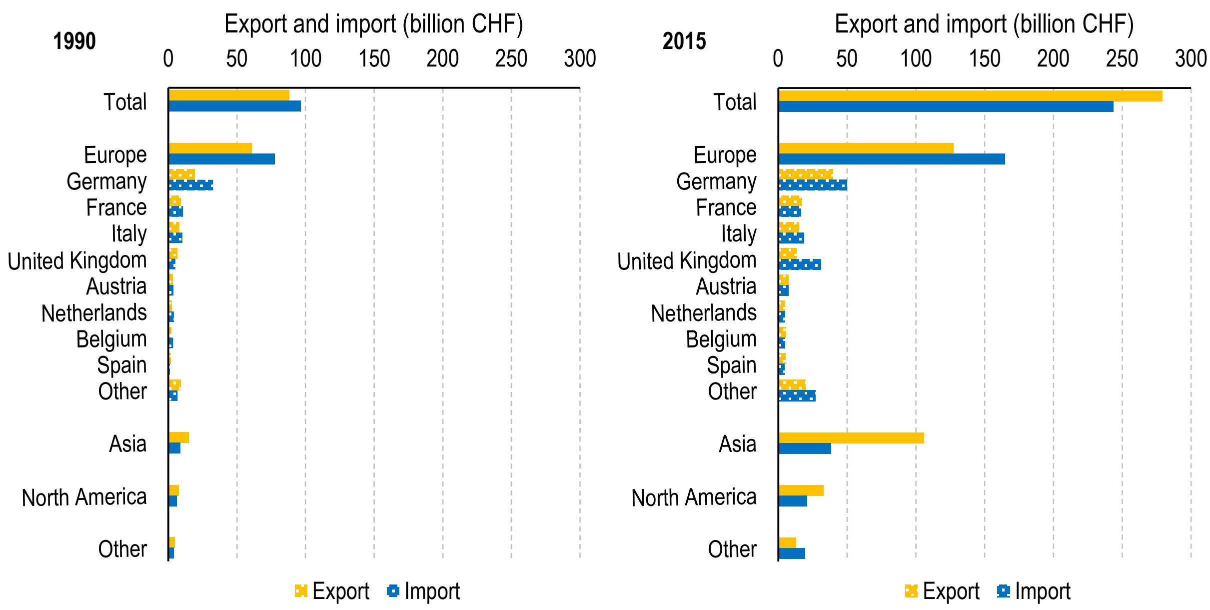


SFSO (2016f), *SECO* (2017)

International trade patterns

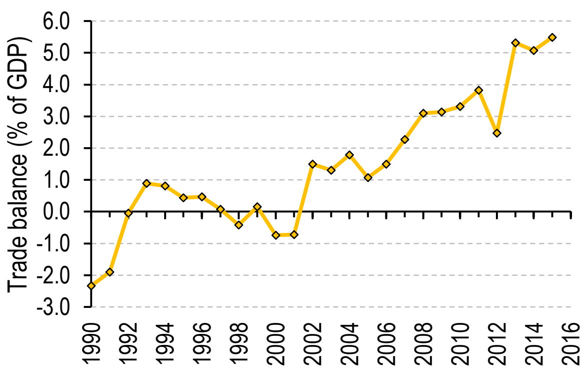
Switzerland has virtually no mineral resources and, historically, no heavy industry. Accordingly, the economy strongly depends on trade with other countries, as Switzerland imports bulk raw materials and exports high-quality goods (in 2015, the value of one tonne of exported goods was more than three times higher than the value of one tonne of imported goods). The relatively small size of its domestic market is another factor which has encouraged and encourages Swiss manufacturers to look to foreign markets in order to make investments in research and development worthwhile. As shown in Fig. 8 (left), Switzerland's exports accounted for 88 billion Swiss francs in 1990, while the imports accounted for 97 billion Swiss francs. In 2015, both the exports and imports were substantially higher, accounting for 279 billion and 244 billion Swiss francs, respectively (Fig. 8, right). Switzerland's trade balance (exports minus imports) was about balanced between 1992 and the early 2000s (within ±1 per cent of the gross domestic product). Since 2002, exports growth has been accelerating as compared to imports growth. By 2015, Switzerland's trade balance (export minus imports) equalled about five per cent of the gross domestic product (Fig. 9). European countries are by far the most important trading partners for Switzerland, accounting for 67.6 per cent of exports and 45.7 per cent of imports. Largest volumes are traded with Germany, with imports accounting for 50 billion Swiss francs and exports accounting for 40 billion Swiss francs in 2015 (Fig. 8, right). Trade volumes with Italy, France and the United Kingdom are also considerable, with small differences between imports and exports for France and Italy, but a bias to imports for the United Kingdom. In contrast, trade with North America and Asia is heavily biased towards exports. Among the most important traded goods in term of monetary value are chemical and pharmaceutical products, noble metals, jewels and gemstones, machines, instruments and electronics, precision instruments, and watches (Fig. 10).

Fig. 8 > Switzerland's foreign trade (export and import) with important partners in 1990 (left) and 2015 (right).



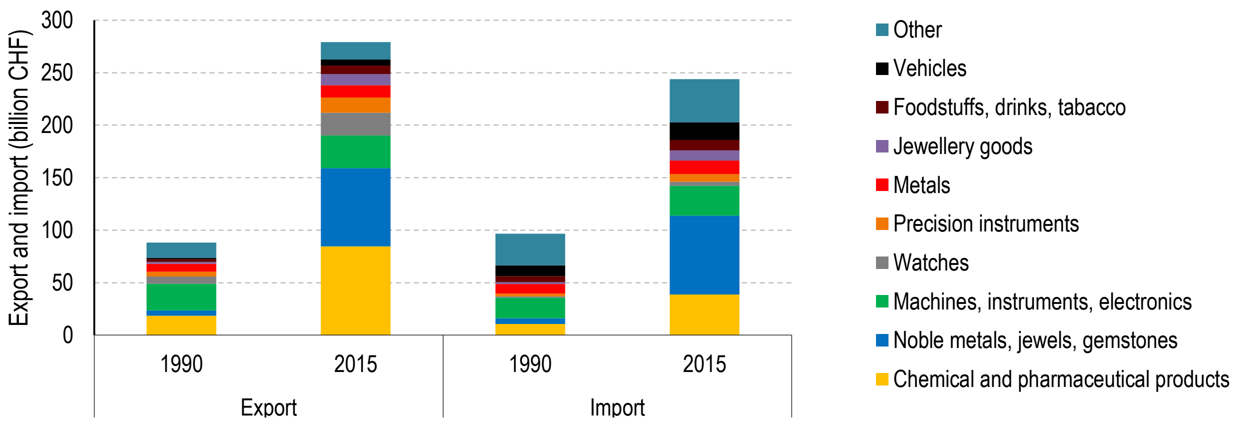
SFSO (2016g), *SFSO* (2016h)

Fig. 9 > Switzerland's trade balance (export minus import) in per cent of the gross domestic product (GDP).



SFSO (2016g), *SFSO* (2016h), *SECO* (2017)

Fig. 10 > Switzerland's foreign trade (export and import) by goods.

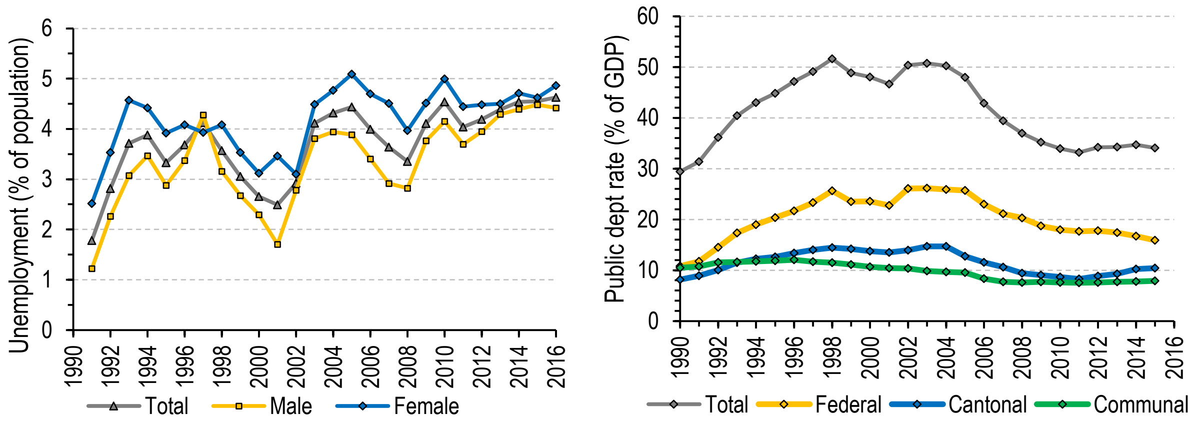


SFSO (2016i)

Unemployment, public debt rate and general government spending ratio

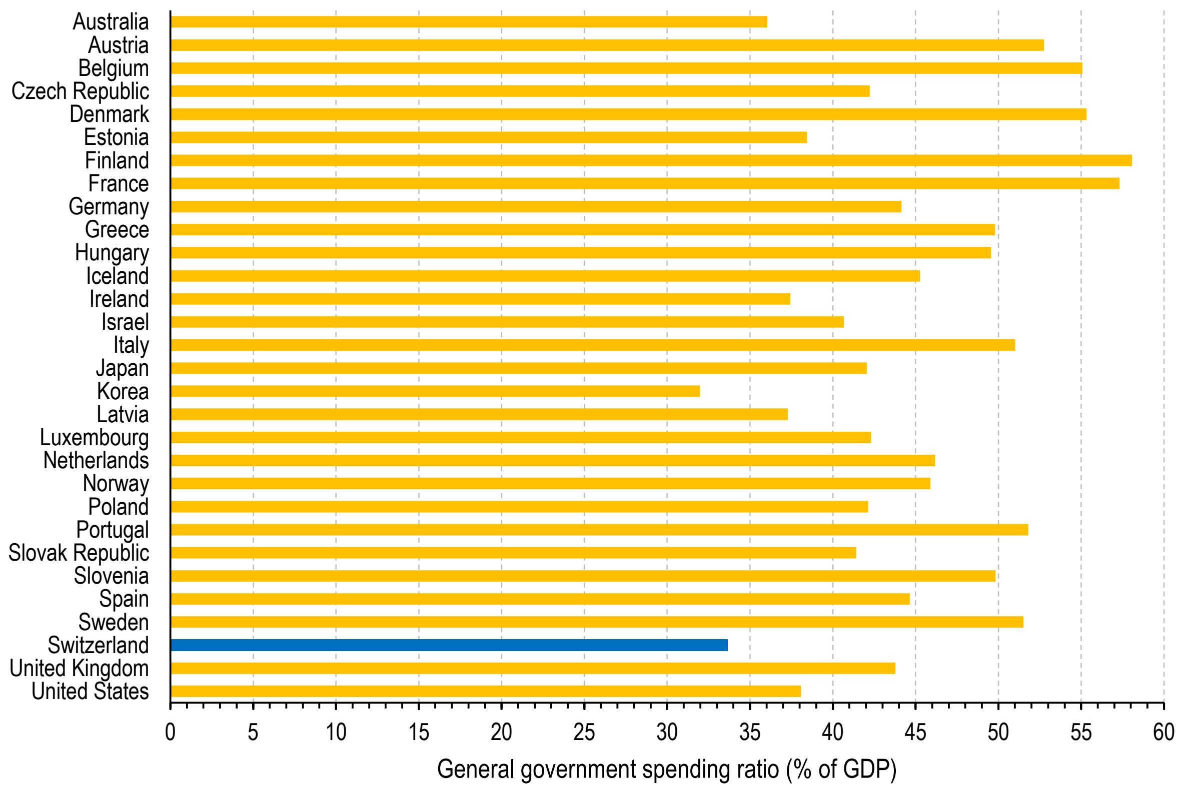
Traditionally a country with low unemployment (less than one per cent), Switzerland experienced a dramatic increase in unemployment from the beginning of the 1990s, as a consequence of the overall economic slow-down. Apart from foreign nationals (both female and male), the category most affected by this development was Swiss women and young people (aged 15 to 25 years). The total rate of unemployment has peaked at 4.1 per cent in 1997 and at 4.4 per cent in 2005, and reached values of around 4.5 per cent since 2010 (Fig. 11, left). In parallel with rising unemployment, aggregate government spending has exceeded revenues at all three administrative levels (federal, cantonal and communal), which has led to increasing public debt in the early to late 1990s (Fig. 11, right). Following a relatively stable period at a high level of around 50 per cent of gross domestic product, the revenues have exceeded the expenditures between 2004 and 2010, and the total public debt rate has remained stable at about 34 per cent of the gross domestic product since 2011. In 2014, Switzerland's general government spending ratio amounted to 33.7 per cent of the gross domestic product, being one of the lowest of OECD countries (*OECD*, 2017; Fig. 12).

Fig. 11 > Rates of unemployment (left) and public debt rate at all administrative levels (federal, cantonal and communal) in percentage of gross domestic product (GDP, right).



SFSO (2017b), *SFSO (2016j)*

Fig. 12 > General government spending ratio in 30 OECD countries in 2014.

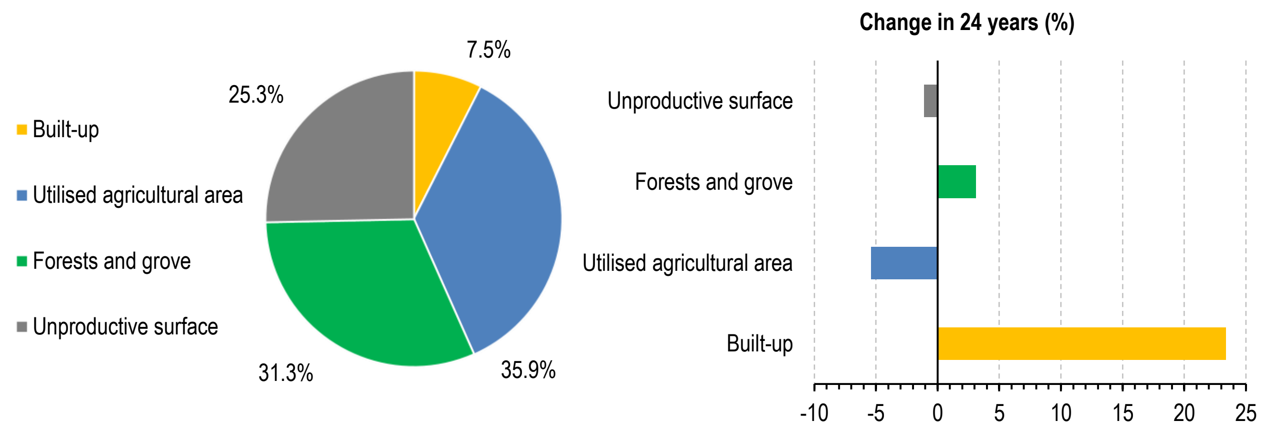


OECD (2017)

2.4 Geographical profile

Switzerland, located in the centre of Europe, extends from 45°49' to 47°48' north and from 5°57' to 10°30' east. It covers an area of 41'285 square kilometres, comprising 31.3 per cent forests and grove, 35.9 per cent utilised agricultural area, 7.5 per cent built-up and 25.3 per cent unproductive surface (situation 2004/2009; *SFSO*, 2015b; Fig. 13, left; Fig. 14). While the built-up area is relatively small, it increased by 23 per cent between 1985 and 2009, and has continued to expand ever since, mainly at the expense of utilised agricultural area (*SFSO*, 2015b; Fig. 13, right). Currently, the next version of Switzerland's land-use statistics is compiled, based on aerial photographs from the years 2013 to 2018.

Fig. 13 > Land-use types in Switzerland 2004/2009 (left) and changes in land use between 1979/1985 and 2004/2009 (right). The utilised agricultural area includes alpine pastures.



SFSO (2015b)

Fig. 14 > Switzerland's land use based on the land-use statistics 2004/2009.

SFSO (2015b)

Switzerland's topography is defined by the Swiss Plateau, the Jura Mountains and the Alps. According to the snow and avalanche research institute SLF[4] around 50 per cent of Switzerland's surface area is located above 1'000 metres above sea level and around 25 per cent above 2'000 metres above sea level. About one third of the relatively abundant precipitation occurs as snow. 4.3 per cent of the surface area of Switzerland is further covered by fresh water bodies. Although Switzerland covers only 0.4 per cent of the surface area of Europe, the amount of water stored within Switzerland corresponds to five per cent of the total European water resources. Accordingly, Switzerland plays an important role in the water supply of its neighbouring, mostly drier countries downstream.

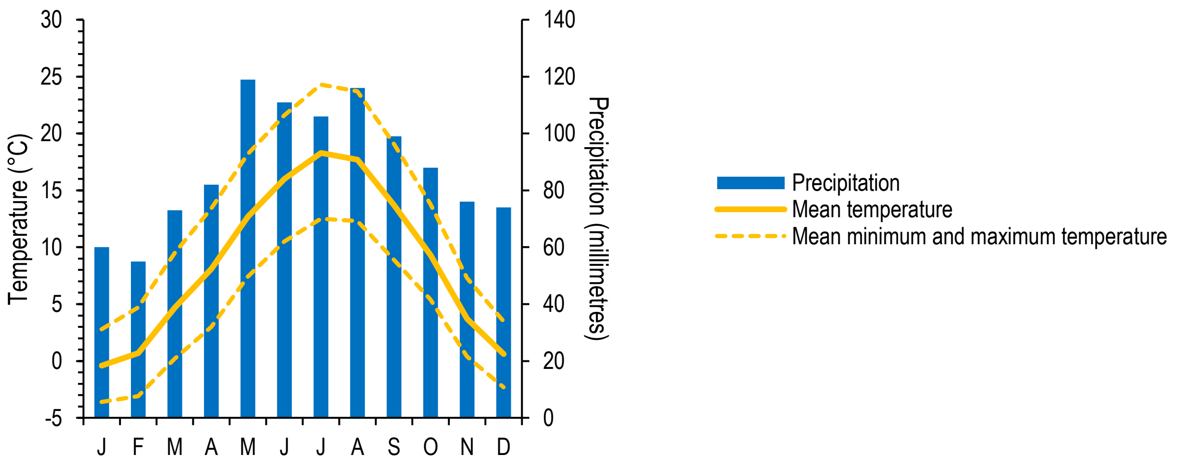
[4] http://www.slf.ch

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 across Switzerland. The Alps represent a natural barrier for traffic moving in the north-south direction, i.e. between northern Europe and Italy, but a number of tunnels facilitate large-scale road and rail traffic across the Alps (section 2.7).

2.5 Climate profile

Climatic conditions of temperature and precipitation patterns vary significantly across Switzerland, depending mainly on altitude and location (as an example for local conditions, the climate graph for Switzerland's capital is provided in Fig. 15). The Alps – running from south-west to east – act as a major climatic divide. Long-term measurements since 1864 indicate a marked shift towards a warmer climate. Changes in mean precipitation are less clear. Trends in annual mean precipitation are predominantly positive but not statistically significant in most regions over the last 100 years. There are indications for robust increases in winter precipitation when analysing time series starting in 1901 or before (*Scherrer et al.*, 2015), and evidence for increases in the frequency and intensity of heavy precipitation has been presented (*Scherrer et al.*, 2016). Pronounced trends are also found for cloudiness and sunshine duration (see below). For expected future developments and impacts thereof see section 6.1 (*CH2011*, 2011).

Fig. 15 > Climate graph for Bern, Switzerland's capital, located on the Swiss Plateau at 553 metres above sea level. Provided are mean values for the period 1981–2010. The mean annual temperature is 8.8 degrees Celsius, the mean minimum and maximum temperatures are 4.3 and 13.5 degrees Celsius. Mean annual precipitation is 1059 millimetres.



MeteoSwiss[5]

Temperature

Fig. 16 shows the annual temperature anomaly in Switzerland with respect to 1961–1990 average conditions. Annual temperature has increased by almost 2 degrees Celsius between 1864 and 2016, which corresponds to a linear increasing temperature trend of about 0.13 degrees Celsius per decade. Temperature trends have accelerated substantially for more recent time periods (Fig. 17). Over the last 100 years (1917–2016), annual temperature has increased by about 0.13 to 0.22 degrees Celsius per decade with no pronounced differences between geographical locations (north-south, low-high altitudes). The trend magnitude is similar for all seasons with a slight tendency to somewhat higher values in summer and autumn (up to 0.24 degrees Celsius per decade). Annual temperature trends for the last 70 years (1947–2016) are 0.18 to 0.30 degrees Celsius per decade, for the last 50 years (1967–2016) 0.31 to 0.50 degrees Celsius per decade and for the last 30 years (1987–2016) 0.07 to 0.44 degrees Celsius per decade. This is roughly two to three times the globally averaged temperature trend (*IPCC*, 2013 and Fig. 16) and in agreement with the trends in other parts of Western and Central Europe. In the last 30 years, the trends were largest and significant in summer (0.35 to 0.60 degrees Celsius per decade), positive but not always significant in spring (0.20 to 0.52 degrees Celsius per decade) and autumn (0.05 to 0.58 degrees Celsius per decade) and insignificant in winter (–0.53 to 0.33 degrees Celsius per decade).

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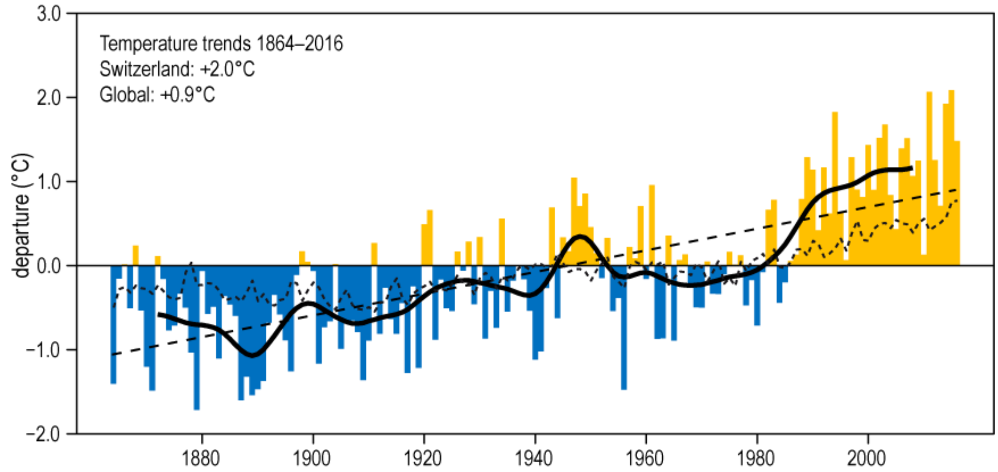
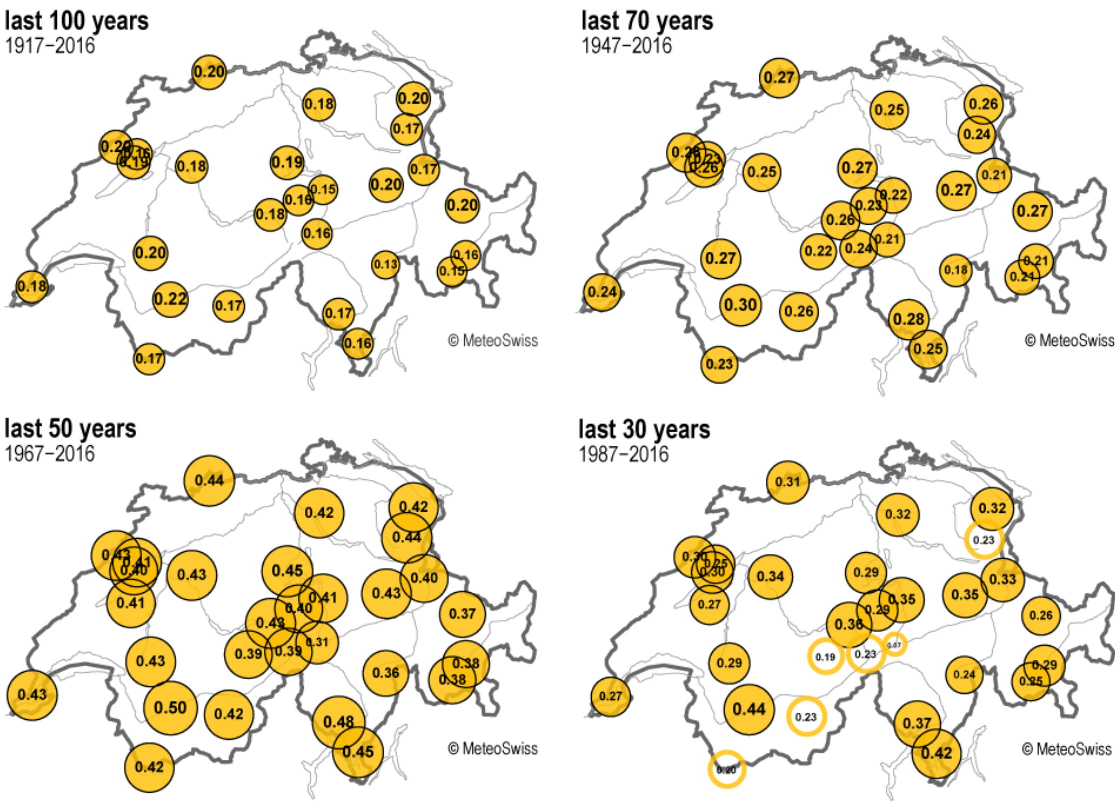
5 http://www.meteoswiss.admin.ch/home/climate/past/climate-normals/climate-diagrams-and-normal-values-per-station.html?region=Map

Fig. 16 > Mean annual temperature anomalies in Switzerland 1864–2017. Annual temperature anomalies in Switzerland shown as deviation from the mean of 1961–1990. The years with positive anomalies (warmer) are shown in orange and those with negative anomalies (cooler) in blue. The black line represents 20-year Gaussian low-pass filtered data and the bold dashed line the linear trend (+1.29 degrees Celsius per 100 years). The thin dashed line shows the global temperature according to the HadCRUT4 dataset (*Morice et al.*, 2012).



MeteoSwiss (2017)

Fig. 17 > Observed annual temperature trends in Switzerland for homogenised station data. Shown are trends in degrees Celsius per decade of the last 100 years (1917–2016, top left), the last 70 years (1947–2016, top right), the last 50 years (1967–2016, bottom left) and the last 30 years (1987–2016, bottom right). All trends are positive. Filled circles: Trends that are statistically significant (five per cent significance level), open circles: non-significant trends.

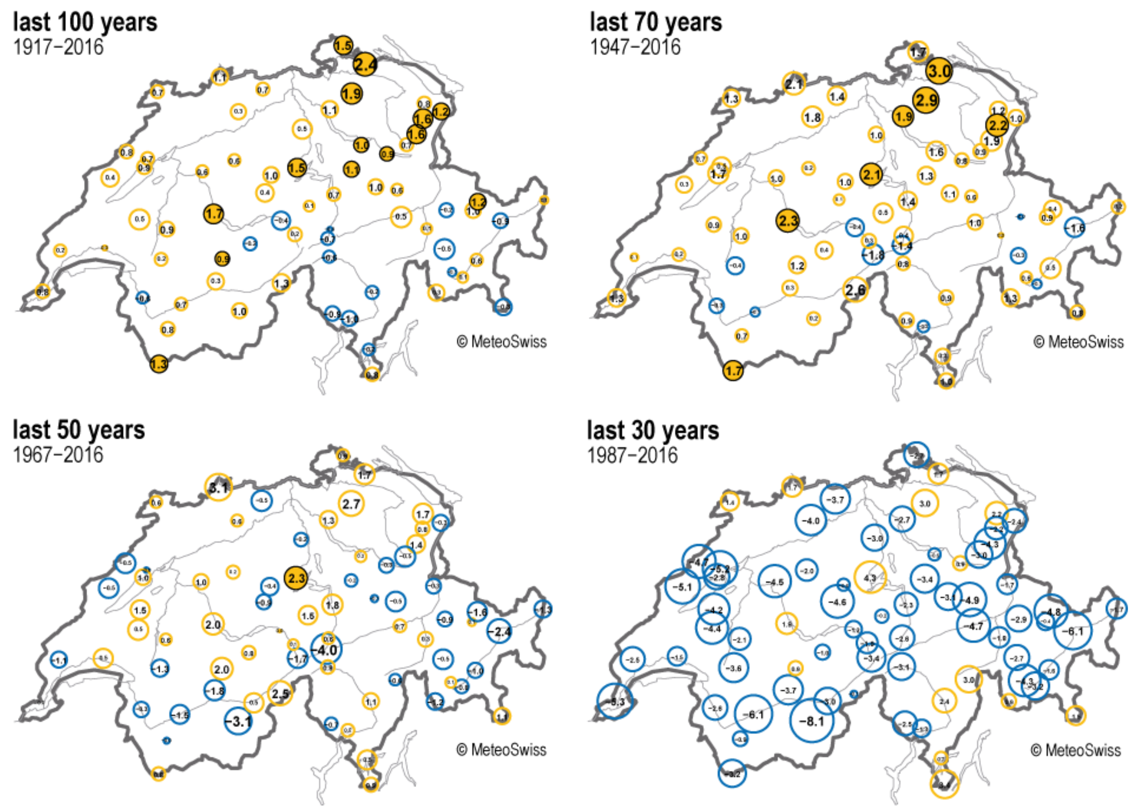


MeteoSwiss (2017)

Precipitation

Fig. 18 shows the annual mean precipitation trends in Switzerland for the last 100 years (1917–2016), the last 70 years (1947–2016), the last 50 years (1967–2016) and the last 30 years (1987–2016) years. In contrast to temperature, precipitation trends are insignificant for most stations and time periods considered. Some significantly positive trends are found in northern Switzerland and the Alps considering the longer time periods (50–100 years). For the majority of the stations, the trend magnitudes are insignificant. Also on the seasonal scale, most trends are insignificant or not consistent over time (not shown). For example: Some stations show significant precipitation increases in winter for the last 100 years but predominantly precipitation decreases in the last 30 years. This shows that internal decadal variability can still be larger than any underlying long-term trend. There are, however, robust indications for changes in heavy precipitation. Since 1901 the intensity of the annual 1-day precipitation maxima has increased by about 12 per cent and the frequency of the all-day 99th percentile events (i.e. precipitation sums of more than 25–105 millimetres per day, depending on the region) by almost 30 per cent on average (*Scherrer et al.*, 2016). The observed changes are consistent with climate model projections, with theoretical understanding of a human-induced change in the energy budget and water cycle and with detection and attribution studies of extremes on larger spatial scales.

Fig. 18 > Observed annual-mean precipitation trends in Switzerland for homogenised station data. Shown are trends in per cent per decade of the last 100 (1917–2016, top left), the last 70 years (1947–2016, top right), the last 50 years (1967–2016, bottom left) and the last 30 years (1987–2016, bottom right). Positive trends (i.e. more precipitation) are shown in orange, negative trends (i.e. less precipitation) are shown in blue. Filled circles: Trends that are statistically significant (five per cent significance level), open circles: non-significant trends.



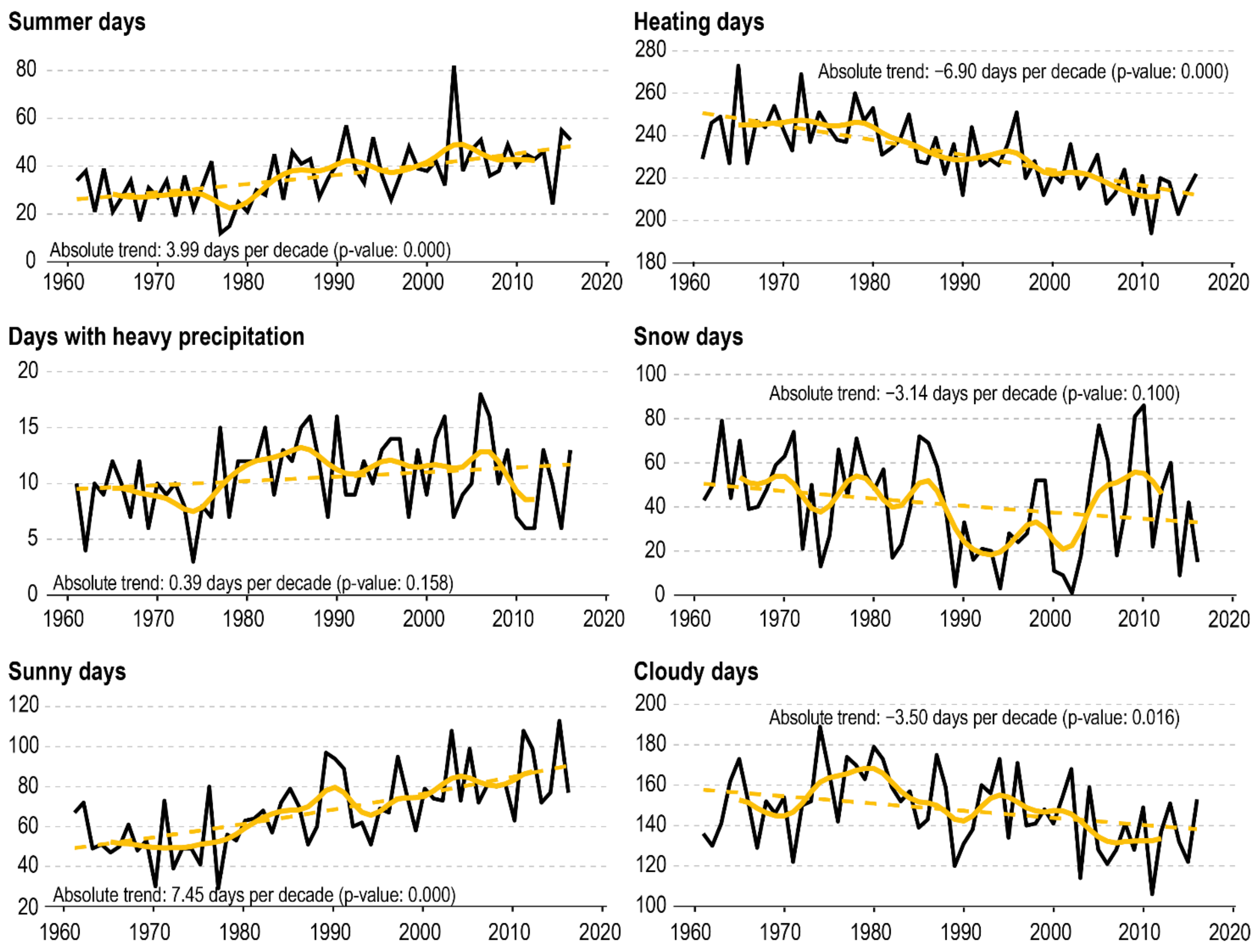
MeteoSwiss (2017)

Climate indices

Fig. 19 shows the evolution of some important climate indices at the station Bern/Zollikofen for the time period from 1961–2016. This station can be considered as representative for the general evolution on the Swiss Plateau. The average number of summer days increased from roughly 25 days per year in the 1960s to almost 50 days per year today (Fig. 19, top left). This increase is highly significant and very similar trends are found for most stations on the Swiss Plateau. In contrast, the number of heating days decreased by about 15 to 20 per cent in the same time period (Fig. 19, top right). The number of days with heavy precipitation (Fig. 19, middle left) increased somewhat, although the trend is not statistically significant. Similar insignificant increases are found for most stations on the Swiss Plateau. A decrease is found for the number of snow days (Fig. 19, middle right). The number of very sunny days (rel. sunshine duration larger than 80 per cent, Fig. 19, bottom left) shows a significant increase whereas the number of very cloudy days (rel.

sunshine duration less than 20 per cent) is decreasing (Fig. 19, bottom right). These trends are consistent with most stations on the Swiss Plateau. Trends in sunshine duration have been negative especially in the period of the late 1940s to about 1980. Today's values are now back to the level seen in the late 19th, early 20th century.

Fig. 19 > Climate indices for the period 1961–2016 at the station Bern/Zollikofen. Observed annual number of summer days (days with maximum temperature ≥25 degrees Celsius, top left), heating days (days with a daily average temperature below 12 degrees Celsius, top right), days with heavy precipitation (daily precipitation >20 mm, middle left), snow days (days with snow depth of at least one centimetre, middle right), sunny days (days with relative sunshine duration larger than 80 per cent, bottom left) and cloudy days (days with relative sunshine duration lower than 20 per cent, bottom right). Homogenised station data is used for the temperature-based and precipitation-based indices. The thick orange line represents 11-year Gaussian low pass filtered data, the dashed orange line the linear fit (logistic-regression).

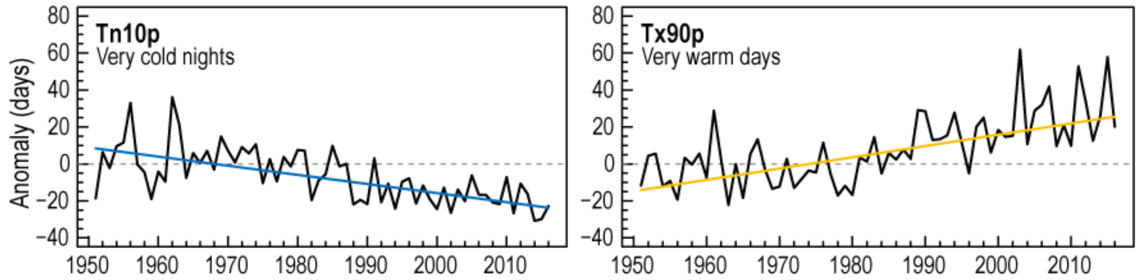


MeteoSwiss (2017)

Extreme events

Numerous extreme climate and weather events struck Switzerland during the last decades (flooding, heat waves, dry periods, storms, etc.). However, due to the strong natural variability, it is challenging to provide evidence for changes in the frequency or intensity of extreme events, in particular in view of Switzerland's relatively small area. Nevertheless, most meteorological stations in Switzerland show a highly significant trend to less very cold nights as well as an increase in very warm days (Fig. 20). Further, the frequency and intensity of heavy precipitation events have increased at most (>90 per cent) of the meteorological stations in Switzerland (*Scherrer et al.*, 2016). However, numbers of other extreme events – such as floods, debris flows, landslides, dry periods, hail events, etc. – did not show any significant tendency over the past decades (*Swiss Academies of Arts and Sciences*, 2016). Extreme events, including related risks, vulnerability and damages, are further discussed in chapter 6.

Fig. 20 > Observations of very cold nights and very warm days in Switzerland, 1951–2016. The mean Mann-Kendall trends for the period 1951 to 2016 are –4.9 days per 10 years for Tn10p and +6.3 days per 10 years for Tx90p. Both trends are highly significant ($p<10^{-3}$).



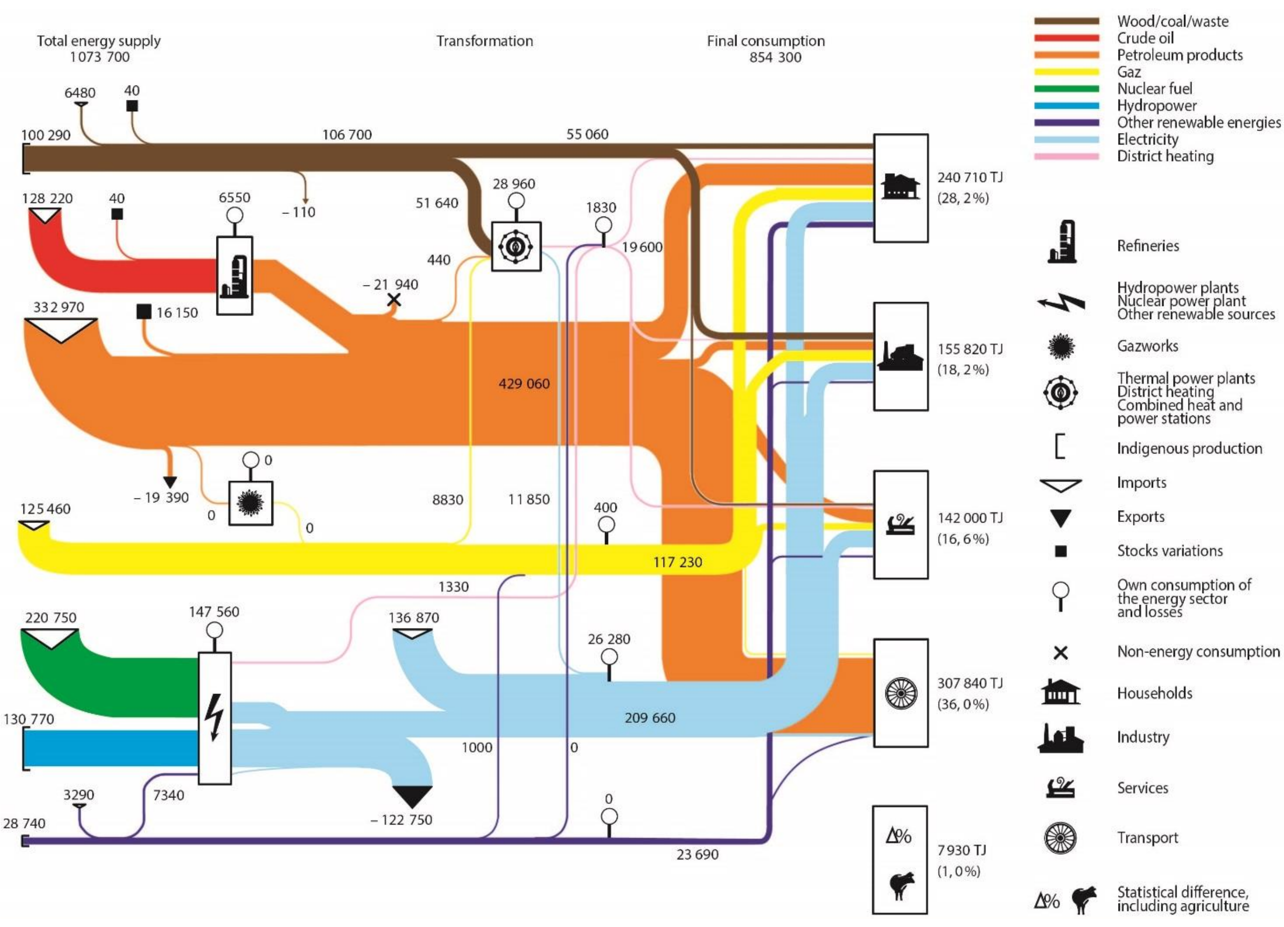
Swiss Academies of Arts and Sciences (2016), redrawn with data from 1951–2016

2.6 Energy

Energy supply and final energy consumption

As there are no domestic gas, oil, coal or nuclear fuel resources, Switzerland's primary energy sources are limited to wood, hydropower, waste and other forms of renewable energy sources (wind and solar power, biogas, etc.). Accordingly, Switzerland's energy system largely depends on energy imports, as highlighted in the detailed energy flow diagram provided in Fig. 21.

Fig. 21 > Energy flow diagram for Switzerland for 2016 (numbers in TJ).

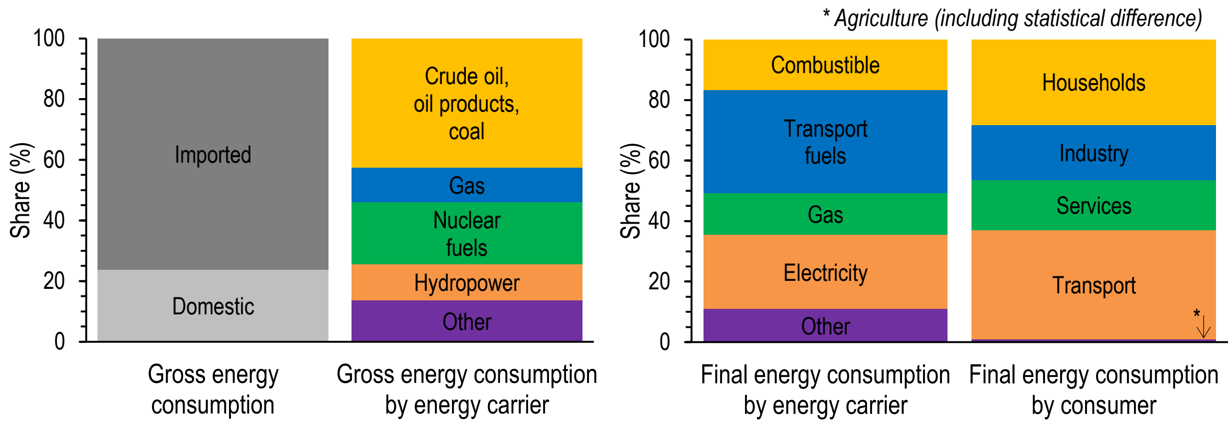


SFOE (2017a)

In 2016, the gross energy consumption was 1'087'820 TJ, composed as follows: (i) 259'800 TJ had a domestic origin (50.3 per cent hydropower, 22.7 per cent waste, 15.9 per cent wood, 11.1 per cent other renewable energy sources), (ii) 954'040 TJ were imported (48.3 per cent crude oil and oil products, 13.2 per cent gas, 23.1 per cent nuclear fuel, 14.3 per cent electricity, 0.5 per cent wood and other renewable energy resources, and 0.5 per cent coal), (iii) exports accounted for a total of 142’250 TJ (86.3 per cent electricity, 13.6 per cent oil products, 0.1 per cent wood), and (iv) the remaining 16’230 TJ corresponded to changes in the stocks of crude oil, oil products and coal (*SFOE*, 2017a).

In 2016, the final energy consumption totalled at 854’300 TJ. The shares of the different energy carriers as well as the consumption in the sectors transport, services, industry, households, and agriculture (including statistical difference) is shown in Fig. 22.

Fig. 22 > Switzerland’s gross energy consumption (left) and final energy consumption (right) in 2016. The category other for gross energy consumption includes wood, waste, other renewables, and net electricity; for final energy consumption it includes wood, waste, other renewables, and district heating. Gross energy consumption was 1’087’820 TJ, final energy consumption was 854’300 TJ.

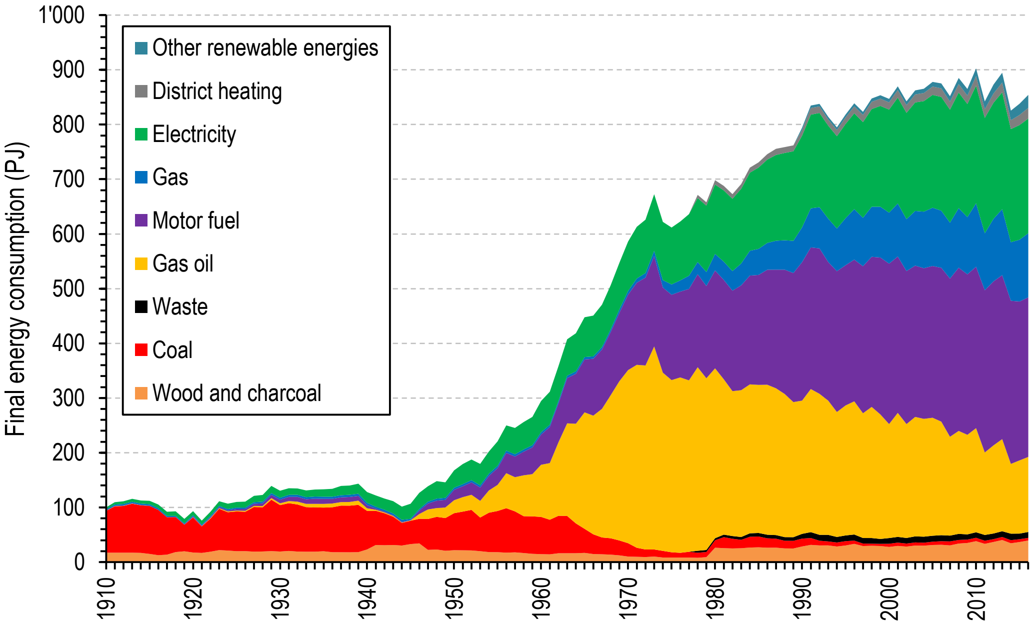


SFOE (2017a)

Final energy consumption started to increase substantially after the first half of the last century, with the largest increases seen in gas oil, motor fuel and electricity (Fig. 23). In order to average the strong impact of meteorological conditions on heating demand, leading to rather large year-to-year variations in the final energy consumption (see also sections 2.5 and 3.2.3), mean values over several years are discussed in the following. Compared to the mean final energy consumption between 1910 and 1915, the mean final energy consumption was almost a factor of eight higher between 2010 and 2016. The highest final energy consumption over a period of five years occurred between 2006 and 2010, 7.5 per cent higher compared to 1990 to 1994. However, looking at the final energy consumption of the last about five years, it appears that final energy consumption started to decrease. Renewable energy sources (not including hydropower) still contributed a minor share of 2.8 per cent to the final energy consumption in 2016. Nevertheless, supported by the SwissEnergy programme (section 4.3.2), renewable energy sources gained importance during the last years. Between 1990 and 2016, the annual generation of solar electricity increased from 5 to 4800 TJ, while the annual generation of wind electricity increased from 0 to 391 TJ.

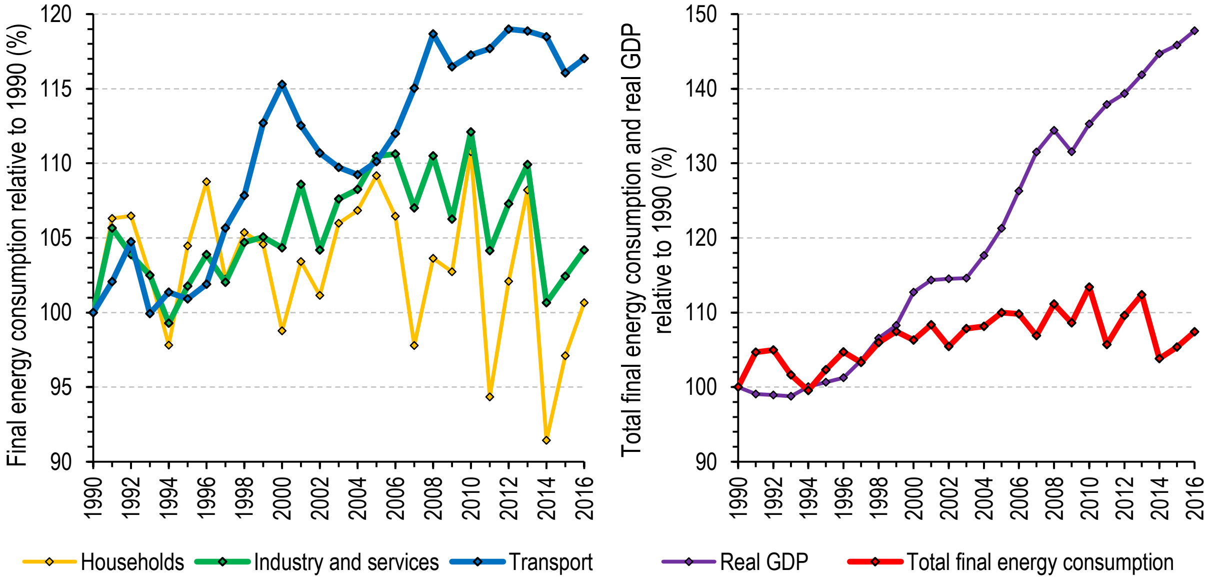
The evolution of energy consumption by households, industry and services, and transport is shown in Fig. 24 (left), relative to 1990. The transport sector shows an increase of 19 per cent between 1990 and 2012, with fluctuations that correlate with the economic development, e.g. periods of stagnation from 1993 to 1996 and from 2001 to 2003, and periods of growth (gross value added) from 1997 to 2000 and 2004 to 2008. The strong decrease in 2015 mostly results from the collapsing ‘fuel tourism’ as a consequence of a sudden drop in the exchange rate between the Euro and the Swiss franc once the Swiss National Bank ceased sustaining a minimal exchange rate. As mentioned above, energy demand of households strongly depends on meteorological conditions. The extraordinary decreases from 2006 to 2007, 2010 to 2011, and 2013 to 2014 reflect the changes from relatively cool to relatively warm winters. From 1990 to 2016, the number of buildings and apartments, as well as the average floor space per person increased (section 2.10). 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 (section 4.3.4). Although the energy consumption of industry and services is, to some extent, also influenced by the meteorological conditions, the trend from 1990 to 2016 primary reflects the development of economic activity during this period. However, while the real gross domestic product strongly increased over about the last 10 years, total final energy consumption remained relatively stable (Fig. 24, right). The reasons for this diverging developments are, on the one hand, an increase in energy efficiency thanks to modern production processes leading to a lower energy input per gross value added. On the other hand, starting in the early 1990s, the production of many energy intensive goods was sourced out to foreign countries, leading to an even more service-based economy in Switzerland. Although energy-intensive goods are further consumed in Switzerland, the energy required for their production is no longer accounted for in the national total.

Fig. 23 > Final energy consumption between 1910 and 2016 according to energy source.



SFOE (2017a)

Fig. 24 > Final energy consumption by household, industry and services and transport between 1990 and 2016, relative to 1990 (left). Total final energy consumption and real gross domestic product (GDP, reference year 2010) between 1990 and 2016, relative to 1990 (right).

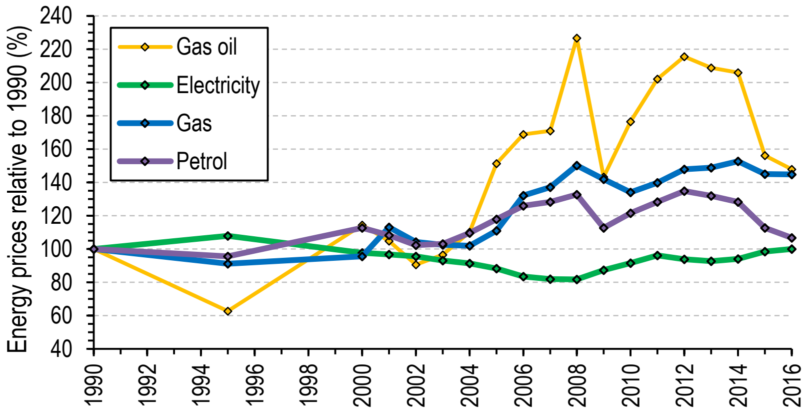


SFOE (2017a)

Energy prices, taxes and subsidies

The evolution of energy prices at the level of consumers is shown in Fig. 25. Prices for gas oil reached historic low values in the mid-1990s, then substantially increased to more than double the prices in 1990 in some of the most recent years. Prices for gas and petrol show similar patterns, although the maximum prices – reached after 2010 – were about 50 and 30 per cent above the prices in 1990, respectively. Until 2008, prices for electricity decreased to about 80 per cent of the prices in 1990, however, then returned to the same values in the most recent years.

Fig. 25 > Relative development of real energy prices (level of consumers) in Switzerland between 1990 and 2016.



SFOE (2017a)

In Switzerland, energy prices at the level of consumers are composed of the basic price, the value-added tax, as well as various energy taxes and climate levies. Regarding the value-added tax, the normal rate of eight per cent applies. Energy taxes and climate levies depend on the fuel type and were as follows (as of January 2016; e.g. *FCA*, 2016a):

- Heating and process fuels: (i) mineral oil tax (e.g. 3.00 Swiss francs per 1'000 litres of fuel oil or 2.10 Swiss francs per 1'000 kilograms of natural gas) and (ii) CO_2 levy (e.g. 222.60 Swiss francs per 1'000 litres of fuel oil or 216.70 Swiss francs per 1'000 kilograms of natural gas);
- Motor fuels: (i) mineral oil tax (e.g. 431.20 Swiss francs per 1'000 litres petrol, 458.70 Swiss francs per 1'000 litres of diesel, or 112.50 Swiss francs per 1'000 kilograms of natural gas), (ii) mineral oil surtax (e.g. 300.00 Swiss francs per 1'000 litres of petrol, 300.00 Swiss francs per 1'000 litres of diesel, or 109.70 Swiss francs per 1'000 kilograms of natural gas), and (iii) for the partial compensation of CO_2 emissions from motor fuels (section 4.4.5), the permitted compensation surcharge on motor fuels amounts to a maximum of 50.00 Swiss francs per 1'000 litres;
- Kerosene: As in other countries, kerosene used for international flights is exempt from taxation, but similar taxes as for other motor fuels apply for kerosene used for domestic flights.

Additionally including transport costs and the trade margin, consumers had to pay the following energy prices as of January 2016 (*FCA*, 2016b):

- Fuel oil (per litre): 0.635 Swiss francs, including 33.1 per cent of taxes and levies;
- Petrol (per litre): 1.35 Swiss francs, including 61.9 per cent of taxes and levies;
- Diesel (per litre): 1.41 Swiss francs, including 61.5 per cent of taxes and levies.

Compared to neighbouring countries and other countries within the European Union, energy prices in Switzerland as of January 2016 were quite similar for petrol (seven per cent below the median of the prices in other European countries), high for diesel (22 per cent above the median of the prices in other European countries), and about the same for fuel oil (one per cent above the median of the prices of other European countries; *FCA*, 2016b). Switzerland promotes, on a national and international level, the regulation of fuel consumption and associated greenhouse gas emissions by means of CO_2 pricing, as highlighted in the OECD's report on effective carbon rates (*OECD*, 2016). According to this report, Switzerland's effective carbon rates[6] for emissions from all non-road energy covers 73 per cent of total emissions,

[6] According to *OECD* (2016), effective carbon rates are the total price that applies to CO_2 emissions from energy use as a result of market-based policy instruments. They are the sum of taxes and tradable emission permit prices, and have three components:

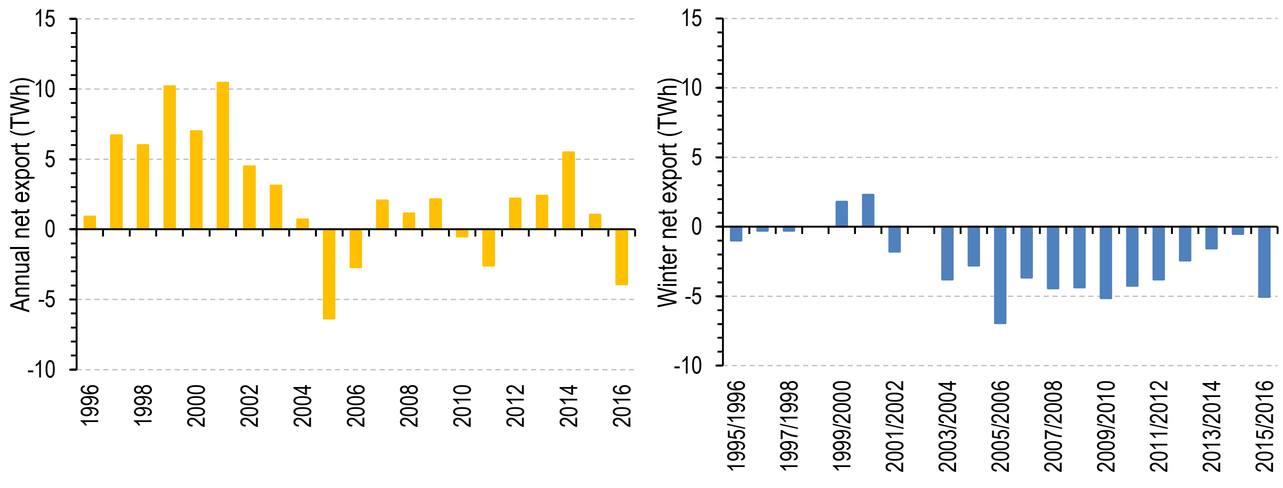
- Carbon taxes, which typically set a tax rate on energy based on its carbon content;
- Specific taxes on energy use (primarily excise taxes), which are typically set per physical unit or unit of energy, but which can be translated into effective tax rates on the carbon content of each form of energy;
- The price of tradable emission permits, regardless of the permit allocation method, representing the opportunity cost of emitting an extra unit of CO_2.

whereby 72 and 42 per cent of total emissions are priced with carbon rates exceeding five and 30 Euro per tonne of CO_2, respectively. The carbon rates for emissions from road energy cover 100 per cent of total emissions, with all carbon rates exceeding 30 Euro per tonne of CO_2. In comparison, across the 41 countries included in the report, only 30 per cent of total emissions from non-road energy are priced, and only four per cent of total emissions from non-road energy are priced with carbon rates exceeding 30 Euro per tonne of CO_2. Regarding total emissions from road energy, 98 per cent of the total emissions across the 41 countries included in the report are priced with carbon rates, whereby 46 per cent of total emissions are priced with carbon rates exceeding 30 Euro per tonne of CO_2.

Electricity trade

According to the Swiss electricity statistics (*SFOE*, 2017b), electricity is traded across Switzerland's borders on a fairly large scale. In 2016, exports accounted for 34.1 terawatt-hours and imports for 38.0 terawatt-hours, corresponding to roughly 60 per cent of the total inland electricity production (61.6 terawatt-hours). Exchanges take place with the neighbouring countries Austria, France, Germany, Italy and Liechtenstein. Apart from the years 2005, 2006, 2010, 2011 and 2016, Switzerland's annual electricity exports exceeded the imports by up to about 10 terawatt-hours (Fig. 26, left). However, during winter time the situation is different, as Switzerland's imports exceeded the exports in every single of the last ten years (Fig. 26, right). While in 1960/1961 the share of winter consumption on the total consumption of the (hydrological) year was 49.5 per cent, this value increased to 54.3 per cent in 2015/2016. However, average winter production only accounted for about 42 per cent of the total production during the last ten (hydrological) years. Among the factors affecting the volume of electricity traded across the borders of Switzerland are hydrological and climatic conditions.

Fig. 26 > Switzerland's net export of electricity from 1996 to 2015. Positive values refer to exports, negative values refer to imports. Left: Total annual net exports. Right: Net exports during winter time.



SFOE (2017b)

2.7 Transport

Overview

According to the Swiss Federal Statistical Office (*SFSO*, 2016b), Switzerland's transport infrastructure is in a very advanced state. Individual and freight transport is facilitated by the road and rail networks, which overall occupy about two per cent of the total land surface. Public transport is of great importance, meaning that virtually every location can be reached by train or, in particular in more remote regions of the Alps, by scheduled public buses.

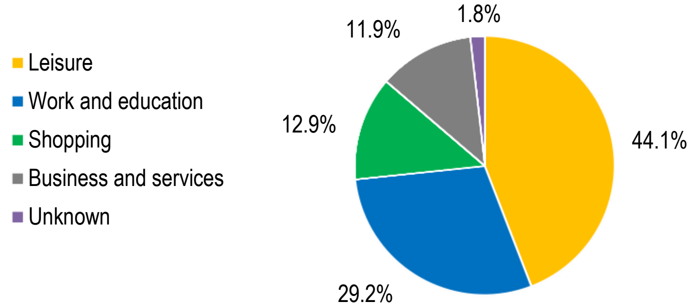
The road network is divided into national roads (1'823 kilometres, thereof 1'440 kilometres highways), cantonal roads (17'898 kilometres) and communal roads (51'799 kilometres). Most Swiss can reach a highway access within a distance of about 10 kilometres.

The rail network, which is fully electrified, currently has a total length of 5'196 kilometres and includes 1'735 stations. To enhance capacity, reduce travel times, and to allow for synchronised timetables between major connecting stations, several railway projects have been implemented since 1987. Under the first stage of the project RAIL 2000, implemented until 2004, the length of the rail network did not increase significantly, but a schedule with 30-minutes intervals could be widely introduced between all major cities, in particular reducing travel time between Zurich and Bern by 13 minutes. In the framework of the project New Rail Link through the Alps, three new railway tunnels have been under construction over the past decades to increase transalpine transport capacity and speed and to foster the shift from road to rail – the Lötschberg base tunnel (34.6 kilometres) opened in December 2007, the Gotthard base tunnel (57.1 kilometres) opened in December 2016, and the Ceneri base tunnel (22.6 kilometres) is scheduled to open in December 2020. Thanks to the Gotthard base tunnel, the highest elevation for transalpine railway traffic is now as low as 549 metres above sea level. The Federal Act on the Future Development of the Railway Infrastructure (*Swiss Confederation*, 2009) and the Federal Decree on the Financing and Development of Railway Infrastructure (FABI, approved by a popular vote in 2014) regulate the next steps of the modernisation and development of the Swiss rail network, focussing on a further increase of capacity and even better access to the major tunnels crossing the Alps (*FOT*, 2015; *FOT*, 2016).

The three national airports Zurich, Geneva and Basel-Mulhouse[7] are the most important aviation infrastructures of Switzerland. A dense network of flight routes connects Switzerland with Europe and with direct flights to important destinations worldwide. More than 100 airlines are serving Switzerland, with eight operating as Swiss companies (*LUPO*, 2016).

Last but not least, the Swiss Confederation supports SwitzerlandMobility, the network for non-motorised traffic. In particular, this network maintains the sign-posting of a great many of cycling paths and hiking trails on the national and regional level.

Fig. 27 > Shares of different purposes on total travel distance within Switzerland (i.e. excluding travel distances abroad) in 2015.



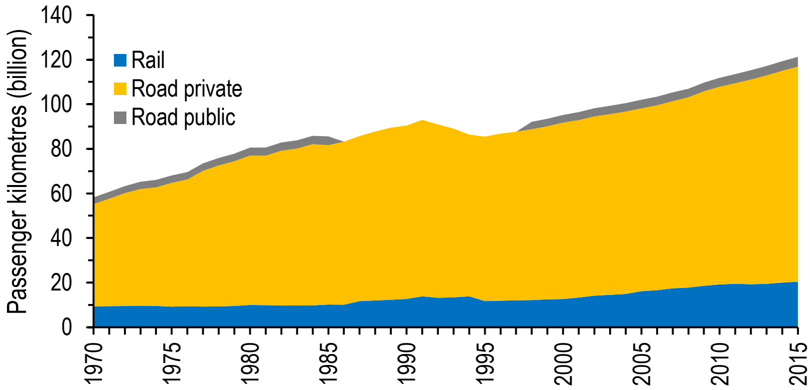
SFSO (2017c)

Passenger transport (land-based)

In 2015, each Swiss over the age of six years travelled an average daily distance within Switzerland of 36.8 kilometres, spending 90 minutes (82 minutes without waiting times). In 1994, 2000, 2005, and 2010 the average daily travel distance was 31.3, 35.0, 35.2, and 36.7 kilometres, respectively. The average daily travel distance by car slightly increased between 1994 and 2000 and remained stable at about 23.8 kilometres thereafter. In contrast, the average daily travel distance using public transport steadily increased from 5.6 kilometres in 1994 to 9.0 kilometres in 2015, corresponding to an increase of more than 61 per cent. Travel distances for leisure purposes increased since 1994, accounting for a share of 44 per cent of the total travel distance within Switzerland in 2015. In contrast, travel distances related to work and education accounted for a share of 29 per cent, while travel distances for shopping purposes accounted for a share of 13 per cent (Fig. 27; *SFSO*, 2017c). While the average daily travel distance per person remained about constant since 2010, passenger kilometres continued to increase as a result of the growth of population (Fig. 3 and Fig. 28; *SFSO*, 2016k). Between 1980 and 2015, motorised private transport (total passenger kilometres) increased by 43.9 per cent and public transport on road and rail (total passenger kilometres) increased by 83.4 per cent. In 2015, 20.4 per cent of total motorised passenger kilometres were travelled by public transport means (3.6 per cent public road, 16.8 per cent rail). For comparison, modal split of public transport in the European Union (EU-28) was 16.7 per cent in 2014 (*Eurostat*, 2017). In Switzerland, non-motorised transport (walking, cycling, hiking, etc.) accounted for almost eight billion passenger kilometres in 2015.

[7] The airport Basel-Mulhouse is located in France, but operated jointly by France and Switzerland.

Fig. 28 > Passenger kilometres by motorised traffic on road (private and public) and rail from 1970 to 2015. Road public data from 1986 to 1997 is missing.



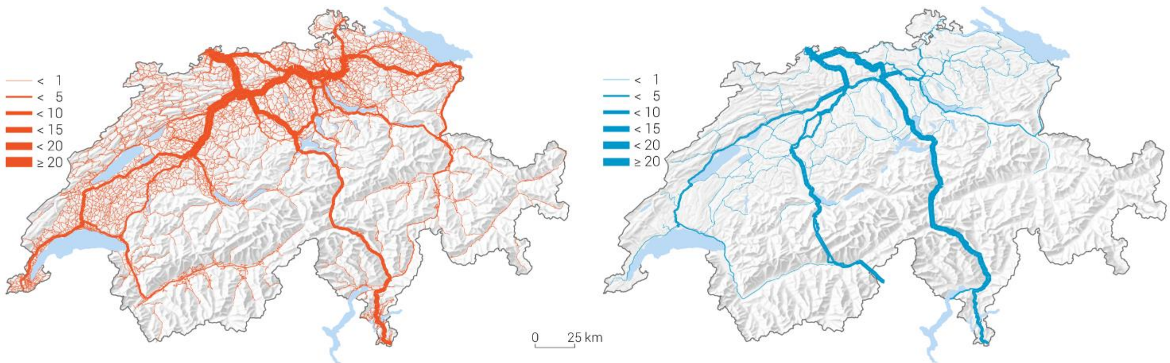
SFSO (2016k)

The number of cars in Switzerland increased from 3.0 million in 1990 to 4.5 million in 2016 (*SFSO*, 2017a), i.e. today less than two persons share a car on average. At the same time, the weight of new passenger cars continuously increased, but more efficient motors became available and a continuous shift from petrol to diesel occurred. Accordingly, specific fuel consumption of new passenger cars showed a decreasing trend, reaching a value of 5.84 litres petrol equivalent per 100 kilometres in 2015, corresponding to a decrease of 35 per cent compared to 1996 (*SFOE*, 2016c). The related emissions of new passenger cars averaged at 135.2 grams of CO_2 per kilometre in 2015.

Freight transport (land-based)

Freight transport in Switzerland is focussed on the Swiss Plateau and the major transalpine routes (Fig. 29). While freight transport on road and rail has been increasing since the mid-19th century, the shares of freight transported on rail decreased from more than 50 per cent in 1982 and before to 42 per cent in 2015 (Fig. 30; *SFSO*, 2016c). However, the dwindling trend in the share of rail transport has been stalled at around 40 per cent since the early 1990s (Fig. 30, right), mostly due to the restrictions on road freight transport inscribed in the Federal Constitution of the Swiss Confederation in 1994[8], the implementation of the distance-related heavy vehicle charge and corresponding bilateral agreements with the European Union. Moreover, in contrast to France and Austria, the transalpine freight transport in Switzerland is dominated by rail (Fig. 31; *SFSO*, 2016d), inter alia, thanks to newly constructed railway tunnels.

Fig. 29 > Freight transport in Switzerland on road (left, red) and rail (right, blue) in 2015 (numbers correspond to million tonnes per year).



SFSO (2015c)

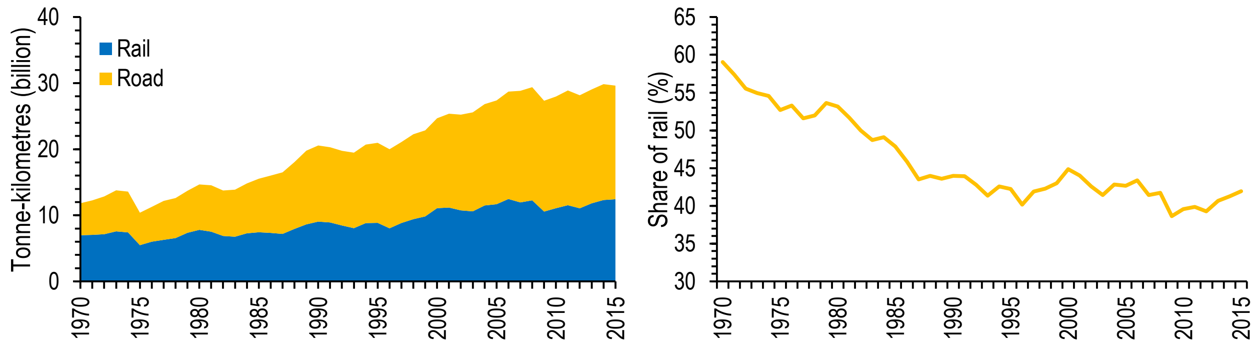
[8] Federal Constitution of the Swiss Confederation, Article 84 'Alpine transit traffic':

The Swiss Confederation shall protect the Alpine region from the negative effects of transit traffic. It shall limit the nuisance caused by transit traffic to a level that is not harmful to people, animals and plants or their habitats.

(i) Transalpine goods traffic shall be transported from border to border by rail. The Swiss Federal Council shall take the measures required. Exceptions are permitted only when there is no alternative. They must be specified in detail in a federal act.

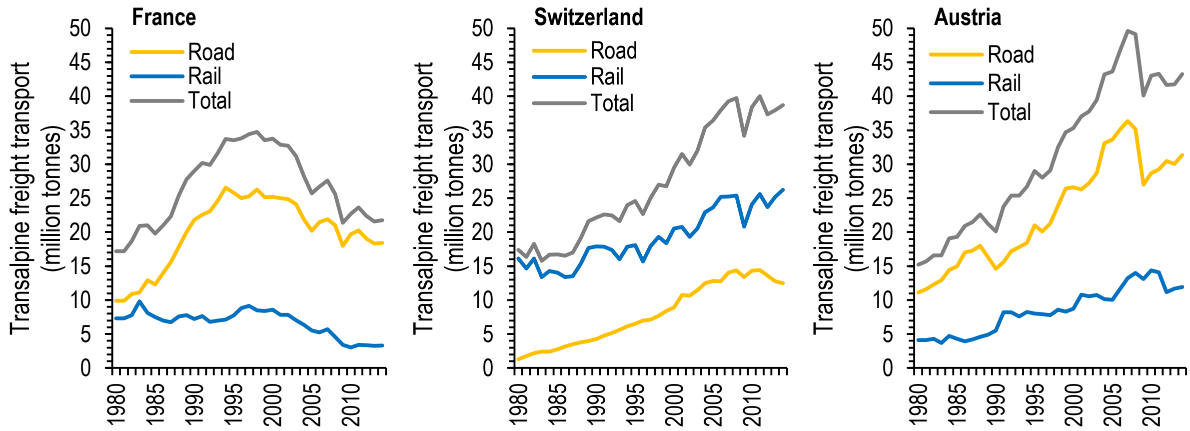
(ii) The capacity of the transit routes in the Alpine region may not be increased. This does not apply to by-pass roads that reduce the level of transit traffic in towns and villages.

Fig. 30 > Freight transport on rail and road (tonne-kilometres, right) and share of rail (left) between 1970 and 2015.



SFSO (2016c)

Fig. 31 > Transalpine freight transport including inland, import, export and transit on road (orange) and rail (blue) in France (left), Switzerland (centre) and Austria (right) from 1980 to 2014. For Switzerland, transalpine freight transport is dominated by rail, which was responsible for 69 per cent of the total of 39.0 million tonnes transported in 2014.

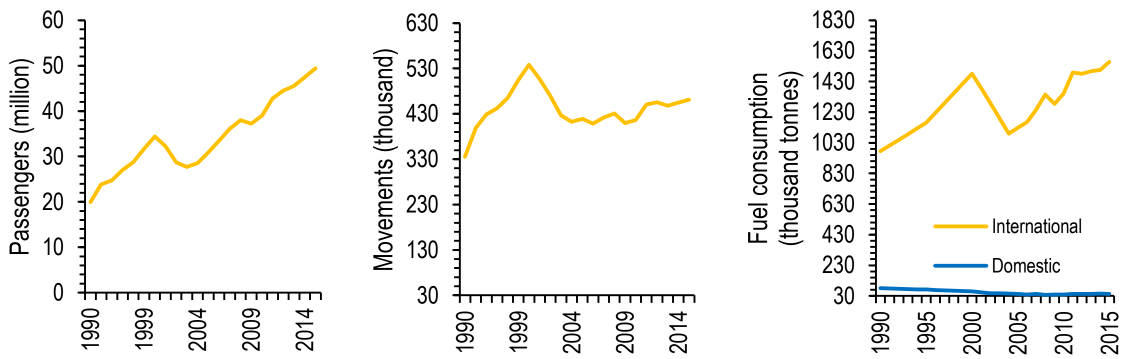


SFSO (2016d)

Aviation

In Switzerland, thanks to the relatively short distances and the dense and fast road and railway networks, domestic aviation is negligible. However, due to the establishment of a dense network of flight routes to Europe and direct flights to important destinations worldwide, the number of scheduled and charter flights departing from and landing in Switzerland has increased considerably between 1990 and 2000. After 2001, the grounding of the national airline and a general crisis in aviation led to a reduction of flight movements in Switzerland (Fig. 32).

Fig. 32 > Left: Number of passengers between 1990 and 2015 (included are all local and transit passengers of scheduled and charter flights of all national and regional airports of Switzerland). Centre: Number of aircraft movements between 1990 and 2015 (included are all domestic and transit passengers of scheduled and charter flights of all national and regional airports of Switzerland). Right: Amount of fuel sold between 1990 and 2015 within Switzerland for domestic and international aviation.



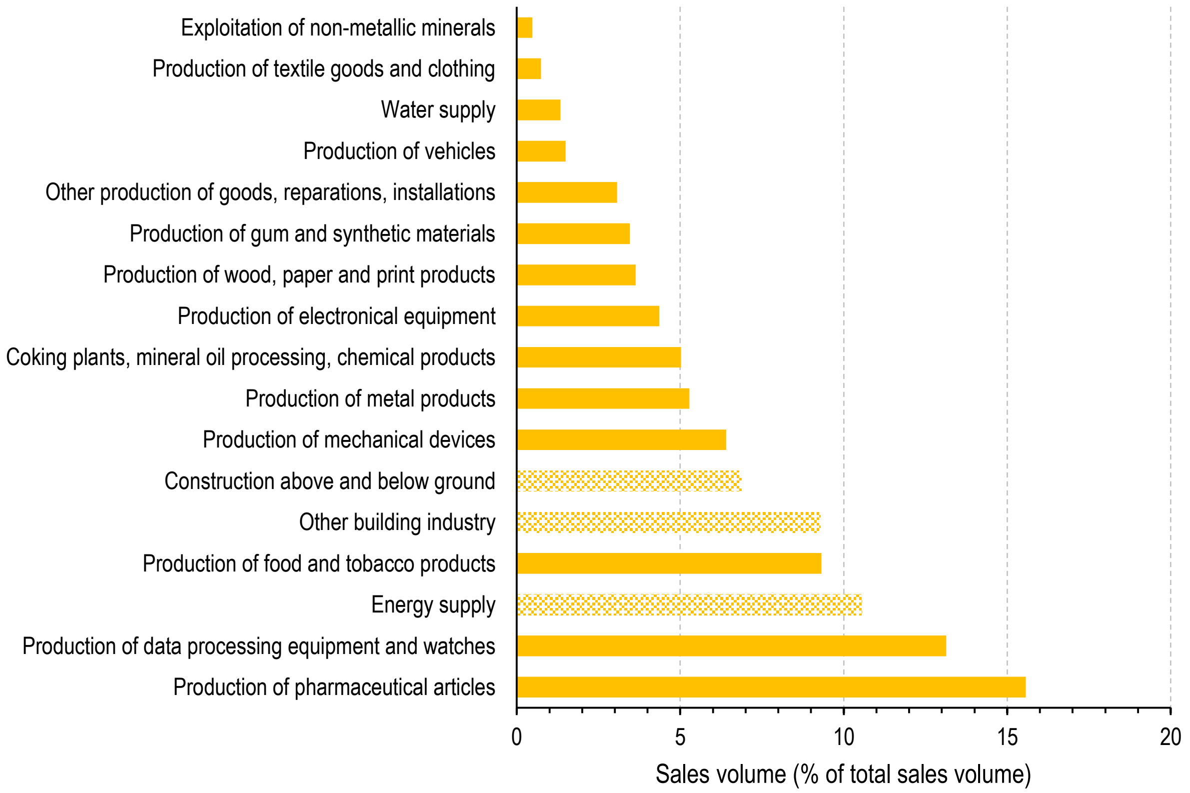
SFSO (2016l); *SFSO* (2016m); *SFSO* (2016n)

Since about 2004, the number of movements (scheduled and charter flights) remained about stable at slightly above 400 thousand movements per year. Nevertheless, the number of passengers (including transfer passengers) steadily increased and almost reached 50 million in 2015, about 2.5 times as much as in 1990 and about 1.6 times as much as in 2000. In 2015, the fuel consumption was, however, at the level of the year 2000. The strong increase in energy efficiency per passenger kilometre is considered to be the result of operating larger aircraft at even increased load factors, fleet renewal (new aircraft technology) as well as operational optimisations.

2.8 Industry and services

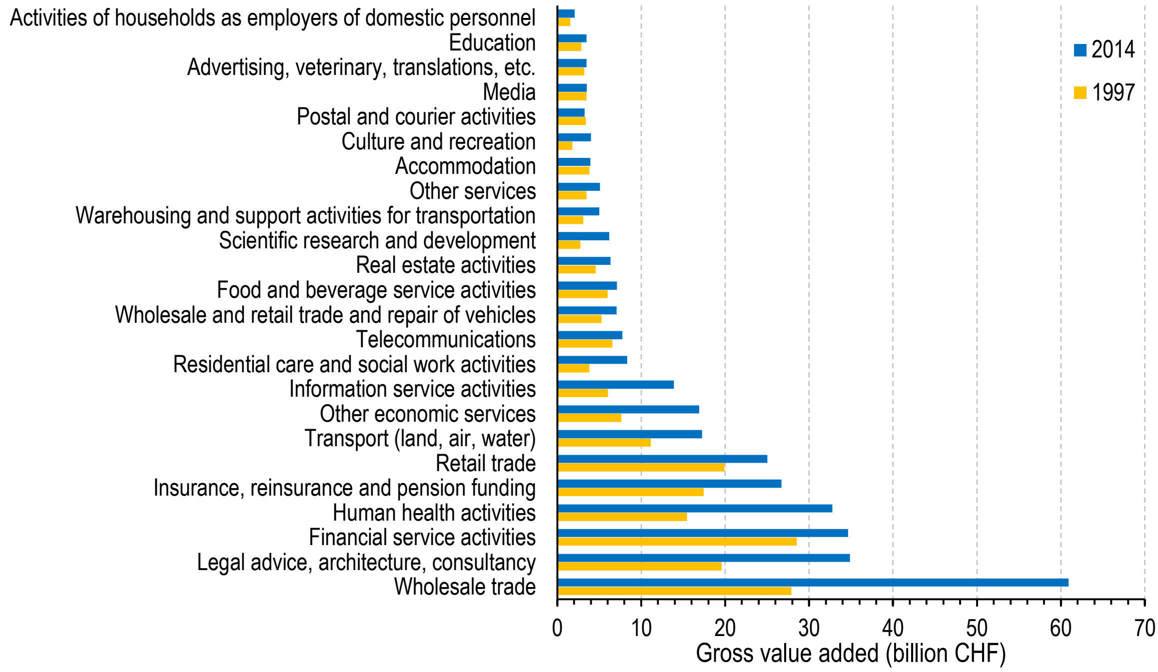
The structure of Switzerland's industry sector clearly reflects the fact that the country is relatively poor in natural resources. Once evolving from the textile industry – which marked the beginning of industrialisation in Switzerland – mechanical engineering continued to form an important pillar of Switzerland's industry. Currently, in addition to mechanical devices and engines, Switzerland's industry is specialised in the production of data processing equipment and high-precision instruments, particularly watches and goods for medical uses (medical technique). Of greatest importance are the food processing and chemical industries, in particular the production of pharmaceutical articles. An overview of goods imported to and exported from Switzerland is provided in Fig. 10, while Fig. 33 shows the sales volume within the industry sector in 2014. As highlighted in section 2.3 (in particular in Fig. 7), Switzerland's economy is largely based on the services sector. The services sector is highly diverse, important contributions (in descending order) to the total gross value added currently come for instance from (i) wholesale trade, (ii) legal advice, architecture, consultancy, (iii) financial service activities, (iv) human health activities, (v) insurance, reinsurance and pension funding, (vi) retail trade, etc. (Fig. 34).

Fig. 33 > Sales volume within the industry sector in 2014. Shown are relative contribution of different branches to the total sales volume of about 450 billion Swiss francs. Included are sales volumes from energy supply and the building industry (lighter colour).



SFSO (2016o)

Fig. 34 > Gross value added by different branches of the services sector in Switzerland in 1997 and 2014.

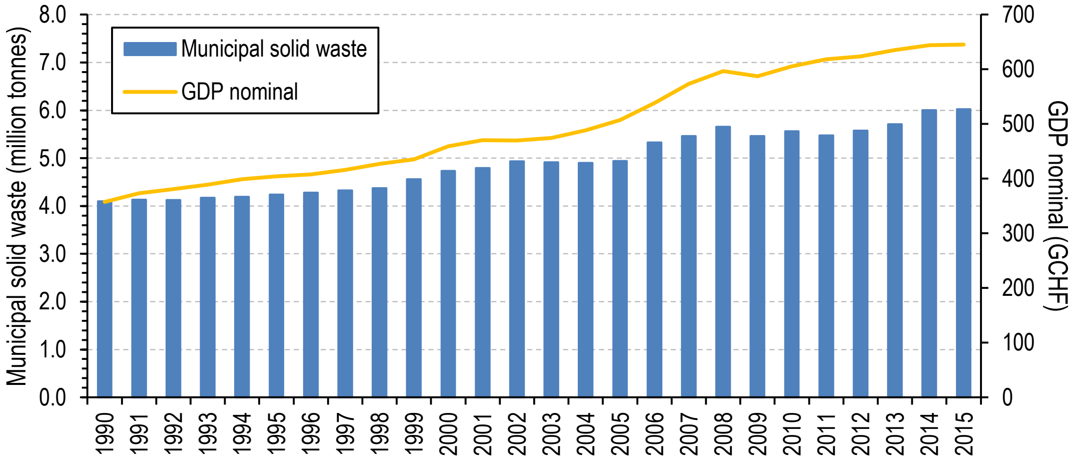


SFSO (2016e)

2.9 Waste

With regard to waste treatment, Switzerland has efficient infrastructure, high standards and clear legislative stipulations in place. The evolution of the amount of municipal solid waste is highly related to increasing prosperity and the steady growth of population. This is shown in Fig. 35, where the evolution of the total amount of municipal solid waste in Switzerland is provided together with the nominal gross domestic product.

Fig. 35 > Evolution of the total amount of municipal solid waste in Switzerland, 1990–2014 (since 2004 without imports of municipal solid waste), together with the nominal gross domestic product.



FOEN (2016d), *SECO* (2017)

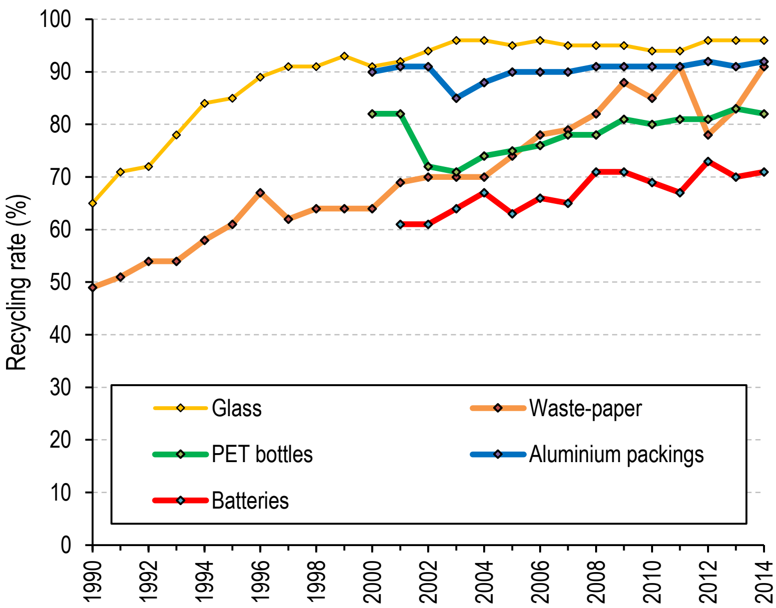
As incineration is mandatory for combustible waste since the year 2000, inputs into solid waste disposal sites have dropped to zero. According to the latest waste statistics (*FOEN*, 2017c; Tab. 1), which covers Switzerland and the principality of Liechtenstein, the total amount of waste (including municipal solid waste, construction waste, industrial and commercial solid waste, sewage sludge, special waste) incinerated amounted to 3.89 million tonnes (corresponding to 465 kilograms per inhabitant) in 2015. Thereof, 0.38 million tonnes originated from abroad, as Switzerland imports waste to operate waste incineration plants at full capacity for power and heat generation. In addition, 3.18 million tonnes (corresponding to 380 kilograms per inhabitant) of municipal solid waste were collected separately (including compost, paper and cardboard, glass, tins, tinfoil, aluminium, PET, textiles, electrical and electronical devices, batteries). The amount of municipal solid waste collected separately for recycling purposes more than doubled since 1990, indicating that today recycling systems are highly developed and supported by the population in Switzerland (Fig. 36). In particular, separate collection of PET bottles, which are relevant regarding CO_2 emissions as they comprise petrochemical material, has increased significantly in recent years, with 82 per cent of the total PET bottles being recycled in 2014. Recycling rates of glass, aluminium packings, and waste-paper currently all exceed 90 per cent of the total amounts. In addition to municipal solid waste, 15.9 million tonnes of construction waste were generated in Switzerland in 2015. Thereof, 8.4 million tonnes stem from infrastructures such as streets, railways, as well as systems for water, wastewater, gas and electricity systems (*FOEN*, 2016c), and 7.5 million tonnes stem from the building infrastructure (*FOEN*, 2015a). Where possible, construction waste is recycled on site. Finally, 2.34 million tonnes of waste were classified as special waste in 2015 (*FOEN*, 2017c; Tab. 1). In Switzerland, the wastewater of virtually the full population (i.e. of about 97 per cent of the population) is sewered to a wastewater treatment plant.

Tab. 1 > Amount of waste in Switzerland (CH) and the principality of Liechtenstein (FL) in 2015. The provided number for sewage sludge is an estimate for Switzerland only.

Type of waste	Total (tonnes)	Per capita (kilograms per inhabitant)
Municipal solid waste incinerated (CH, FL)	2'850'000	341
Imports of municipal solid waste for incineration	384'000	46
Waste incinerated in waste incineration plants (municipal solid waste, construction waste, industrial waste, sewage sludge, special waste)	3'889'000	465
Special waste (CH, FL)	2'342'000	280
Sewage sludge (CH, dry matter)	210'000	25
Municipal solid waste collected separately (CH, FL), thereof:	3'176'000	380
Waste-paper	*1'307'056*	*156*
Compost (digested at central composting sites)	*1'255'844*	*150*
Waste glass	*356'062*	*43*
Electric and electronic devices	*134'000*	*16*
Textiles	*56'900*	*6.8*
PET bottles	*38'661*	*4.6*
Cans	*11'590*	*1.4*
Aluminium packings	*12'900*	*1.5*
Batteries	*2'724*	*0.3*

FOEN (2017c)

Fig. 36 > Evolution of recycling rates in Switzerland, 1990–2014.



FOEN (2016b)

2.10 Building stock and urban structure

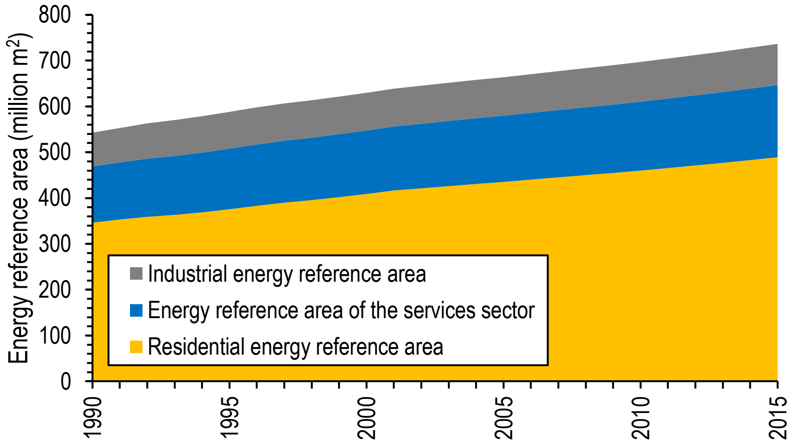
Building stock

The Swiss Federal Statistical Office keeps track of the building stock in Switzerland (*SFSO*, 2017p). The investigations are based on a complete inventory according to data extracted from the registry of buildings and apartments, with a focus on buildings with (at least partial) residential use[9]. The following points are noteworthy:

- In 2015, the building stock in Switzerland consisted of 1.7 million buildings with at least partial residential use. This corresponds to an increase of 30 per cent compared to 1990, an increase of 17 per cent compared to the year 2000, and an increase of four per cent compared to 2010. In 2015, 57.4 per cent of all buildings were one-family homes, 26.3 per cent multi-family homes, and the rest were buildings with residential and non-residential use. These shares remained relatively constant over the last 15 years, although about 69 per cent of new buildings constructed since 2000 were one-family homes. About one third of all buildings was constructed before 1945, about one third between 1946 and 1980, and about one third after 1980 (*SFSO*, 2017p);
- In 2015, there was a stock of 4.4 million apartments in Switzerland, corresponding to an increase of 22 per cent compared to the year 2000 and an increase of seven per cent compared to 2010. While more than 54 per cent of all apartments have three or four rooms, about 25 per cent are larger and about 21 per cent are smaller. Apartments with an area of 60 to 119 square metres accounted for 54 per cent of the total stock, whereas 28 per cent were larger and 18 per cent were smaller. The average area was 99 square metres, about the same as in the year 2000. The average area per capita increased from 39 square metres in 1990 to 45 square metres in 2015 (*SFSO*, 2017p);
- In accordance with the increase in buildings and apartments, the energy reference area, i.e. the area heated or cooled, is steadily increasing for all types of buildings. Between 1990 and 2015, the energy reference area of buildings in the services sector increased by 28 per cent, of buildings in the industry sector by 22 per cent, and of buildings for residential use by 41 per cent (*SFOE*, 2017; Fig. 37);
- In 2015, 28 per cent of the Swiss population lived in one-family homes, 52 per cent in multi-family homes and the rest in buildings with residential and non-residential use. Only nine per cent of one-family homes are inhabited by more than four persons. About 48 per cent of the population lived in a building constructed between 1961 and the year 2000 and 35 per cent of the population lived in a building constructed before 1961 (*SFSO*, 2017p). The spatial distribution of Switzerland’s population is shown in Fig. 4;
- In 2015, 63 per cent of all buildings were heated with fossil fuels (i.e. gas oil or gas, while coal became negligible). However, because multi-family homes are more often heated with fossil fuels (72 per cent), the majority of the Swiss population (72 per cent) currently lives in buildings heated with fossil fuels (Fig. 38). While fossil heating systems are, thus, still dominating, heat pumps accounted for about 70 per cent of heating systems installed in newly constructed buildings during 2011–2015 (Fig. 39; *SFSO*, 2017p). *Wüest and Partner* (2016) estimate, that in the context of replacements of heating systems in existing buildings, the non-fossil shares account for about half in the case of one-family homes and for about one third in the case of multi-family homes. Nine out of ten persons lived in a building with a central heating system serving one or more buildings. Two per cent of the complete building stock and four per cent of the population are connected to a public district heating (*SFSO*, 2017p);
- Homeownership rates in Switzerland stay relatively low, as only about 40 per cent of households in Switzerland lived in their own homes in 2015. While the percentage of homeowners has increased compared to 1970 (when it was below 30 per cent), it is still low compared to other European countries. The low homeownership rates may, to some extent, represent a hurdle with regard to the modernisation of buildings (*SFSO*, 2017p).

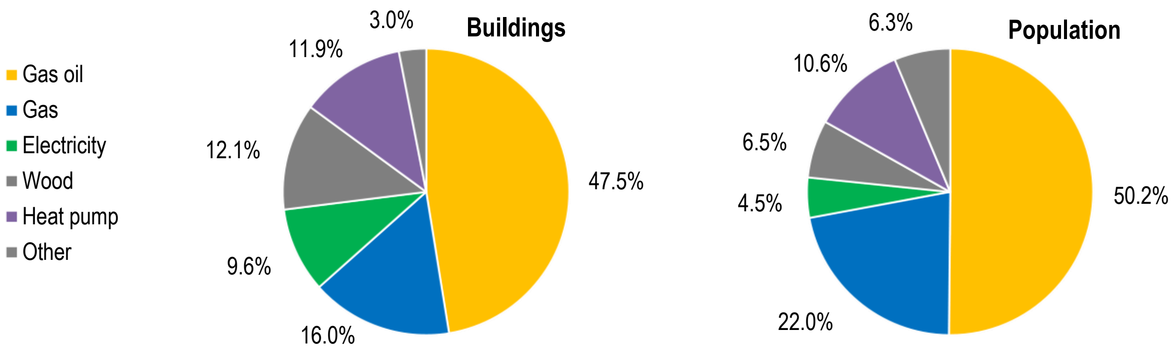
[9] However, the registry of buildings and apartments may not entirely be up-to-date regarding heating systems, in particular because replacements of heating systems in existing buildings may not be captured by the statistics of all authorities at the communal and cantonal levels. Accordingly, the provided numbers may, to some extent, overestimate the current share of fossil energy carriers (*SFSO*, 2017p).

Fig. 37 > Energy reference area in Switzerland between 1990 and 2015.



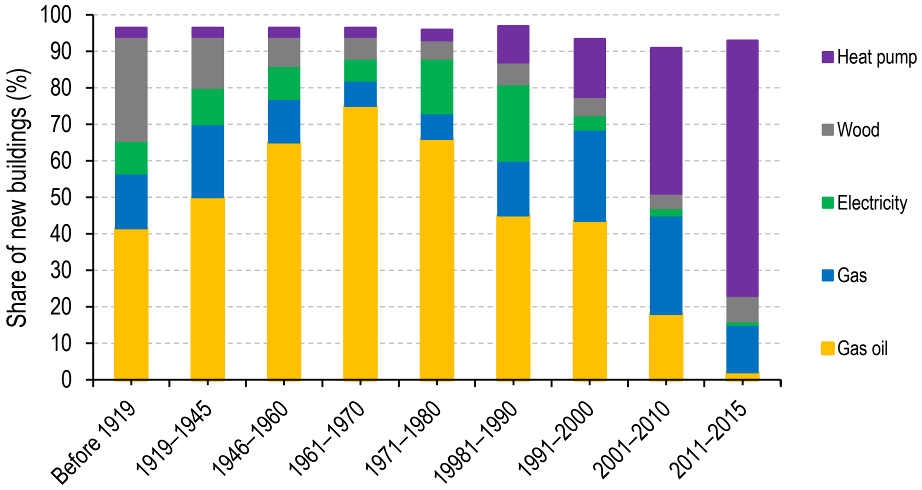
SFOE (2017)

Fig. 38 > Relative distribution of energy sources for heating systems in 2015. Left: Buildings. Right: Population.



SFSO (2017p)

Fig. 39 > Share of the five most important energy sources for heating systems in different construction periods (new constructions).



SFSO (2017p)

Urban structure

Constrained by the topography, Switzerland's settlements originally developed along rivers, lakes and valleys – which formed the major trading routes – as well as on the Swiss Plateau. Although not homogeneously in every area due to different factors such as industrialisation and the development of the rail and road networks, the formation of settlements continued incessantly. Today, Switzerland's urban structure may be best described by the term 'network city', i.e. a large number of interconnected 'nodes' with high densities of population, goods and information which have an extensive and efficient mutual exchange. As showcased in Fig. 40, agricultural areas and forests are an integral part of Switzerland's urban structure. Information regarding Switzerland's population density and the spatial distribution of population is provided in section 2.2 (in particular Fig. 4).

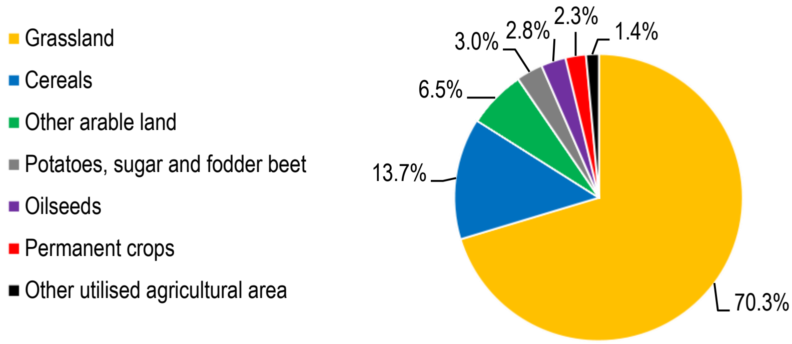
Fig. 40 > Typical example of Switzerland's urban structure (Kloten, Wallisellen, Opfikon, Hard).

OcCC (2007)

2.11 Agriculture

Switzerland's utilised agricultural area (excluding alpine pastures) accounted for 1.049 million hectares in 2015, corresponding to 25.4 per cent of the total land surface. When alpine pastures are included, the agricultural land surface covers 35.9 per cent of the total land surface. Alpine pastures thus account for roughly one third of the agricultural land surface, while the rest is cultivated according to the shares shown in Fig. 41, with more than 70 per cent being grassland. Due to the spread of built-up and forest areas, the agricultural land surface (including alpine pastures) is steadily decreasing, namely by 5.4 per cent between 1979/1985 and 2004/2009 (Fig. 13).

Fig. 41 > Use of utilised agricultural area (excluding alpine pastures) in Switzerland, 2015.

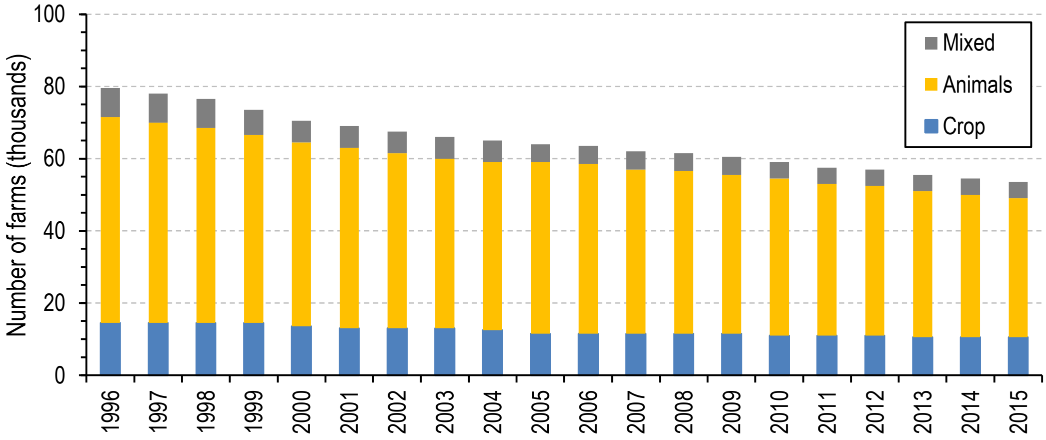


SFSO (2016q)

According to the Swiss Federal Statistical Office (*SFSO*, 2016q), the number of farms decreased from about 80 thousand in 1996 to about 53 thousand in 2015 (Fig. 42). This decrease corresponds to the closure of almost four farms each day. In concert with the decreasing number of farms, a substantial increase of the area per farm (+45 per cent) and a substantial decrease in employees in the agriculture sector occurred. While in 1960 still 14.5 per cent of the population worked in the agriculture sector, this share decreased to 3.2 per cent in 2015 (*SFSO*, 2016r).

The large share of grassland indicates that the majority of farms keep ruminants (Fig. 42). Nevertheless, as shown in Tab. 2, the number of cattle decreased by 16 per cent between 1990 and 2015. Swine population decreased by the same percentage. In contrast, an increase occurred for poultry (+82 per cent). Noteworthy, the milk yield of mature dairy cattle increased from 16.1 kilograms per head and day in 1990 to 23.1 kilograms per head and day in 2015 (*FOEN*, 2017a). Since the early 1990s, and increasingly since a new agricultural article was stipulated in the Federal Constitution of the Swiss Confederation 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 met by almost all farms and the share of organic farms reached 12 per cent in 2015.

Fig. 42 > Number of farms and their economic orientation in Switzerland, 1996–2015.



SFSO (2016q)

Tab. 2 > Livestock population in Switzerland in the years 1990, 2000, 2010, and 2015.

	1990	2000	2010	2015
	1'000 head			
Cattle	1'855	1'588	1'591	1'554
Whereof mature cattle	*795*	*714*	*700*	*701*
Horses, mules and asses	34	62	82	75
Swine	1'787	1'498	1'589	1'496
Sheep	395	421	434	347
Goat	68	62	83	71
Poultry	5'938	6'983	9'025	10'825
Rabbit	61	28	35	25

FOEN (2017a)

2.12 Forest

The intermediate results of the fourth national forest inventory (NFI4/2009–2013; *Abegg et al.*, 2014; *FOEN and WSL*, 2015) indicate that 32 per cent of Switzerland's area is covered by forests. According to *Trading economics* (2015), this percentage is matched or even exceeded by some of Switzerland's neighbouring countries: Austria (47 per cent), Germany (33 per cent), and Italy (32 per cent). Forest cover is not evenly distributed across Switzerland. More than 50 per cent of forests are located above 1000 metres above sea level. The Alps have therefore the highest forest cover, with forest areas still expanding. Forest exploitation is concentrated in the central lowlands (about 40 per cent of total wood harvest), which are more easily accessible than alpine regions and therefore less cost-intensive in terms of harvest.

30 per cent of Swiss woodland is privately owned, whereas 70 per cent is public property. The majority of the state owned woodland belongs to bourgeois communities and cooperatives (42 per cent) and political communities (46 per cent; comprising municipalities and cantons). Only one per cent is owned by the Swiss Confederation.

Since the first national forest inventory surveyed between 1983 and 1985, the forested area has grown by 9.7 per cent. The differences between the regions are striking: the greatest increase was recorded in the Alps (18.3 per cent) and the Southern Alps (17.8 per cent) as a consequence of natural regeneration of abandoned land previously used by agriculture, whereas the forested area in the central lowlands (+0.5 per cent) and the Jura (+0.9 per cent) only slightly changed.

According to intermediate results of the fourth national forest inventory (NFI4/2009–2013), Switzerland's forests account for 419 million cubic metres of wood. Of this, 32 per cent are deciduous trees such as beech (18 per cent) and 68 per cent are coniferous trees such as spruce (44 per cent) and fir (15 per cent). Standing volume of living trees is increasing since 30 years. During the last five years, standing volume in Swiss forests increased by 1.5 per cent on average to 356 cubic metres per hectare. The highest increase was observed in alpine forests which are difficult to access and exploit. This increase is mainly due to a slight decrease in harvest and also a lower share of mortality. Annual harvest and mortality decreased from 8.6 (periods of NFI2/1993–1995 and NFI3/2004–2006); *Brassel and Brändli*, 1999; *Brändli*, 2010) to 8.2 cubic metres per hectare per year (periods of NFI3/2004–2006 and NFI4/2009–

2013; *Abegg et al.*, 2014). This can mainly be attributed to the fact that between the periods of NFI2/1993–1995 and NFI3/2004–2006, the storm 'Lothar' of December 1999 was responsible for high amounts of salvage logging and high mortality rates within Swiss forests. The average annual growth rate increased from 8.9 (periods of NFI2/1993–1995 and NFI3/2004–2006) to 9.3 (periods of NFI3/2004–2006 to NFI4/2009–2013) cubic metres per hectare.

Since 1998, a few scattered forest areas have obtained certification for sustainable forest management under the FSC system (*http://www.fsc.org*) or the Q/PEFC system (*http://www.pefc.org*). Starting in the year 2000, group certifications enabled larger areas joining the scheme, so that the area of certified forest increased by 100 thousand hectares per year. In 2005, this trend began to slab. At the moment, 56 per cent of the Swiss forest area and 67 per cent of the harvested roundwood are certified under either one or both of the two certifying systems.

2.13 Other circumstances

Switzerland reported all national circumstances relevant to greenhouse gas emissions and removals in section 2.1 to 2.12, there are no relevant other circumstances to be reported.

2.14 Relationship between national circumstances and greenhouse gas emissions

Switzerland's greenhouse gas emissions and removals, disaggregated by gas and by sector, are presented and discussed in detail in chapter 3. This section provides information on how the national circumstances presented in section 2.1 to 2.12 affect greenhouse gas emissions and removals, and how the national circumstances and changes therein affect greenhouse gas emissions and removals over time. In this regard, the Swiss Federal Office for the Environment regularly publishes a report which discusses the influence of key parameters on greenhouse gas emissions in Switzerland (*FOEN*, 2017d). Based on the last update of this report, the relationship between key parameters – reflecting Switzerland's national circumstances – and greenhouse gas emissions resulting from different activities[10] are briefly discussed in the following.

Total greenhouse gas emissions

Fig. 43 shows the relative evolution of Switzerland's total greenhouse gas emissions. When compared to relevant key parameters, the following important observations emerge:

- Despite a substantial increase in population, total greenhouse gas emissions were first stable and then started to slightly decrease over the period from 1990 to 2015. Accordingly, per capita greenhouse gas emissions decreased by 27.5 per cent, from 8.1 tonnes of CO_2 equivalents per capita in 1990 to 5.8 tonnes of CO_2 equivalents per capita in 2015;
- At the same time, Switzerland's gross domestic product substantially increased, but economic growth and greenhouse gas emissions evolved decoupled from each other. Accordingly, greenhouse gas emissions per gross domestic product decreased by 38.4 per cent, from 150 grams of CO_2 equivalents per Swiss franc in 1990 to 92 grams of CO_2 equivalents per Swiss franc in 2015;
- Year-to-year variations in total greenhouse gas emissions were to a large part the consequence of changing meteorological conditions (such as heating degree days and solar insolation), which had a major influence on the demand on heating fuel during winter time. Nevertheless, multi-annual mean greenhouse gas emissions were de-

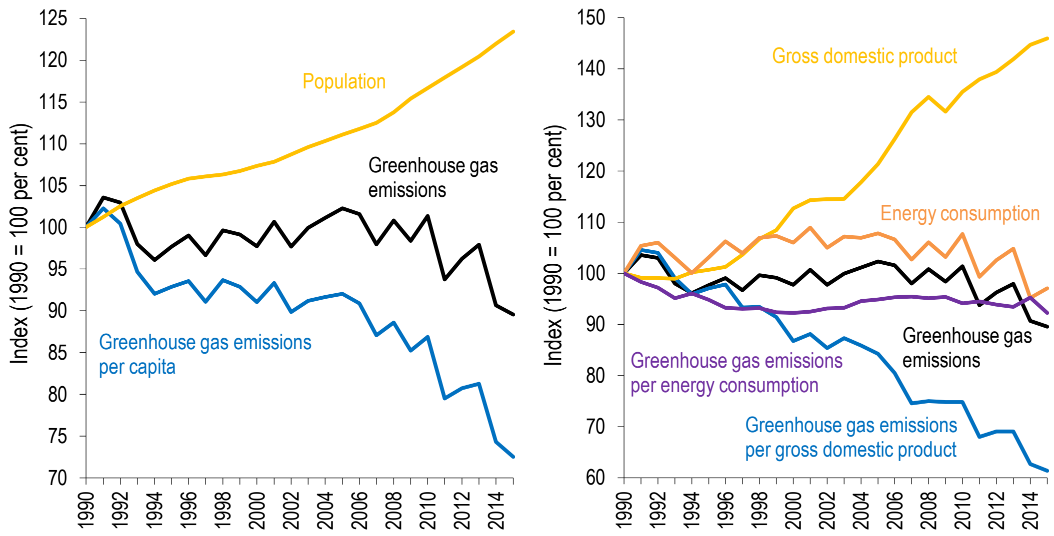
[10] For the discussion in section 2.14, the disaggregation follows *FOEN* (2017d) and does not necessarily agree with the definition of sectors in other chapters of Switzerland's seventh national communication:

- Emissions related to industry: 1.A.1 'Energy industries' + 1.A.2 'Manufacturing industries and construction' + 1.B 'Fugitive emissions from fuels' + 2 'Industrial processes and product use' – 1.A.1 'Energy industries' (other fuels) – 1.A.2 'Manufacturing industries and construction' (other fuels) – 1.A.1 'Energy industries' (biomass) – 1.A.2 'Manufacturing industries and construction' (biomass);
- Emissions related to services: 1.A.4.a 'Commercial/institutional';
- Emissions related to households: 1.A.4.b 'Residential';
- Emissions related to transport: 1.A.3 'Transport' + 1.A.5 'Other';
- Emissions related to agriculture: 3 'Agriculture' + 1.A.4.c 'Agriculture/forestry/fishing';
- Emissions related to waste: 5 'Waste' + 1.A.1 'Energy industries' (other fuels) + 1.A.2 'Manufacturing industries and construction' (other fuels) + 1.A.1 'Energy industries' (biomass) + 1.A.2 'Manufacturing industries and construction' (biomass).

creasing over time, indicating the increasing energy-efficiency, as well as the ongoing substitution of heating and process fuels by renewable energy sources and natural gas;

- The reporting under the UNFCCC (i.e. the national greenhouse gas inventory) does not include 'grey emissions', i.e. emissions from the production of imported goods and energy as well as from the disposal of products abroad. Switzerland mainly depends on imported energy and the Swiss economy is strongly based on the services sector. Traditionally, heavy industry is virtually absent in Switzerland due to a lack of local mineral resources. This implies that substantial grey emissions are associated with Switzerland's imports of goods. In 2011, greenhouse gas emissions in Switzerland accounted for 13.6 tonnes of CO_2 equivalents per capita when grey emissions are included, i.e. more than a factor of two higher compared to the emissions of 6.4 tonnes of CO_2 equivalents per capita based on national emissions only (*FOEN*, 2011).

Fig. 43 > Evolution of Switzerland's total greenhouse gas emissions, together with population (left panel), Switzerland's gross domestic product, and total energy consumption (right panel), 1990–2015 (relative evolutions with reference year 1990). The respective panels also show the greenhouse gas emissions per capita, per gross domestic product, and per energy consumption.

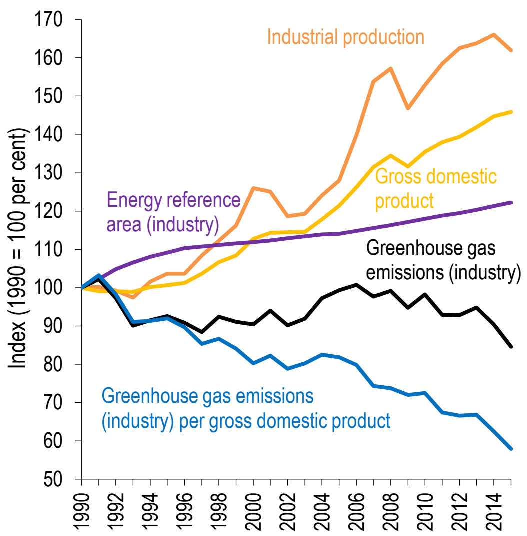


FOEN (2017d)

Greenhouse gas emissions related to industry

Fig. 44 shows the relative evolution of Switzerland's greenhouse gas emissions related to industry[10]. When compared to relevant key parameters, the following important observations emerge:

Fig. 44 > Evolution of Switzerland's greenhouse gas emissions related to industry[10], together with industrial production, Switzerland's gross domestic product, and the energy reference area related to industry, 1990–2015 (relative evolutions with reference year 1990). Also shown are the greenhouse gas emissions related to industry per gross domestic product.



FOEN (2017d)

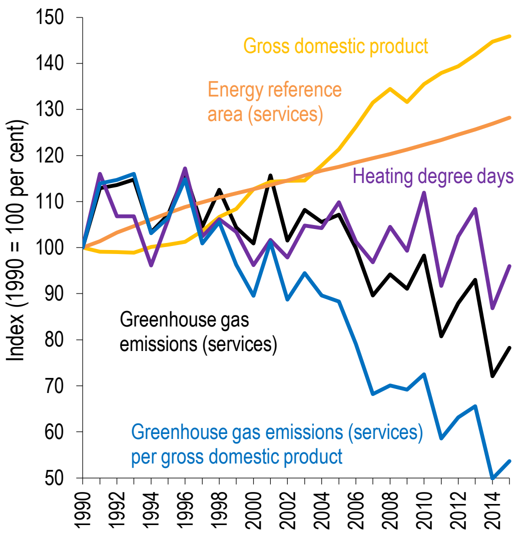
- Despite a substantial increase in Switzerland's gross domestic product, in industrial production, as well as in the energy reference area related to industry, greenhouse gas emissions related to industry did not increase and were 15 per cent lower in 2015 compared to 1990;
- Accordingly, greenhouse gas emissions related to industry per gross domestic product steadily decreased, by a total of 42 per cent from 1990 to 2015. This indicates a certain decoupling of economic growth and greenhouse gas emission.

Greenhouse gas emissions related to services

Fig. 45 shows the relative evolution of Switzerland's greenhouse gas emissions related to services[10]. When compared to relevant key parameters, the following important observations emerge:

- Greenhouse gas emissions related to services were mostly driven by the influence of meteorological conditions (such as heating degree days and solar insolation);
- Despite a substantial increase in the energy reference area related to services, as well as in Switzerland's gross domestic product, greenhouse gas emissions related to services showed a prolonged decrease (overlain by the year-to-year variability caused by meteorological conditions);
- Accordingly, the greenhouse gas emissions related to services per gross domestic product decreased by 46 per cent from 1990 to 2015.

Fig. 45 > Evolution of Switzerland's greenhouse gas emissions related to services[10], together with Switzerland's gross domestic product, the energy reference area related to services, and the heating degree days, 1990–2015 (relative evolutions with reference year 1990). Also shown are the greenhouse gas emissions related to services per gross domestic product.



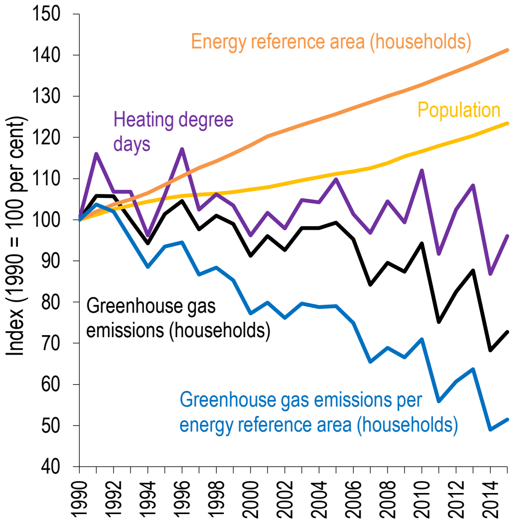
FOEN (2017d)

Greenhouse gas emissions related to households

Fig. 46 shows the relative evolution of Switzerland's greenhouse gas emissions related to households[10]. When compared to relevant key parameters, the following important observations emerge:

- Like the greenhouse gas emissions related to services, greenhouse gas emissions related to households were strongly driven by meteorological conditions (such as heating degree days and solar insolation);
- Apart from the strong influence of meteorological conditions, greenhouse gas emission related to households showed a decreasing trend, despite the fact that the energy reference area related to households, i.e. the heated or cooled living space, as well as population were steadily increasing;
- Accordingly, greenhouse gas emissions related to households per energy reference area related to households steadily decreased, thanks to improving insulation standards, the renovation of older buildings, and the increasing replacement of heating fuel by natural gas and renewables (heating pumps, wood, etc.).

Fig. 46 > Evolution of Switzerland's greenhouse gas emissions related to households[10], together with the energy reference area related to households, population, and heating degree days, 1990–2015 (relative evolutions with reference year 1990). Also shown are the greenhouse gas emissions related to households per energy reference area related to households.



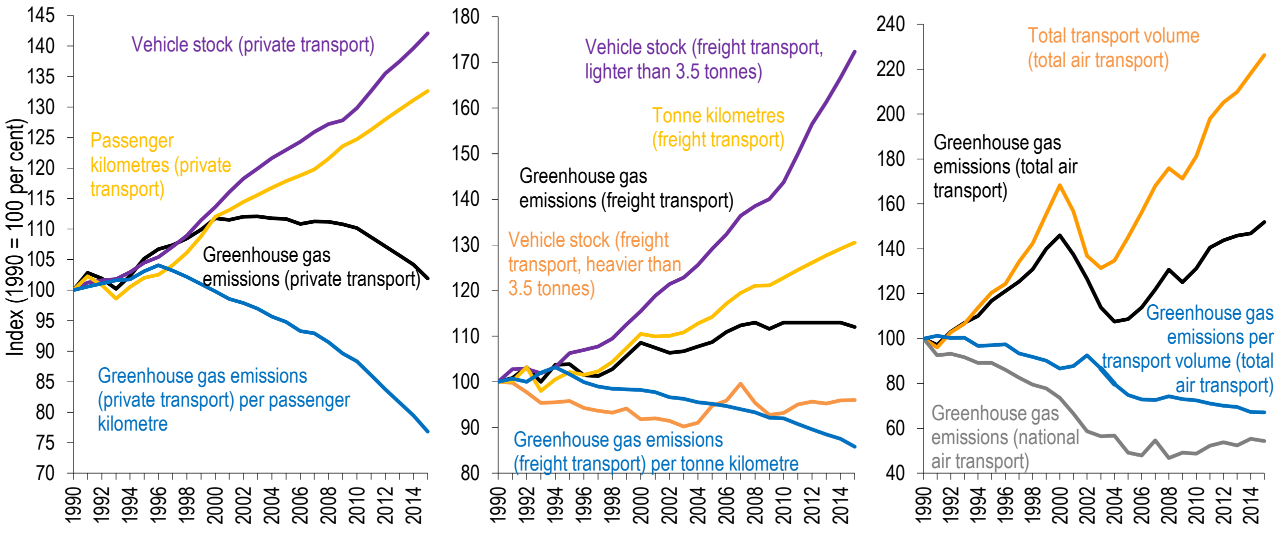
FOEN (2017d)

Greenhouse gas emissions related to transport

Fig. 47 shows the relative evolution of Switzerland's greenhouse gas emissions related to transport[10]. When compared to relevant key parameters, the following important observations emerge:

- The vehicle stock of private transport increased by 42 per cent between 1990 and 2015. As the passenger kilometres increased by 33 per cent over the same period, the passenger kilometres per vehicle slightly decreased;
- Greenhouse gas emissions related to private transport increased by 12 per cent between 1990 and the year 2000, then remained constant until 2008, followed by a decreasing trend. Overall, available data indicated that greenhouse gas emission related to private transport per passenger kilometre showed a decreasing trend since about 1996, and were 23 per cent lower in 2015 compared to 1990. This evolution can be explained by technological progress, i.e. more efficient motors, as well as the increasing use of diesel;
- The vehicle stock of freight transport increased by 56 per cent between 1990 and 2015, predominantly due to an increase in the number of light commercial vehicles (lighter than 3.5 tonnes);
- While greenhouse gas emission related to freight transport increased by 12 per cent between 1990 and 2015, greenhouse gas emissions related to freight transport per tonne kilometre decreased by 14 per cent over the same time period;
- Between 1990 and 2015, the total transport volume of air transport (including passenger and freight on national and international flights) increased by 126 per cent, with a temporary decrease between 2001 and 2004 as a consequence of the grounding of the national airline and a general crisis in aviation. In contrast to total transport volume, national transport volume is of minor importance and steadily decreased from 1990 to 2005 and then remained at around 50 per cent of the transport volume in 1990;
- Greenhouse gas emissions related to air transport generally followed the same evolution as the transport volume, but thanks to increasing efficiency, the greenhouse gas emissions per transport volume decreased by 33 per cent between 1990 and 2015.

Fig. 47 > Evolution of Switzerland's greenhouse gas emissions related to private transport, freight transport and air transport[10], together with the vehicle stock and passenger kilometres of private transport, the vehicle stock and tonne kilometres of freight transport, as well as the total volume transported by air, 1990–2015 (relative evolutions with reference year 1990). Also shown are the greenhouse gas emissions related to private transport per passenger kilometre, the greenhouse gas emissions related to freight transport per tonne kilometre, and the greenhouse gas emissions related to air transport per air transport unit (corresponding to one person or 100 kilograms).



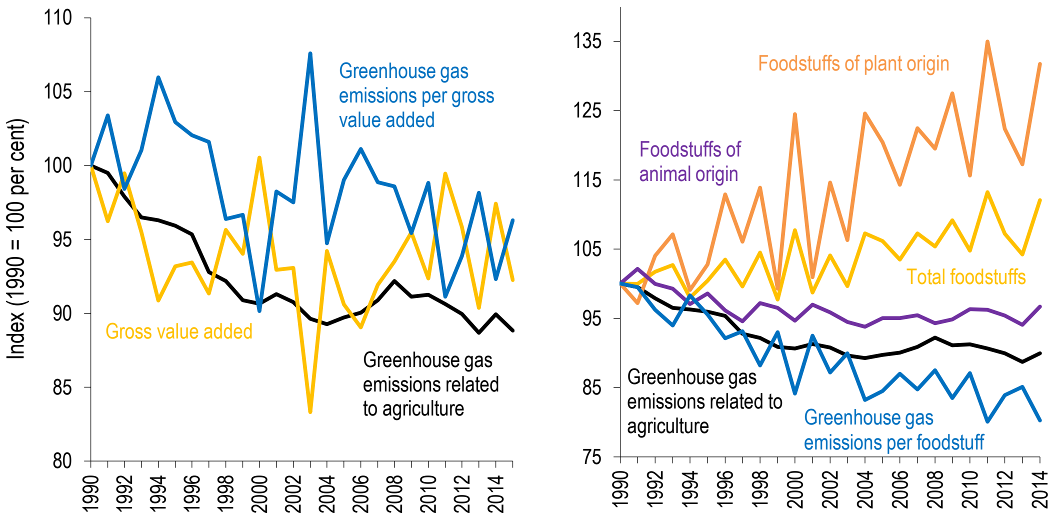
FOEN (2017d)

Greenhouse gas emissions related to agriculture

Fig. 48 shows the relative evolution of Switzerland's greenhouse gas emissions related to agriculture[10]. When compared to relevant key parameters, the following important observations emerge:

- Greenhouse gas emission related to agriculture decreased by 11 per cent from 1990 to 2015. However, as the greenhouse gas emission related to agriculture about followed the gross value added, no improvement in the economic greenhouse gas efficiency (outside the observed variability) can be observed from 1990 to 2015;
- Between 1990 and 2014, the production of foodstuffs increased by 12 per cent, whereby the production of foodstuffs of plant origin increased and the production of foodstuffs of animal origin decreased. As greenhouse gas emissions related to agriculture decreased, the greenhouse gas intensity (greenhouse gases emitted per unit of foodstuff produced) overall decreased. The decrease in greenhouse emissions related to agriculture about followed the decrease in the production of foodstuffs of animal origin.

Fig. 48 > Evolution of Switzerland's greenhouse gas emissions related to agriculture[10], together with the gross value added and foodstuffs produced (total, of plant origin, and of animal origin), 1990–2014/2015 (relative evolutions with reference year 1990). Also shown are the greenhouse gas emissions related to agriculture per gross value added and per foodstuff produced.



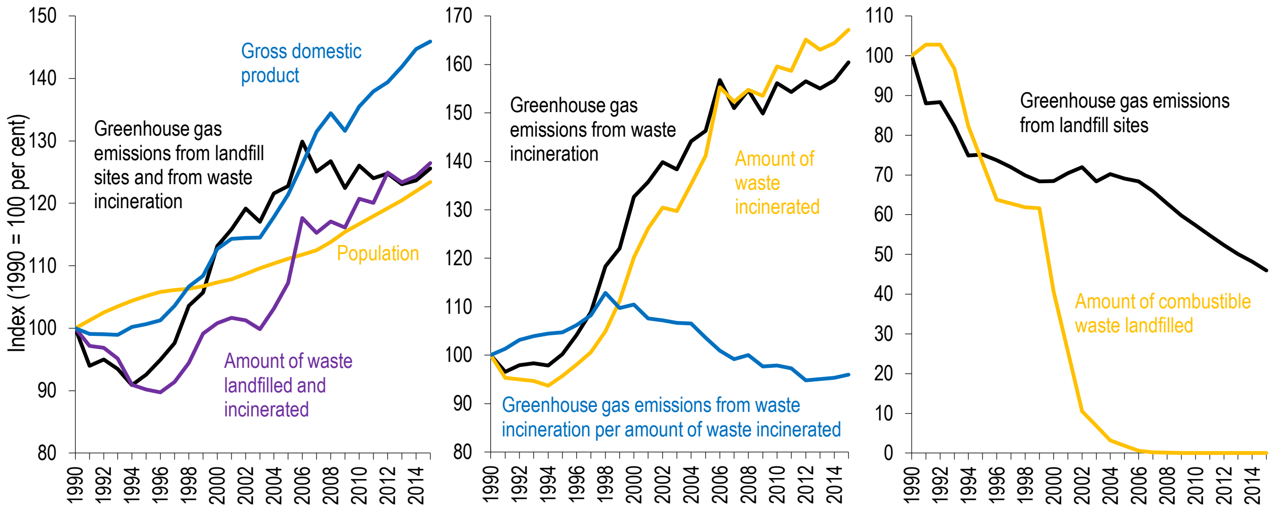
FOEN (2017d)

Greenhouse gas emissions related to waste

Fig. 49 shows the relative evolution of Switzerland's greenhouse gas emissions related to waste[10]. When compared to relevant key parameters, the following important observations emerge:

- In concert with the increase in Switzerland's gross domestic product and population, the amount of incinerated or landfilled waste steadily increased, by 26 per cent from 1990 to 2015. Notably, Switzerland also imports waste to run waste incineration plants at full capacity. A contribution to the increasing trend in the amount of incinerated waste also comes from the ban on landfilling of combustible waste since the year 2000;
- Greenhouse gas emissions related to the incineration of waste closely followed the amount of waste incinerated, despite some variations in the fossil share of incinerated waste (in 2015, the incineration of the same amount of waste led to four per cent lower emissions compared to 1990). Greenhouse gas emissions from landfilled waste steadily decreased, by 54 per cent from 1990 to 2015. However, the greenhouse gas emissions did not closely follow to amount of waste deposited, as the major part of greenhouse gas emissions since the year 2000 resulted from waste landfilled in the years to decades before.

Fig. 49 > Evolution of Switzerland's greenhouse gas emissions related to waste[10] (shown are greenhouse gas emissions from waste incineration and from solid waste disposal sites), together with Switzerland's gross domestic product, population, and the amount of waste incinerated and/or landfilled, 1990–2015 (relative evolutions with reference year 1990). Also shown are the greenhouse gas emissions from waste incineration per amount of waste incinerated.



FOEN (2017d)

2.15 Flexibility in accordance with Article 4, paragraphs 6 and 10, of the Convention

Switzerland does not request any flexibility or consideration in accordance with Article 4, paragraphs 6 and 10, of the Convention.

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Relevant websites

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Swiss Federal Office for the Environment: *http://www.bafu.admin.ch*

MeteoSwiss: *http://www.meteoswiss.ch*

Swiss Federal Office of Energy: *http://www.bfe.admin.ch*

Swiss Federal Statistical Office (SFSO): *http://www.bfs.admin.ch*

3 Greenhouse gas inventory information

3.1 Summary tables

Comprehensive summary tables from Switzerland's most recent greenhouse gas inventory covering the years 1990 to 2015 are provided in Switzerland's third biennial report (BR CTF table 1). To further increase transparency, additional tables which support the descriptive summary in section 3.2 are provided below (Tab. 3 to Tab. 10). All data presented are consistent with the reporting tables (CRF) and the national inventory report submitted in April 2017 (*FOEN*, 2017a), where emissions were calculated using the 2006 IPCC guidelines for national greenhouse gas inventories (*IPCC*, 2006) and the global warming potential values according to the Second Assessment Report of the Intergovernmental Panel on Climate Change (*IPCC*, 1995) based on the effect of greenhouse gases over a 100-year time horizon[11].

Tab. 3 > Switzerland's greenhouse gas emissions by sector and gas, 2015. The total in the second last column includes indirect CO_2.

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	Indirect CO_2	Total	Share
	kt CO_2eq									
1 Energy	36'595	286.5	231.3	0.0	0.0	0.0	0.0	5.1	**37'118**	*77.1%*
2 Industrial processes and product use	2'091	2.1	49.5	1'536	57.2	255.8	0.5	105.8	**4'098**	*8.5%*
3 Agriculture	44.2	4'153	1'877	0.0	0.0	0.0	0.0	0.0	**6'074**	*12.6%*
5 Waste	9.9	643.4	193.1	0.0	0.0	0.0	0.0	1.2	**847.6**	*1.8%*
6 Other	11.3	0.6	0.5	0.0	0.0	0.0	0.0	1.0	**13.5**	*0.0%*
Total (excluding LULUCF)	**38'751**	**5'086**	**2'352**	**1'536**	**57.2**	**255.8**	**0.5**	**113.2**	**48'151**	***100.0%***
4 LULUCF	–980.7	13.3	73.6	0.0	0.0	0.0	0.0	0.0	–893.8	*–1.9%*
Total (including LULUCF)	37'771	5'099	2'425	1'536	57.2	255.8	0.5	113.2	47'258	*98.1%*
International aviation bunkers	4'902	0.6	40.1	0.0	0.0	0.0	0.0	0.0	4'943	*10.3%*
International marine bunkers	24.6	0.0	0.2	0.0	0.0	0.0	0.0	0.0	24.8	*0.1%*

FOEN (2017a)

Tab. 4 > Switzerland's greenhouse gas emissions by gas (excluding LULUCF and international bunkers, including emissions from the sectors 1, 2, 3, 5, and 6), selected years. Also provided are the shares of the different gases in total emissions.

	1990		1995		2000		2005	
	kt CO_2eq	Share	kt CO_2eq	Share	kt CO_2eq	Share	kt CO_2eq	Share
CO_2 (excluding LULUCF)	44'171	*82.2%*	43'423	*82.7%*	43'607	*83.0%*	45'799	*83.3%*
CH_4 (excluding LULUCF)	6'102	*11.3%*	5'782	*11.0%*	5'396	*10.3%*	5'307	*9.7%*
N_2O (excluding LULUCF)	2'829	*5.3%*	2'689	*5.1%*	2'547	*4.8%*	2'438	*4.4%*
HFCs	0.0	*0.0%*	244.9	*0.5%*	622.2	*1.2%*	1'064	*1.9%*
PFCs	116.5	*0.2%*	17.5	*0.0%*	49.9	*0.1%*	44.1	*0.1%*
SF_6	137.0	*0.3%*	93.2	*0.2%*	143.8	*0.3%*	203.2	*0.4%*
NF_3	0.0	*0.0%*	0.0	*0.0%*	0.0	*0.0%*	0.0	*0.0%*
Indirect CO_2	411.9	*0.8%*	274.2	*0.5%*	187.7	*0.4%*	129.6	*0.2%*
Total (excluding LULUCF, including indirect CO_2)	**53'769**	*100.0%*	**52'525**	*100.0%*	**52'553**	*100.0%*	**54'986**	*100.0%*

	2010		2013		2014		2015	
	kt CO_2eq	Share	kt CO_2eq	Share	kt CO_2eq	Share	kt CO_2eq	Share
CO_2 (excluding LULUCF)	45'053	*82.7%*	43'202	*82.1%*	39'269	*80.6%*	38'751	*80.5%*
CH_4 (excluding LULUCF)	5'276	*9.7%*	5'119	*9.7%*	5'121	*10.5%*	5'086	*10.6%*
N_2O (excluding LULUCF)	2'496	*4.6%*	2'385	*4.5%*	2'400	*4.9%*	2'352	*4.9%*
HFCs	1'324	*2.4%*	1'514	*2.9%*	1'527	*3.1%*	1'536	*3.2%*

[11] These global warming potential values are consistently used by Switzerland, i.e. in particular also regarding the definition of the quantified economy-wide emission reduction target (Annex B.3.4) and for the calculation of the projections of greenhouse gas emissions (chapter 5).

PFCs	64.5	*0.1%*	51.9	*0.1%*	44.0	*0.1%*	57.2	*0.1%*
SF_6	148.0	*0.3%*	252.5	*0.5%*	258.8	*0.5%*	255.8	*0.5%*
NF_3	8.5	*0.0%*	0.1	*0.0%*	0.4	*0.0%*	0.5	*0.0%*
Indirect CO_2	123.4	*0.2%*	119.9	*0.2%*	119.6	*0.2%*	113.2	*0.2%*
Total (excluding LULUCF, including indirect CO_2)	**54'493**	*100.0%*	**52'643**	*100.0%*	**48'740**	*100.0%*	**48'151**	*100.0%*

FOEN (2017a)

Tab. 5 > Switzerland's greenhouse gas emissions by gas (excluding international bunkers, including emissions from the sectors 1, 2, 3, 4, 5, and 6), 1990–2015. Also indicated are the relative changes in emissions in 2015 relative to 1990 (last column). In 1990, there were virtually no emissions of HFCs and no emissions of NF_3, therefore the relative increases are not indicated for these gases (for absolute changes see Fig. 53).

	1990	1991	1992	1993	1994	1995	1996	1997	1998
	kt CO_2eq								
CO_2 (excluding net CO_2 from LULUCF)	44'171	46'196	46'025	43'605	42'669	43'423	44'153	43'043	44'608
CO_2 (including net CO_2 from LULUCF)	43'776	42'123	42'206	39'521	40'392	39'647	39'071	39'655	42'531
CH_4 (excluding CH_4 from LULUCF)	6'102	6'036	5'953	5'844	5'791	5'782	5'743	5'601	5'532
CH_4 (including CH_4 from LULUCF)	6'132	6'053	5'969	5'859	5'809	5'802	5'761	5'633	5'549
N_2O (excluding N_2O from LULUCF)	2'829	2'825	2'795	2'730	2'702	2'689	2'685	2'591	2'587
N_2O (including N_2O from LULUCF)	2'916	2'903	2'872	2'808	2'782	2'771	2'765	2'681	2'667
HFCs	0.0	1.6	15.6	32.6	81.1	244.9	296.1	360.0	454.2
PFCs	116.5	98.5	80.6	34.7	20.9	17.5	20.4	21.0	23.8
SF_6	137.0	139.2	141.4	120.5	106.9	93.2	90.1	124.2	152.6
NF_3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect CO_2	411.9	385.7	357.5	324.6	295.6	274.2	253.5	234.7	213.5
Total (excluding LULUCF, including indirect CO_2)	**53'769**	**55'681**	**55'368**	**52'691**	**51'667**	**52'525**	**53'242**	**51'975**	**53'570**
Total (including LULUCF, including indirect CO_2)	**53'490**	**51'704**	**51'643**	**48'700**	**49'488**	**48'849**	**48'257**	**48'709**	**51'591**

	1999	2000	2001	2002	2003	2004	2005	2006	2007
	kt CO_2eq								
CO_2 (excluding net CO_2 from LULUCF)	44'430	43'607	45'070	43'445	44'658	45'238	45'799	45'380	43'388
CO_2 (including net CO_2 from LULUCF)	42'498	48'532	44'448	41'080	42'671	42'478	43'474	45'928	43'123
CH_4 (excluding CH_4 from LULUCF)	5'430	5'396	5'435	5'401	5'323	5'291	5'307	5'321	5'301
CH_4 (including CH_4 from LULUCF)	5'444	5'411	5'450	5'420	5'343	5'305	5'321	5'336	5'317
N_2O (excluding N_2O from LULUCF)	2'552	2'547	2'561	2'537	2'489	2'447	2'438	2'437	2'461
N_2O (including N_2O from LULUCF)	2'629	2'624	2'638	2'618	2'570	2'523	2'516	2'517	2'541
HFCs	527.5	622.2	719.7	798.2	892.8	1'014	1'064	1'111	1'186
PFCs	25.6	49.9	27.8	32.8	61.6	65.2	44.1	51.4	49.0
SF_6	139.9	143.8	144.8	158.4	164.6	186.1	203.2	185.6	171.6
NF_3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect CO_2	198.8	187.7	177.5	163.2	150.1	135.4	129.6	127.9	123.2
Total (excluding LULUCF, including indirect CO_2)	**53'303**	**52'553**	**54'136**	**52'536**	**53'740**	**54'377**	**54'986**	**54'614**	**52'680**
Total (including LULUCF, including indirect CO_2)	**51'463**	**57'571**	**53'606**	**50'270**	**51'853**	**51'707**	**52'752**	**55'257**	**52'511**

	2008	2009	2010	2011	2012	2013	2014	2015	Change 1990 to 2015
	kt CO_2eq								
CO_2 (excluding net CO_2 from LULUCF)	44'708	43'538	45'053	40'993	42'259	43'202	39'269	38'751	*–12.3%*
CO_2 (including net CO_2 from LULUCF)	43'594	41'745	43'713	40'049	40'913	42'040	38'346	37'771	*–13.7%*
CH_4 (excluding CH_4 from LULUCF)	5'379	5'295	5'276	5'217	5'179	5'119	5'121	5'086	*–16.7%*
CH_4 (including CH_4 from LULUCF)	5'392	5'309	5'289	5'232	5'193	5'132	5'134	5'099	*–16.8%*
N_2O (excluding N_2O from LULUCF)	2'484	2'448	2'496	2'440	2'423	2'385	2'400	2'352	*–16.9%*
N_2O (including N_2O from LULUCF)	2'561	2'523	2'570	2'515	2'496	2'460	2'475	2'425	*–16.8%*
HFCs	1'236	1'247	1'324	1'406	1'486	1'514	1'527	1'536	*See caption*
PFCs	57.8	62.9	64.5	67.7	71.3	51.9	44.0	57.2	*–50.9%*
SF_6	222.2	179.6	148.0	159.5	208.9	252.5	258.8	255.8	*86.7%*
NF_3	0.1	5.1	8.5	6.2	0.4	0.1	0.4	0.5	*See caption*
Indirect CO_2	124.0	123.3	123.4	122.6	120.7	119.9	119.6	113.2	*–72.5%*
Total (excluding LULUCF, including indirect CO_2)	**54'211**	**52'899**	**54'493**	**50'412**	**51'748**	**52'643**	**48'740**	**48'151**	***–10.4%***
Total (including LULUCF, including indirect CO_2)	**53'187**	**51'195**	**53'240**	**49'558**	**50'489**	**51'570**	**47'904**	**47'258**	***–11.7%***

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Tab. 6 > Switzerland's greenhouse gas emissions by sector (excluding LULUCF and international bunkers), selected years. Also indicated are the shares of the different sectors and source categories in total greenhouse gas emissions.

	1990		1995		2000		2005	
	kt CO_2eq	Share	kt CO_2eq	Share	kt CO_2eq	Share	kt CO_2eq	Share
1 Energy	41'846	*77.8%*	41'878	*79.7%*	42'171	*80.2%*	44'006	*80.0%*
1A1 Energy industries	2'519	*4.7%*	2'643	*5.0%*	3'172	*6.0%*	3'816	*6.9%*
1A2 Manufacturing industries and construction	6'453	*12.0%*	6'206	*11.8%*	5'928	*11.3%*	6'000	*10.9%*
1A3 Transport	14'660	*27.3%*	14'266	*27.2%*	15'930	*30.3%*	15'860	*28.8%*
1A4 Other sectors	17'632	*32.8%*	18'171	*34.6%*	16'630	*31.6%*	17'879	*32.5%*
1A5 Other (military)	219.8	*0.4%*	163.0	*0.3%*	151.3	*0.3%*	138.9	*0.3%*
1B Fugitive emissions from oil and natural gas	362.1	*0.7%*	429.9	*0.8%*	359.0	*0.7%*	312.8	*0.6%*
2 Industrial processes and product use	3'585	*6.7%*	2'922	*5.6%*	3'139	*6.0%*	3'795	*6.9%*
3 Agriculture	6'780	*12.6%*	6'489	*12.4%*	6'108	*11.6%*	6'078	*11.1%*
5 Waste	1'133	*2.1%*	949.7	*1.8%*	934.3	*1.8%*	963.9	*1.8%*
6 Other	12.2	*0.0%*	12.1	*0.0%*	12.9	*0.0%*	13.5	*0.0%*
Indirect CO_2	411.9	*0.8%*	274.2	*0.5%*	187.7	*0.4%*	129.6	*0.3%*
from 1 Energy	43.7	*0.1%*	27.6	*0.1%*	17.0	*0.0%*	13.2	*0.0%*
from 2 Industrial processes and product use	365.1	*0.7%*	243.9	*0.5%*	167.9	*0.3%*	113.9	*0.2%*
from 5 Waste	2.0	*0.0%*	1.7	*0.0%*	1.6	*0.0%*	1.4	*0.0%*
from 6 Other	1.0	*0.0%*	1.0	*0.0%*	1.1	*0.0%*	1.2	*0.0%*
Total (excluding LULUCF, including indirect CO_2)	**53'769**	*100.0%*	**52'525**	*100.0%*	**52'553**	*100.0%*	**54'986**	*100.0%*

	2010		2013		2014		2015	
	kt CO_2eq	Share	kt CO_2eq	Share	kt CO_2eq	Share	kt CO_2eq	Share
1 Energy	43'218	*79.3%*	41'489	*78.8%*	37'464	*76.9%*	37'113	*77.1%*
1A1 Energy industries	3'847	*7.1%*	3'737	*7.1%*	3'609	*7.4%*	3'279	*6.8%*
1A2 Manufacturing industries and construction	5'832	*10.7%*	5'500	*10.4%*	5'108	*10.5%*	4'989	*10.4%*
1A3 Transport	16'336	*30.0%*	16'184	*30.7%*	16'075	*33.0%*	15'338	*31.9%*
1A4 Other sectors	16'785	*30.8%*	15'697	*29.8%*	12'303	*25.2%*	13'151	*27.3%*
1A5 Other (military)	137.5	*0.3%*	133.6	*0.3%*	138.9	*0.3%*	135.4	*0.3%*
1B Fugitive emissions from oil and natural gas	281.6	*0.5%*	238.6	*0.5%*	230.3	*0.5%*	221.3	*0.5%*
2 Industrial processes and product use	4'022	*7.4%*	4'096	*7.8%*	4'140	*8.5%*	3'992	*8.3%*
3 Agriculture	6'213	*11.4%*	6'060	*11.5%*	6'150	*12.6%*	6'074	*12.6%*
5 Waste	903.8	*1.7%*	864.0	*1.6%*	854.8	*1.8%*	846.5	*1.8%*
6 Other	12.4	*0.0%*	14.4	*0.0%*	11.5	*0.0%*	12.5	*0.0%*
Indirect CO_2	123.4	*0.2%*	119.9	*0.2%*	119.6	*0.2%*	113.2	*0.2%*
from 1 Energy	11.1	*0.0%*	11.0	*0.0%*	10.8	*0.0%*	5.1	*0.0%*
from 2 Industrial processes and product use	110.1	*0.2%*	106.4	*0.2%*	106.6	*0.2%*	105.8	*0.2%*
from 5 Waste	1.3	*0.0%*	1.2	*0.0%*	1.2	*0.0%*	1.2	*0.0%*
from 6 Other	1.0	*0.0%*	1.2	*0.0%*	1.0	*0.0%*	1.0	*0.0%*
Total (excluding LULUCF, including indirect CO_2)	**54'493**	*100.0%*	**52'643**	*100.0%*	**48'740**	*100.0%*	**48'151**	*100.0%*

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Tab. 7 > Greenhouse gas emissions and removals in different sectors and source categories (excluding international bunkers), 1990–2015. Also indicated are the relative changes in emissions in 2015 relative to 1990 (last column).

	1990	1991	1992	1993	1994	1995	1996	1997	1998
	kt CO_2eq								
1 Energy	41’846	44’279	44’269	42’086	40’967	41’878	42’792	41’825	43’383
1A1 Energy industries	2’519	2’802	2’895	2’563	2’605	2’643	2’861	2’861	3’224
1A2 Manufacturing industries and construction	6’453	6’735	6’273	6’101	6’038	6’206	6’004	5’922	6’113
1A3 Transport	14’660	15’150	15’471	14’400	14’584	14’266	14’325	14’879	15’088
1A4 Other sectors	17’632	18’990	19’023	18’409	17’127	18’171	19’021	17’586	18’400
1A5 Other (military)	219.8	202.4	194.1	185.9	180.4	163.0	152.1	162.1	161.1
1B Fugitive emissions from oil and natural gas	362.1	399.6	412.4	427.2	433.1	429.9	429.9	414.5	397.8
2 Industrial processes and product use	3’585	3’212	3’050	2’738	2’933	2’922	2’793	2’706	2’821
3 Agriculture	6’780	6’744	6’629	6’527	6’513	6’489	6’446	6’261	6’218
5 Waste	1’133	1’048	1’051	1’003	946.2	949.7	945.5	936.4	923.4
6 Other	12.2	12.2	12.2	12.2	12.1	12.1	12.1	12.0	11.0
Indirect CO_2	411.9	385.7	357.5	324.6	295.6	274.2	253.5	234.7	213.5
from 1 Energy	43.7	46.0	45.3	40.1	29.5	27.6	27.5	26.3	23.2
from 2 Industrial processes and product use	365.1	336.7	309.1	281.7	263.3	243.9	223.3	205.8	187.7
from 5 Waste	2.0	2.0	1.9	1.9	1.7	1.7	1.6	1.6	1.6
from 6 Other	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.9
Total (excluding LULUCF, including indirect CO_2)	**53’769**	**55’681**	**55’368**	**52’691**	**51’667**	**52’525**	**53’242**	**51’975**	**53’570**
4 LULUCF	–278.7	–3’978	–3’725	–3’990	–2’179	–3’676	–4’984	–3’266	–1’980
Total (including LULUCF, including indirect CO_2)	53’490	51’704	51’643	48’700	49’488	48’849	48’257	48’709	51’591

	1999	2000	2001	2002	2003	2004	2005	2006	2007
	kt CO_2eq								
1 Energy	43’171	42’171	43’586	41’978	43’200	43’561	44’006	43’612	41’578
1A1 Energy industries	3’249	3’172	3’314	3’390	3’387	3’682	3’816	4’032	3’719
1A2 Manufacturing industries and construction	5’972	5’928	6’183	5’730	5’849	5’989	6’000	6’169	5’981
1A3 Transport	15’696	15’930	15’631	15’555	15’722	15’800	15’860	15’975	16’299
1A4 Other sectors	17’728	16’630	17’964	16’816	17’785	17’650	17’879	17’002	15’163
1A5 Other (military)	146.9	151.3	148.6	154.7	140.3	129.0	138.9	142.9	135.8
1B Fugitive emissions from oil and natural gas	380.1	359.0	346.2	332.0	316.2	310.2	312.8	291.2	279.7
2 Industrial processes and product use	2’884	3’139	3’239	3’273	3’364	3’658	3’795	3’785	3’848
3 Agriculture	6’124	6’108	6’170	6’136	6’059	6’036	6’078	6’112	6’168
5 Waste	912.1	934.3	949.5	973.1	952.8	972.0	963.9	964.6	949.2
6 Other	12.3	12.9	13.8	12.9	14.0	13.9	13.5	12.5	13.8
Indirect CO_2	198.8	187.7	177.5	163.2	150.1	135.4	129.6	127.9	123.2
from 1 Energy	17.7	17.0	17.3	15.1	14.4	14.0	13.2	13.5	12.4
from 2 Industrial processes and product use	178.5	167.9	157.5	145.5	133.1	118.7	113.9	111.9	108.2
from 5 Waste	1.6	1.6	1.6	1.5	1.5	1.4	1.4	1.4	1.4
from 6 Other	1.1	1.1	1.2	1.1	1.2	1.2	1.2	1.1	1.2
Total (excluding LULUCF, including indirect CO_2)	**53’303**	**52’553**	**54’136**	**52’536**	**53’740**	**54’377**	**54’986**	**54’614**	**52’680**
4 LULUCF	–1’839	5’017.7	–530	–2’266.1	–1’886	–2’670	–2’234	643.2	–169
Total (including LULUCF, including indirect CO_2)	51’463	57’571	53’606	50’270	51’853	51’707	52’752	55’257	52’511

	2008	2009	2010	2011	2012	2013	2014	2015	Change 1990 to 2015
	kt CO_2eq								
1 Energy	42’943	41’844	43’218	39’162	40’552	41’489	37’464	37’113	–11.3%
1A1 Energy industries	3’837	3’674	3’847	3’598	3’641	3’737	3’609	3’279	30.1%
1A2 Manufacturing industries and construction	6’025	5’717	5’832	5’389	5’397	5’500	5’108	4’989	–22.7%
1A3 Transport	16’650	16’446	16’336	16’155	16’273	16’184	16’075	15’338	4.6%
1A4 Other sectors	16’025	15’607	16’785	13’610	14’850	15’697	12’303	13’151	–25.4%
1A5 Other (military)	130.7	132.7	137.5	124.8	132.6	133.6	138.9	135.4	–38.4%
1B Fugitive emissions from oil and natural gas	275.5	268.6	281.6	285.5	260.1	238.6	230.3	221.3	–38.9%
2 Industrial processes and product use	3’924	3’811	4’022	4’064	4’066	4’096	4’140	3’992	11.3%
3 Agriculture	6’273	6’194	6’213	6’159	6’126	6’060	6’150	6’074	–10.4%
5 Waste	933.0	914.7	903.8	890.3	868.5	864.0	854.8	846.5	–25.3%
6 Other	13.0	12.6	12.4	13.4	14.0	14.4	11.5	12.5	2.0%
Indirect CO_2	124.0	123.3	123.4	122.6	120.7	119.9	119.6	113.2	–72.5%
from 1 Energy	12.5	12.0	11.1	10.8	9.6	11.0	10.8	5.1	–88.2%
from 2 Industrial processes and product use	108.9	109.0	110.1	109.4	108.7	106.4	106.6	105.8	–71.0%
from 5 Waste	1.4	1.3	1.3	1.2	1.2	1.2	1.2	1.2	–41.2%
from 6 Other	1.1	1.1	1.0	1.1	1.2	1.2	1.0	1.0	0.0%
Total (excluding LULUCF, including indirect CO_2)	**54’211**	**52’899**	**54’493**	**50’412**	**51’748**	**52’643**	**48’740**	**48’151**	–10.4%
4 LULUCF	–1’024	–1’705	–1’253	–854	–1’260	–1’073	–835.7	–893.8	220.7%
Total (including LULUCF, including indirect CO_2)	53’187	51’195	53’240	49’558	50’489	51’570	47’904	47’258	–11.7%

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Tab. 8 > Emissions of precursor gases and SO_2 (excluding emissions from LULUCF), 1990–2015.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
	kt												
NO_x	143.4	141.0	134.4	123.0	121.6	117.9	113.9	110.0	109.5	109.2	106.8	103.5	97.1
CO	797.8	763.4	710.9	625.5	574.6	533.0	514.2	485.0	464.9	452.0	425.6	404.9	377.3
NMVOC	298.0	280.4	260.4	233.3	213.1	197.0	184.5	172.8	159.8	150.9	142.2	134.1	123.7
SO_2	39.7	36.4	33.0	26.5	27.3	25.9	25.4	23.4	22.2	16.7	15.3	18.0	15.5

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	kt												
NO_x	95.2	93.5	92.9	89.7	86.6	84.7	79.1	77.1	72.3	72.2	71.5	67.3	63.2
CO	365.9	347.5	330.9	306.4	287.3	276.3	259.6	248.8	227.5	220.2	212.5	194.5	185.2
NMVOC	115.3	106.2	101.9	97.9	93.9	92.4	89.7	88.0	85.2	83.5	82.0	79.9	77.3
SO_2	15.0	14.9	15.1	13.7	11.6	11.8	9.9	10.4	8.6	8.8	8.6	7.8	6.6

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Tab. 9 > Emissions of precursor gases and SO_2 by sector, 2015. The total includes emissions from LULUCF.

	NO_x	CO	NMVOC	SO_2
	kt			
1 Energy	59.23	176.98	22.20	5.89
2 Industrial processes and product use	0.30	5.55	48.71	0.65
3 Agriculture	3.15	NO	3.90	NO
4 LULUCF	0.02	0.68	95.52	NE
5 Waste	0.38	2.00	2.42	0.10
6 Other	0.08	0.68	0.11	0.01
Total	**63.17**	**185.89**	**172.86**	**6.64**

NE, not estimated; NO, not occurring
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Tab. 10 > Net emissions (positive) and removals (negative) for activities under Article 3, paragraphs 3 and 4, of the Kyoto Protocol, 1990–2015. As also noted in BR CTF table 4(a)II, the values for deforestation under Article 3.3 correspond to the values provided in e.g. Table E-7 of Switzerland's National Inventory Report submitted on 13 April 2017. These values do not completely agree with the respective values of the reporting tables (CRF) submitted at the same time (in the reporting tables, 'lossN2O (from LUC)' is erroneously missing, see also Table 11-1 on page 484 of Switzerland's National Inventory Report submitted on 13 April 2017).

Greenhouse gas source and sink activities	1990	1991	1992	1993	1994	1995	1996	1997	1998
	Net emissions/removals (kt CO_2eq)								
A Article 3.3 activities	**90.3**	**90.2**	**89.7**	**91.3**	**101.7**	**107.9**	**109.2**	**111.9**	**122.2**
Afforestation/reforestation	–2.5	–4.9	–7.2	–9.3	–11.1	–12.2	–13.2	–14.0	–14.6
Deforestation	92.8	95.0	96.9	100.7	112.8	120.1	122.4	125.8	136.8
B Article 3.4 activities	**–1'554**	**–4'677**	**–4'217**	**–4'554**	**–3'325**	**–4'153**	**–5'557**	**–3'836**	**–3'005**
Forest management	–324	–3'735	–3'442	–3'924	–2'848	–3'592	–5'160	–3'522	–2'581
Harvested wood products	–1'231	–941.7	–774.3	–630.5	–477.3	–560.9	–396.1	–313.8	–423.5

Greenhouse gas source and sink activities	1999	2000	2001	2002	2003	2004	2005	2006	2007
	Net emissions/removals (kt CO_2eq)								
A Article 3.3 activities	**123.2**	**124.0**	**123.9**	**124.4**	**125.3**	**126.0**	**118.7**	**114.7**	**96.9**
Afforestation	–15.2	–15.8	–16.4	–17.0	–17.7	–18.3	–19.1	–19.9	–20.7
Deforestation	138.4	139.8	140.3	141.5	142.9	144.2	137.8	134.6	117.5
B Article 3.4 activities	**–3'129**	**4'526**	**–1'770**	**–3'160**	**–3'039**	**–2'946**	**–3'114**	**–715**	**–561**
Forest management	–2'650	5'361	–1'193	–2'717	–2'599	–2'309	–2'351	–89.6	170.0
Harvested wood products	–479.0	–834.5	–577.0	–442.5	–440.7	–636.7	–763.1	–625.8	–730.7

Greenhouse gas source and sink activities	2008	2009	2010	2011	2012	2013	2014	2015
	Net emissions/removals (kt CO_2eq)							
A Article 3.3 activities	**73.3**	**117.9**	**130.8**	**133.0**	**134.0**	**133.0**	**133.2**	**135.7**
Afforestation	–21.4	–22.0	–20.6	–18.8	–18.4	–17.4	–15.3	–16.7
Deforestation	94.7	139.8	151.4	151.8	152.3	150.4	148.5	152.4
B Article 3.4 activities	**–1'693**	**–2'539**	**–2'515**	**–1'184**	**–2'521**	**–2'484**	**–1'078**	**–2'536**
Forest management	–1'165	–2'169	–2'103	–926.6	–2'353	–2'323	–972	–2'467
Harvested wood products	–528.2	–370.4	–411.3	–257.7	–167.7	–160.9	–106.0	–69.5

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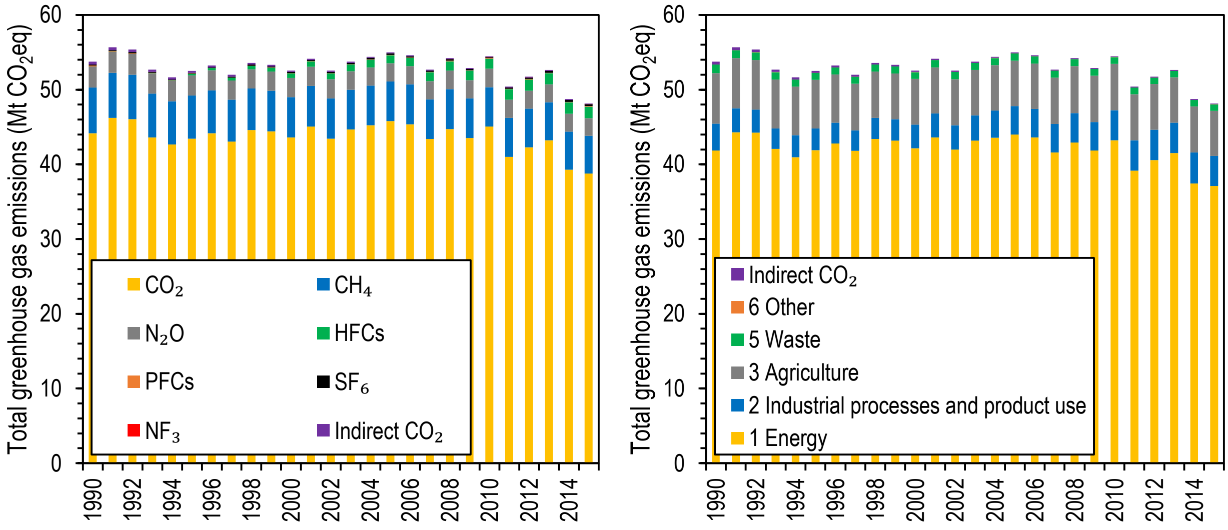
3.2 Descriptive summary

3.2.1 Aggregate greenhouse gas emissions

Switzerland's total greenhouse gas emissions (excluding LULUCF and international bunkers, including indirect CO_2) were 48.151 million tonnes of CO_2 equivalents in 2015 (Tab. 3), corresponding to 5.8 tonnes of CO_2 equivalents per capita. Between 1990 and 2015, total greenhouse gas emissions (excluding LULUCF) were mostly modulated by year-to-year changes in meteorological conditions which drive the amount of fuel needed for heating purposes (Fig. 50). This resulted in minimum emissions of 89.6 per cent in 2015 and maximum emissions of 103.6 per cent in 1991, relative to 1990. However, for the last years, a slightly decreasing trend superimposed the variations from meteorological conditions. Overall, total greenhouse gas emissions evolved largely in parallel with the emissions of CO_2 between 1990 and 2015, since CO_2 persistently constituted the major contributor and since the decrease of CH_4 and N_2O emissions was about offset by the increase of emissions of F-gases (section 3.2.2, Tab. 4, Fig. 52 and Fig. 53) in terms of CO_2 equivalents.

Fig. 50 > Switzerland's total greenhouse gas emissions (excluding LULUCF and international bunkers, including emissions from the sectors 1, 2, 3, 5, and 6, including indirect CO_2), 1990–2015. Left: Subdivided by gas. Right: Subdivided by sector.



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3.2.2 Emission trends by greenhouse gas

The relative contributions of the different gases (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3, and indirect CO_2) to total greenhouse gas emissions in the year 2015 are shown in Fig. 51.

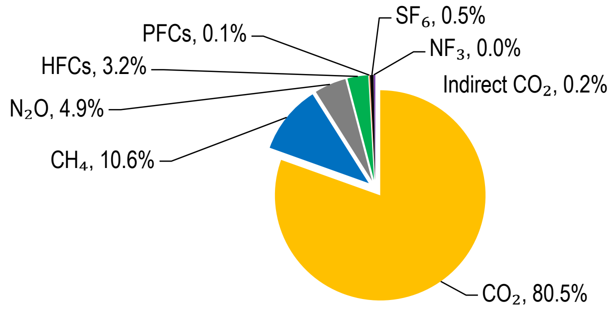
Broken down by gas, the trends in greenhouse gas emissions in Switzerland, from 1990 to 2015, were as follows (Tab. 4, Tab. 5, Fig. 52 and Fig. 53):

- CO_2 was the dominant contributor gas over the full time period (Fig. 50). In 2015, emissions of CO_2 (not including indirect CO_2) amounted to 38.751 million tonnes (4.7 tonnes per capita), corresponding to a share of 80.5 per cent in total greenhouse gas emissions (Fig. 51). CO_2 emissions primarily stem from fuel combustion activities, followed by emissions from industrial processes (mainly cement production);
- CH_4 accounted for a share of 10.6 per cent in total greenhouse gas emissions in 2015 (Fig. 51). Between 1990 and 2015, CH_4 emissions decreased by 16.7 per cent. This decrease is mainly attributable to reduced emissions from agriculture, where a reduction of livestock entailed less emissions from enteric fermentation. However, reduced CH_4 emissions from the energy and waste sectors also contribute to the observed decreasing trend in total CH_4 emissions. Particularly noteworthy is a change in waste legislation banning inputs into solid waste disposal sites as of the year 2000 (section 4.8.2), leading to further decreasing CH_4 emissions from waste disposal sites;
- N_2O accounted for a share of 4.9 per cent in total greenhouse gas emissions in 2015 (Fig. 51). Between 1990 and 2015, total N_2O emissions decreased by 16.9 per cent as N_2O emissions from manure management and agricul-

tural soils declined in concert with CH_4 emissions due to decreasing livestock populations and decreasing use of fertiliser;

- Emissions of CH_4 and N_2O originated mainly from sector 3 ‘Agriculture’;
- All emissions of F-gases are attributed by definition to sector 2 ‘Industrial processes and product use’;
- F-gases increased their share in total greenhouse gas emissions from 0.5 per cent in 1990 to 3.8 per cent in 2015 (Fig. 51, Tab. 4). HFC emissions have substantially increased compared to 1990, because HFCs were introduced as substitutes for CFCs. In contrast, PFC emissions were 50.9 per cent lower in 2015 compared to 1990. In 2015, SF_6 emissions were 86.7 per cent higher compared to 1990, with relatively large year-to-year fluctuations. Emissions of NF_3 were of minor importance over the full time period;
- Net CO_2 emissions/removals from LULUCF also showed considerable year-to-year variability, as heavy storms in 1990 and 1999 (‘Lothar’) and other factors had a large influence on the wood harvesting and tree mortality rates in forests. From 1990 to 2015, wood harvesting generally increased but was still exceeded by the growth of the living biomass pool. Overall, a reduction in net removals within the land use, land-use change and forestry sector is observed between 1990 and 2015 (Fig. 56);
- Indirect CO_2 emissions resulting from the atmospheric oxidation of NMVOC and CO emissions show a decreasing trend, which is mainly due to the implementation of post-combustion facilities and reductions of emissions from solvent use. However, indirect CO_2 emissions are of minor importance over the full time period from 1990 to 2015 (see section 3.2.4 for details about the evolution of emissions of precursor gases and the calculation of the related indirect CO_2 emissions).

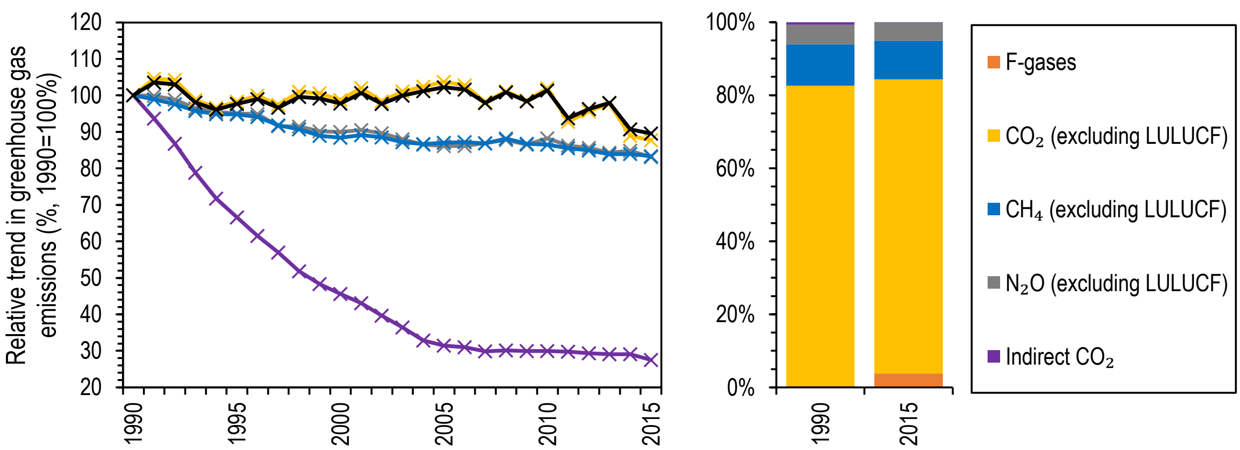
Fig. 51 > Contribution of individual gases to Switzerland’s total greenhouse gas emissions (excluding LULUCF and international bunkers, including emissions from the sectors 1, 2, 3, 5, and 6, including indirect CO_2), 2015.



Total emissions 2015 (including indirect CO_2): 48'151 kt CO_2eq (=100%)

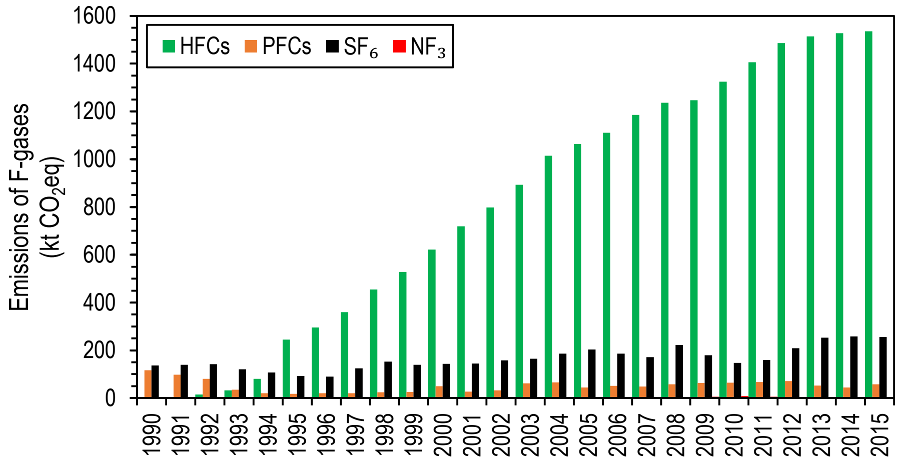
FOEN (2017a)

Fig. 52 > Left: Relative trends in emissions of the greenhouse gases CO_2, CH_4, N_2O, and indirect CO_2 (excluding LULUCF and international bunkers, including emissions from the sectors 1, 2, 3, 5, and 6), 1990–2015. The increase of emissions of F-gases, which amounts to more than a factor of seven in 2015 relative to 1990, is shown in Fig. 53. However, F-gases are included in the total. Right: Relative contributions of CO_2, CH_4, N_2O, F-gases, and indirect CO_2 to the total emissions in the years 1990 and 2015 (see also Fig. 51).



FOEN (2017a)

Fig. 53 > Absolute changes in emissions of HFCs, PFCs, SF_6, and NF_3 in Switzerland, 1990–2015. NF_3 emissions are hardly visible (due to values close to zero, see Tab. 5).



FOEN (2017a)

3.2.3 Emission trends by sources and sinks

In the following, details about Switzerland's greenhouse gas emissions (and removals) by the different sectors are provided (Fig. 50 to Fig. 56, Tab. 6 and Tab. 7).

Sector 1 'Energy'

Sector 1 'Energy' represents the major source of greenhouse gases in Switzerland (77.1 per cent of total emissions in 2015); thus, the respective tables and figures also distinguish source categories (1A1 to 1A5 and 1B). The following characteristics are noteworthy:

- Despite differing trends in the source categories, the overall emissions from sector 1 'Energy' remained at a relatively constant level since 1990 (Fig. 55), with some fluctuations mainly caused by year-to-year variations in meteorological conditions;
- In 2015, more than 93 per cent of Switzerland's electric power was generated by hydroelectric and nuclear power plants (Table 24 in *SFOE*, 2017a). Therefore, source category 1A1 'Energy industries' plays a minor role (8.8 per cent of total emissions from sector 1 'Energy' in 2015) and represents waste incineration plants rather than classical thermal power stations. While overall emissions from source category 1A1 'Energy industries' have increased by 30.1 per cent since 1990, fluctuations are caused by varying combustion activities in the petroleum refinery industry, waste incineration and new installations for district heating;
- Emissions from source category 1A2 'Manufacturing industries and construction' contributed 13.4 per cent to total emissions from sector 1 'Energy' in 2015. Emissions from this source category generally show a decreasing trend and were 22.7 per cent lower in 2015 compared to 1990. The decreasing emissions mainly result from a switch in fuel consumption from other bituminous coal and residual fuel oil (i.e. fuels with relatively high emission factors) to other fossil fuels, natural gas, lignite and biomass (i.e. fuels with relatively low emission factors). For instance, the consumption of other bituminous coal in source category 1A2 'Manufacturing industries and construction' decreased by about 86 per cent since 1990, while the consumption of natural gas more than doubled. At the same time, the production in some industry branches substantially decreased (e.g. iron and aluminium production, cellulose and paper production), while it increased or remained about constant in other industry branches (e.g. steel production, food industry, fibreboard production);
- Emissions from source category 1A3 'Transport' (41.3 per cent of total emissions from sector 1 'Energy' in 2015) increased by 4.6 per cent from 1990 to 2015. Fluctuations indicate a fairly strong correlation between emissions and the economic development, as well as a dependency on the exchange rate between the Euro and the Swiss franc leading to more or less 'fuel tourism' (see also section 2.6 for further discussions);
- Emissions from source category 1A4 'Other sectors' (35.4 per cent of total emission from sector 1 'Energy' in 2015) result from the use of fossil fuels by residential and commercial buildings. Year-to-year variations reflect

the impact of meteorological conditions on heating demand. Indeed, emissions show a strong correlation with the number of heating degree days, an index for cold weather conditions. Throughout the record, emissions generally increased when heating degree days increased and vice versa. From 1990 to 2015, the number of buildings and apartments increased, as well as the average floor space per person and workplace, resulting in a substantial increase of the total area heated. However, over the same period various policies and measures led to higher standards for insulation and to more efficient combustion equipment for both new and renovated buildings, which more than compensate for the emissions from the additional area heated (see section 2.10). Overall, emissions from source category 1A4 'Other sectors' decreased and were 25.4 per cent lower in 2015 compared to 1990;

- Source category 1A5 'Other' covers greenhouse gas emissions from non-road military vehicles including military aviation (0.4 per cent of total emissions from sector 1 'Energy' in 2015). Emissions decreased steadily during the 1990s, due to decreased use of military vehicles and aircrafts. Since 2004 they stabilised at about 60 per cent of the emissions in 1990;
- Emissions from category 1B 'Fugitive emissions from oil and natural gas' (0.6 per cent of total emissions from sector 1 'Energy') are dominated by emissions from transmission and distribution of natural gas. While the natural gas net as well as the amount of gas consumed increased substantially since 1990, emissions from category 1B 'Fugitive emissions from oil and natural gas' decreased thanks to the gradual replacement of cast-iron pipes with polyethylene pipes. In 2015, emissions were 38.9 per cent lower compared to 1990.

Sector 2 'Industrial processes and product use'

Overall, emissions from sector 2 'Industrial processes and product use' showed a decreasing trend in the 1990s and a rebound between 1998 and 2015 (Fig. 54). While – mainly driven by economic development in the respective sectors – CO_2 and N_2O emissions decreased from 1990 to about 1998, remaining about constant thereafter, increasing emissions of F-gases (mainly HFCs) led to a subsequent increase of total greenhouse gas emissions from sector 2 'Industrial processes and product use' to current emissions of roughly 11 per cent higher compared to 1990. The sector's share in total greenhouse gas emissions was 8.3 per cent in 2015 (Tab. 6).

Sector 3 'Agriculture'

Sector 3 'Agriculture' is characterised by CH_4 emissions from enteric fermentation and manure management, as well as by N_2O emissions from agricultural soils and manure management. Overall, CO_2 equivalent emissions decreased by about 10 per cent from 1990 to 2004 and remained about constant thereafter (Fig. 54). The main drivers of this trend are declining livestock (cattle and swine) and reduced fertiliser use. Sector 3 'Agriculture' contributed 12.6 per cent to total greenhouse gas emissions in 2015 (Tab. 6).

Sector 4 'Land use, land-use change and forestry' (LULUCF)

Fig. 56 shows net emissions and removals from sector 4 'Land use, land-use change and forestry' (LULUCF) in Switzerland, which are dominated by biomass dynamics in forests. Throughout the period 1990–2015, except for 2000 and 2006, the removals in the land use, land-use change and forestry sector were higher than the emissions. However, a strong year-to-year variation is evident. The reason for the positive value in 2000 is the winter storm 'Lothar' at the end of 1999 which caused great damages in the forest stands and led to increased harvesting. In 2015, the land use, land-use change and forestry sector was a net CO_2 sink of 1.9 per cent of total greenhouse gas emissions (Tab. 3). For the target under the Kyoto Protocol, Switzerland accounts for afforestation and deforestation under Article 3.3 as well as for forest management under Article 3.4 (see Annex B.3.5). The respective net emissions and removals are provided in Tab. 10.

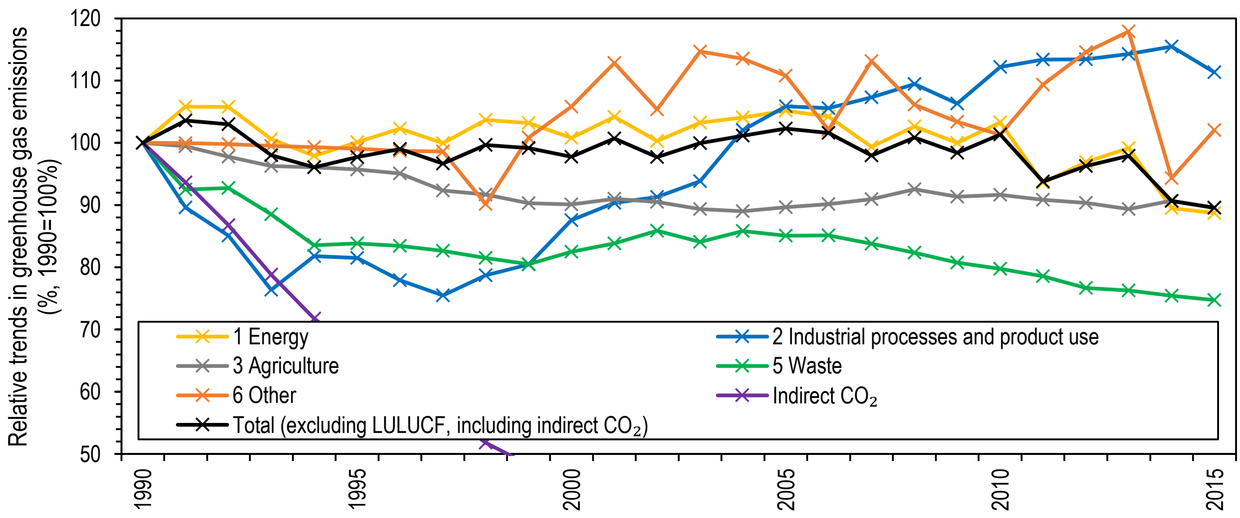
Sector 5 'Waste'

Sector 5 'Waste' contributed 1.8 per cent to total greenhouse gas emissions in 2015 (Tab. 3). Overall, emissions decreased by 25.3 per cent since 1990 (Fig. 54), however, the different source categories within the sector showed a divergent evolution. Emissions from solid waste disposal sites decreased by more than 50 per cent since 1990, as Switzerland continuously increased the share of municipal solid waste incinerated in waste incineration plants. Moreover, since the year 2000, further emission reductions have been induced by a change in legislation completely banning the disposal of combustible municipal solid wastes on solid waste disposal sites. In contrast, emissions from biological treatment of solid waste increased by more than a factor of three since 1990, as the amount of composted organic waste and the number of biogas facilities increased. Emissions from wastewater treatment and discharge steadily increased since 1990, closely related to the increase in population. Finally, emissions from incineration and open burning of waste reported in sector 5 'Waste' show a decreasing trend since 1990. However, the vast majority of emissions from incineration of waste are not reported in sector 5 'Waste', but in sector 1 'Energy'. Taken together, waste-related emissions (including emissions from waste management activities reported in sector 5 'Waste', as well as in the source categories 1A 'Energy industries' and 3D 'Agricultural soils') increased by 26.9 per cent since 1990 (data not shown in Fig. 54; see also Fig. 7-3 and 7-4 in Switzerland's national inventory report; *FOEN*, 2017a).

Sector 6 'Other'

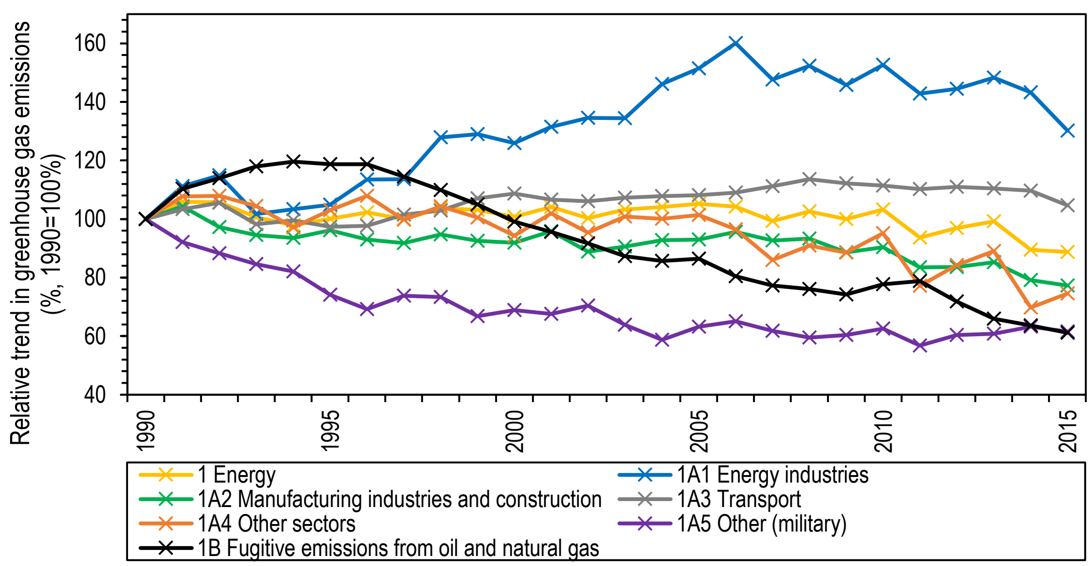
Sector 6 'Other' covers emissions from fire damage in buildings and motor vehicles. The contribution to total greenhouse gas emissions in 2015 was 0.03 per cent (Tab. 3); the sector is, thus, of minor importance. These emissions, as well as the indirect CO_2 emissions from sector 6, are not accounted for in the framework of Switzerland's emission reduction commitment (Annex B.3.3). However, in agreement with the BR CTF tables, total emissions shown in the tables of this chapter include emissions from sector 6.

Fig. 54 > Relative trends in greenhouse gas emissions in the main sectors, 1990–2015. For the relative trend of indirect CO_2 emissions (partly invisible in this figure) see also Fig. 52.



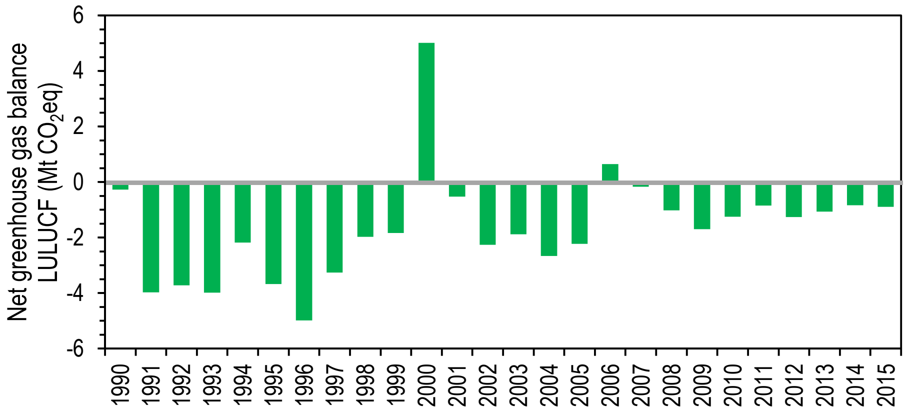
FOEN (2017a)

Fig. 55 > Relative emission trends in sector 1 'Energy' and its source categories (excluding indirect CO_2), 1990–2015.



FOEN (2017a)

Fig. 56 > Net greenhouse gas balance of sector 4 'Land use, land-use change and forestry' (LULUCF), 1990–2015. Positive values refer to emissions, negative values to removals. The contributions of CH_4 and N_2O are very small compared to CO_2.



FOEN (2017a)

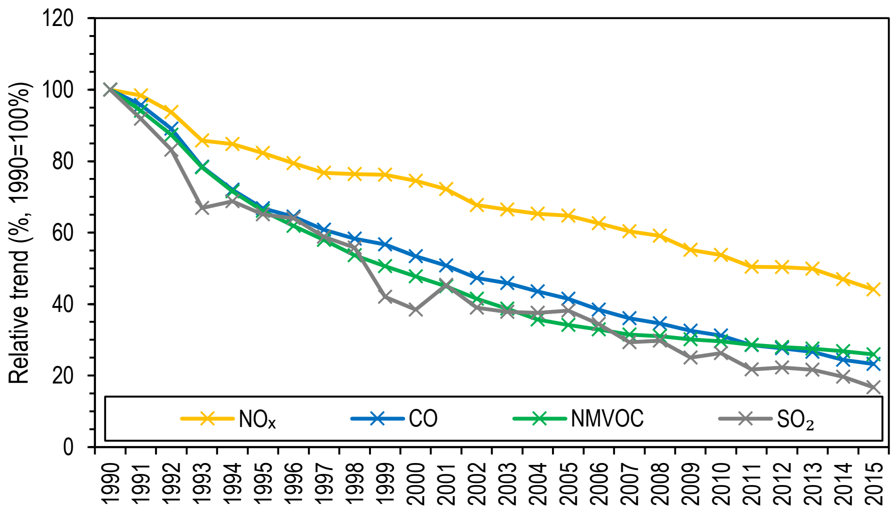
3.2.4 Emission trends of precursor gases and SO_2

Emission trends of precursor gases showed a very pronounced decline since 1990 (Tab. 8 and Fig. 57). By 2015, emissions of the air pollutants NO_x, CO, NMVOC, and SO_2 were between 17 and 44 per cent of the emissions in 1990, owing to a strict air pollution control policy implementing emission reduction measures. 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 (*FOEN*, 2010; *Swiss Confederation*, 1985; *Swiss Confederation*, 1997).

In 2015, sector 1 'Energy' was by far the largest source of precursor gases (Tab. 9), with the only exception being NMVOC, where sector 2 'Industrial processes and product use' and sector 4 'Land use, land-use change and forestry' (LULUCF) substantially contributed to total emissions (the total shown in Tab. 9 includes emissions from LULUCF). Fig. 58 shows the relative contributions of the various sectors for each individual gas in 2015 (data from Tab. 9, excluding emissions from LULUCF, which account for 55.3 per cent of total NMVOC emissions).

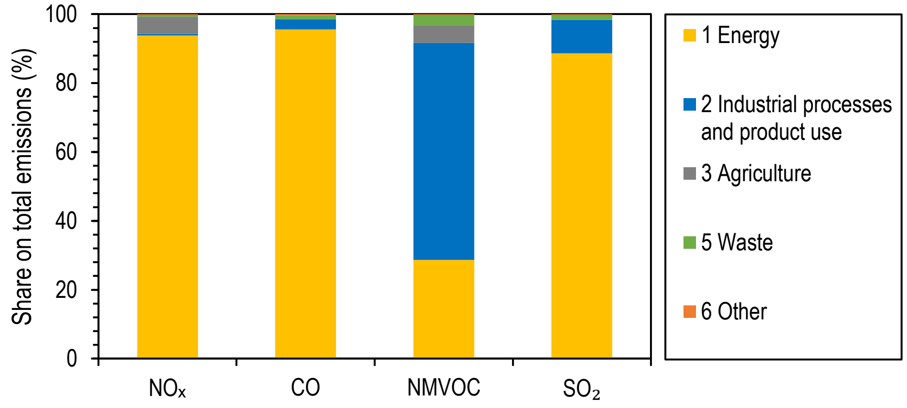
The atmospheric oxidation of the precursor gases lead to indirect emissions of CO_2 and N_2O, but only indirect CO_2 emissions are included in Switzerland's national total. Importantly, only fossil emissions and only emissions not already included under the direct CO_2 emissions in other sectors (e.g. when an oxidation factor of 100 per cent is applied) are considered. Details about the calculation of indirect CO_2 emissions, as presented in Tab. 7, are discussed in chapter 9 of Switzerland's national inventory report (*FOEN*, 2017a).

Fig. 57 > Relative trends of emissions of precursor gases and SO_2 (excluding NMVOC from LULUCF), 1990–2015.



FOEN (2017a)

Fig. 58 > Relative contributions of individual sectors to emissions of precursor gases and SO_2 (excluding LULUCF), 2015.

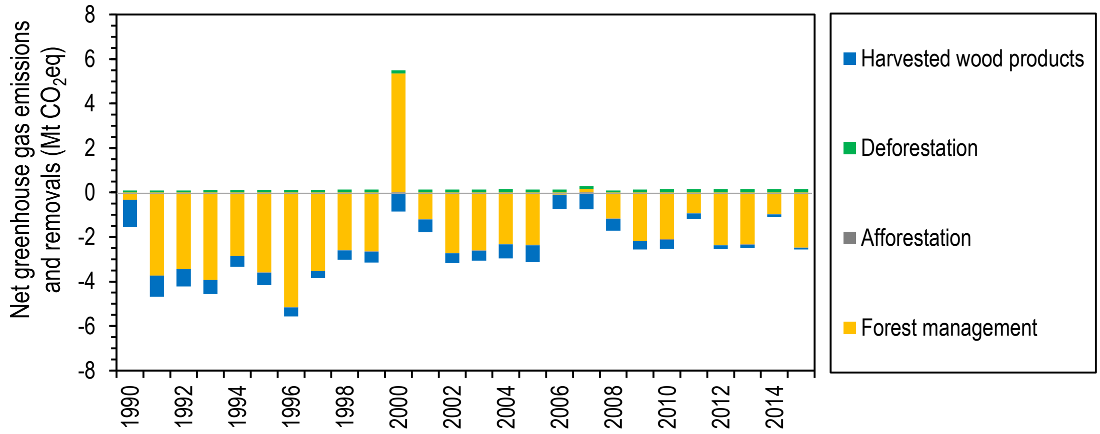


FOEN (2017a)

3.2.5 Activities under Article 3, paragraphs 3 and 4 of the Kyoto Protocol (KP-LULUCF)

Switzerland only accounts for the mandatory activity forest management under the Article 3, paragraph 4, of the Kyoto Protocol (*FOEN*, 2016c; *FOEN*, 2016d). In accordance with Annex I to Decision 2/CMP.7 (Annex I, paragraph 13), credits from forest management are capped in the second commitment period; for Switzerland the cap amounts to 3.5 per cent of total greenhouse gas emissions (excluding LULUCF) in 1990. An overview of greenhouse gas sources and sink activities for the years 1990 to 2015 is given in Fig. 59 and Tab. 10.

Fig. 59 > Net emissions and removals of greenhouse gases for activities under Article 3, paragraph 3 (afforestation, reforestation, deforestation) and paragraph 4 (forest management, harvested wood products) of the Kyoto Protocol, 1990–2015. Positive values refer to emissions, negative values refer to removals.



FOEN (2017a)

3.3 National inventory arrangements

In the following, Switzerland's national greenhouse gas inventory system is presented in brief. An in-depth description is provided in Switzerland's national inventory report (*FOEN*, 2017a, chapter 1).

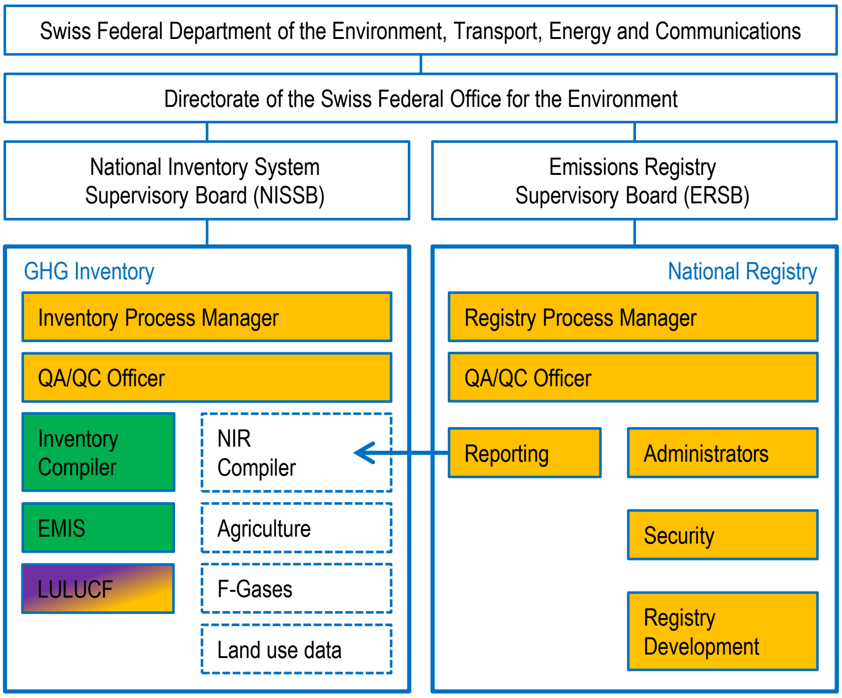
3.3.1 Name and contact information of national entity with overall responsibility

Swiss Federal Office for the Environment
National Greenhouse Gas Inventory System, Dr. Regine Röthlisberger
Climate Division, Section Climate Reporting and Adaptation
CH–3003 Bern, Switzerland
Phone: +41 (0)58 462 92 59
Email: climate@bafu.admin.ch
Web: *www.climatereporting.ch*

3.3.2 Roles and responsibilities: Institutional, legal and procedural arrangements

As shown in Fig. 60, Switzerland's national inventory system is developed and managed under the auspices of the Swiss Federal Department of the Environment, Transport, Energy and Communications. As stipulated in the second CO_2 Act of 23 December 2011 (Article 39), the Swiss Federal Office for the Environment, an office of the Swiss Federal Department of the Environment, Transport, Energy and Communications, is responsible for the assessment of matters relating to climate protection. Accordingly, the Swiss Federal Office for the Environment coordinates the national inventory system.

Fig. 60 > Institutional setting of Switzerland's national inventory system (NIS). The coloured boxes correspond to divisions of the Swiss Federal Office for the Environment (orange: Climate Division; green: Air Pollution Control and Chemicals Division; purple: Forest Division). The white boxes correspond to mandated experts outside the Swiss Federal Office for the Environment (marked with dashed lines) or to executive committees.



Swiss Federal Office for the Environment

In 2004, as part of the Swiss climate reporting project, the directorate of the Swiss Federal Office for the Environment mandated its Climate, Economics and Environmental Monitoring Division to design and establish the national inventory system in order to ensure full compliance with the reporting requirements of the UNFCCC and the Kyoto Protocol by 2006. With the formal approval of Switzerland's first initial report under Article 7, paragraph 4, of the Kyoto Protocol (*FOEN*, 2006) by the Swiss Federal Council on 8 November 2006, the national inventory system became operative. By providing for structures and in defining tasks and responsibilities of institutions, organisations and consultants involved, the national inventory system itself is a key tool in ensuring and improving the quality as well as the process management of the national greenhouse gas inventory preparation. With the overall responsibility carried by the Climate Division of the Swiss Federal Office for the Environment, the national inventory system covers 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 (IDP);
- Setting-up and maintaining the QA/QC system;
- Official consideration and approval of data;
- Upgrading and updating of the national air pollution database EMIS;

- Data documentation and storage;
- Management of the national registry.

Two supervisory boards are currently in place with separate mandates and responsibilities. The **national inventory system supervisory board (NISSB)** oversees all aspects related to the national greenhouse gas inventory and the reporting obligations under the UNFCCC (including reporting of the national registry in the national inventory report). It is independent of the inventory preparation process and, by its composition, combines technical expertise and political authority. The **emission registry supervisory board (ERSB)** on the other hand deals with management issues related to the national registry. The main tasks of the two supervisory boards are:

- Official consideration of the annual inventory submission and recommendation of the inventory for official approval by the directorate of the Swiss Federal Office for the Environment;
- 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 or registry project managers;
- Facilitation of any non-technical negotiation, consideration or approval processes involving other institutions within the federal administration;
- Support of the registry administration in maintaining a secure and reliable registry environment.

The national greenhouse gas inventory is coordinated by the **inventory process manager**. The process of inventory planning, preparation and management is well-established with responsibilities and decision-making power assigned to specific people or groups. The **inventory QA/QC officer** is responsible for enforcement of the defined quality standards of the national greenhouse gas inventory. The inventory QA/QC officer also advises the national inventory system supervisory board on matters relating to the conformity of the greenhouse gas inventory with reporting requirements.

The **greenhouse gas inventory working group** constitutes a fundamental element of the national greenhouse gas inventory and 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, to 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 **greenhouse gas inventory core group** meets four times per year and comprises the inventory experts employed by the Swiss Federal Office for the Environment 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 greenhouse gas inventory core group, which is also responsible for ensuring the conformity of the inventory with the relevant guidelines. The greenhouse gas inventory 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 national air pollution database EMIS, key category analyses, and for the reporting tables (CRF));
- The lead authors of the national inventory report (responsible for the report and carrying out centralised data assessments such as uncertainty analysis);
- Selected sectoral experts;
- The inventory QA/QC officer.

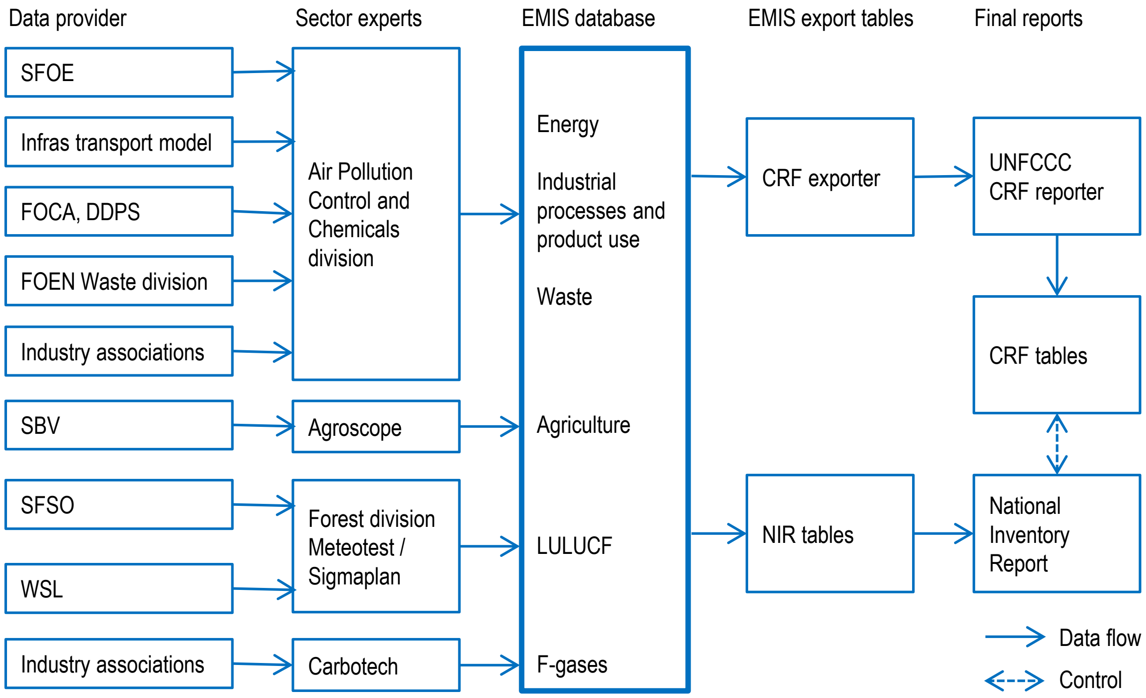
The greenhouse gas inventory core group coordinates and integrates the activities of data suppliers within and outside the Swiss Federal Office for the Environment as well as those of mandated experts. Further data suppliers contributing to the greenhouse gas inventory are institutions of the federal administration, research institutions, industry associations, and other private entities (see *FOEN*, 2017a for details). Everyone is obliged by Article 46 of the Federal Act on the Protection of the Environment (*Swiss Confederation*, 1983) to provide the authorities with the information required to enforce the law and, if necessary, to conduct or acquiesce in the conduct of enquiries.

At the operational level, the national registry is largely run independently of the national greenhouse gas inventory. Its operation is coordinated by the **registry process manager**, whose work is overseen by the **registry QA/QC officer**.

3.3.3 Process of inventory preparation

The Air Pollution Control and Chemicals Division of the Swiss Federal Office for the Environment maintains the national air pollution database EMIS, which contains all data needed to prepare the greenhouse gas inventory. The database was established at SAEFL (former name of the Swiss Federal Office for the Environment) in the late 1980s. Its initial purpose was to record and monitor emissions of air pollutants, but it has since been extended to cover greenhouse gases as well. Its structure corresponds to the EMEP/CORINAIR system for classifying emission-generating activities. The data needed to prepare the national greenhouse gas inventory in the common reporting format (CRF), as requested by the UNFCCC, is collected by various data suppliers and compiled centrally by the Swiss Federal Office for the Environment. At the same time, background information on data sources, activity data, emission factors and methods used for emission estimation is documented in the database and/or the national inventory report. 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, emission factors, and for the selection of methods compliant with the relevant guidelines.

Fig. 61 > Data collection for the national air pollution database EMIS, from where the data is transferred via the CRF reporter to the reporting tables (CRF). The reporting tables are submitted by means of the UNFCCC submission portal and documented in the national inventory report. The authors of the national inventory report and the reviewers control the correctness of the data transferred from the database into the report (figures and tables shown in the national inventory report are exported directly from the database). The authors further check the correspondence between the exports and the reporting tables. DDPS: Swiss Federal Department of Defence, Civil Protection and Sport, FOCA: Swiss Federal Office of Civil Aviation, FOEN: Swiss Federal Office for the Environment, SBV: Swiss Farmers' Union, SFOE: Swiss Federal Office of Energy, SFSO: Swiss Federal Statistical Office, WSL: Swiss Federal Institute for Forest, Snow and Landscape Research.



Swiss Federal Office for the Environment

Fig. 61 illustrates the data collection and processing steps leading to the reporting tables (CRF) required for reporting under the UNFCCC and the Kyoto Protocol. Most important input data for the national air pollution database EMIS comprise the Swiss overall energy statistics of the Swiss Federal Office of Energy, the Swiss wood energy statistics of the Swiss Federal Office of Energy, various statistics (of the Swiss Federal Office for the Environment) and models for emissions from road transport, statistics and models of non-road activities, modelled emissions based on the import statistics for F-gases (fluorinated greenhouse gases), waste and agricultural statistics, as well as extracts from the national forest inventory and the national forest statistics. Emissions and removals from sector 4 'Land use, land-use change and forestry' (LULUCF) and KP-LULUCF are calculated by the Forest Division of the Swiss Federal Office for the Environment; a detailed description of the calculation of these emissions can be found in *FOEN* (2017, chapter 6). Emissions from sector 3 'Agriculture' are compiled by Agroscope, the Swiss Centre of Excellence for Agricultural

Research (affiliated with the Swiss Federal Office for Agriculture). Emissions from all other sectors are calculated or compiled by the Air Pollution Control and Chemicals Division of the Swiss Federal Office for the Environment, in parts with the support of external companies shown in Fig. 61 (Carbotech, Meteotest, and Sigmaplan).

Methodologies: General description

Emissions calculations for the various sectors rely on standard methodologies (tier 1, tier 2, or tier 3) according to the 2006 IPCC guidelines for national greenhouse gas inventories (*IPCC*, 2006). Under the UNFCCC, these guidelines have been adopted for mandatory use in reporting on greenhouse gas inventories. For the sector 1 ‘Energy’, import and fuel consumption statistics (fuel sales in the transport sector) taken from the Swiss overall energy statistics (e.g. *SFOE*, 2017a) are used as input data, while for the other sectors national statistics and data surveys are consulted.

3.3.4 Key category analysis

A key category analysis is performed annually following the 2006 IPCC guidelines for national greenhouse gas inventories (*IPCC*, 2006). Level and trend assessments are performed for both Approach 1 and Approach 2, considering the emissions from the base year 1990 and the latest year reported. Emissions from sector 4 ‘Land use, land-use change and forestry’ (LULUCF) as well as indirect CO_2 emissions are included in the key category analysis. Under Approach 2, emissions are weighed with their uncertainty estimates. Tab. 11 presents an overview of the resulting key categories for 2015. More details are provided in Switzerland’s latest national inventory report (*FOEN*, 2017a).

3.3.5 Recalculation of data

The inventory has been improved continuously and reached a consolidated state. Recalculations that further improve the inventory or that implement recommendations and encouragements from the various review procedures are considered (and approved) by the greenhouse gas inventory core group. Substantial recalculations that impact the national total are presented to the national inventory system supervisory board for approval. Recalculations are documented in *FOEN* (2017a, chapter 10).

3.3.6 Quality assurance and quality control (QA/QC) and verification plans

The national inventory system has an established quality management system (QMS) that complies with the requirements of ISO 9001:2008. Certification has been obtained in 2007 and is upheld since through annual audits. The quality management system is designed to comply with the revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention (FCCC/CP/2013/10/Add.3) to ensure and continuously improve transparency, consistency, comparability, completeness, accuracy, and confidence in national greenhouse gas emission and removal estimates. While a detailed description of the QA/QC procedures, including verification plans, is given in *FOEN* (2017a, section 1.2.3), the most important elements are summarised in the following.

General QC procedures

Routine annual quality control procedures comprise checks related to new data and database operations, spot-checks for transcription errors, correct use of conversion factors and units, and correct calculations:

- There are checklists for the most important sectoral data suppliers and EMIS database experts;
- Consistency of data between categories is to a large extent ensured by the design of the database, where specific emission factors and activity data that apply to various categories are used jointly by all categories to calculate emissions;
- Recalculations are compiled in a document and made available to the members of the greenhouse gas inventory core group;
- QC procedures regarding the reporting tables (CRF) comprise a detailed comparison of the tables of the previous submission with those of the current submission for the base year and the latest common year. In addition, the time-series consistency is incrementally checked by comparing the latest inventory year with the preceding year;
- Finally, Switzerland’s national inventory report is subject to an internal review prior to submission.

Category-specific QC procedures

Whenever new emission factors are considered, they are compared to the default values of the 2006 IPCC guidelines and to the values used in previous years. Similarly, if new activity data have become available for a particular category, a comparison between existing and new activity data is performed. The general procedures regarding category-specific QC are also described in the quality manual (*FOEN*, 2017b), while specific activities are documented in the corresponding sectoral chapters.

Quality assurance procedures

As required by ISO 9001 there are periodic internal audits covering all processes. In addition, an external organisation is mandated to conduct the annual audit of the ISO 9001 quality management system. Results and suggestions for improvements from expert peer reviews commissioned on a case-by-case basis for specific sectors, as well as recommendations and encouragements from the UNFCCC expert review teams (ERT) are added to the inventory development plan and considered by the core group for implementation in future submissions.

Verification activities

For sector 1 ‘Energy’, the standard verification activity carried out on an annual basis is the comparison of the sectoral approach with the reference approach (see *FOEN*, 2017a for more details). In addition, the Swiss Federal Office for the Environment supports a long-term monitoring programme from which Switzerland’s emissions of some fluorinated greenhouse gases can be estimated based on atmospheric measurements. Similar research projects are currently looking into developing independent estimates of CH_4 and N_2O emissions in Switzerland based on atmospheric measurements and inverse modelling of atmospheric transport.

Treatment of confidentiality issues

Nearly all of the data necessary to compile the Swiss greenhouse gas inventory are publicly available. There are a few exceptions (data referring to a single enterprise, disaggregated emissions of F-gases, some data regarding civil aviation, and unpublished land-use statistics), however, these will be made available to the ERT upon request.

Public access to the greenhouse gas inventory

The Swiss Federal Office for the Environment operates a website (*http://www.climatereporting.ch*) where the Swiss greenhouse gas inventories (national inventory report, reporting tables (CRF), and UNFCCC review reports), the Swiss national communications and other reports submitted under the UNFCCC and the Kyoto Protocol are available. On this website, further background information (e.g. internal reports) cited in the Swiss greenhouse gas inventory is provided.

3.3.7 Procedures for official consideration and approval of the inventory

The process for the official consideration of the greenhouse gas inventory is defined in the mandate of the national inventory system supervisory board. At the national inventory system supervisory board meeting taking place after the completion of the inventory (generally in mid-March) the inventory project management hands over the national inventory report and the reporting tables (CRF) to the members of the board for consideration. Subsequently, the chair of the national inventory system supervisory board presents the inventory for official approval to the directorate of the Swiss Federal Office for the Environment.

3.3.8 Changes to the national inventory arrangements since the previous submission

No changes occurred to the national inventory arrangements since the previous national communication or biennial report.

Tab. 11 > Results of the key category analyses of Switzerland's greenhouse gas inventory. Key categories are ordered by NFR code, whereby categories which are not key categories are not shown. In addition to the emissions of all greenhouse gases from the sectors 1, 2, 3, 5, and 6, emissions from the sector land use, land-use change and forestry (4) as well as indirect CO_2 emissions are also considered. The last column indicates the key categories as follows: 'L1' indicates key categories from the level assessment of the most recent inventory year (2015) using Approach 1, 'L2' indicates key categories from the level assessment of the most recent inventory year (2015) using Approach 2, 'T1' indicates key categories from the trend assessment (1990/2015) using Approach 1, and 'T2' indicates key categories from the trend assessment (1990/2015) using Approach 2.

NFR code	Source categories and fuels if applicable	Greenhouse gas	Identification Criteria
1A1	Energy Industries: Gaseous Fuels	CO_2	L1, T1
1A1	Energy Industries: Liquid Fuels	CO_2	L1, T1
1A1	Energy Industries: Other Fuels	CO_2	L1, L2, T1, T2
1A1	Energy Industries: Solid Fuels	CO_2	T2
1A2	Manufacturing Industry and Construction: Gaseous Fuels	CO_2	L1, L2, T1, T2
1A2	Manufacturing Industry and Construction: Liquid Fuels	CO_2	L1, T1
1A2	Manufacturing Industry and Construction: Other Fuels	CO_2	L1, T1
1A2	Manufacturing Industry and Construction: Solid Fuels	CO_2	L1, T1, T2
1A3a	Civil Aviation: Liquid Fuels	CO_2	T1
1A3b	Road Transportation: Gasoline	CH_4	T1, T2
1A3b	Road Transportation: Gasoline	CO_2	L1, T1
1A3b	Road Transportation: Gasoline	N_2O	T1, T2
1A3b	Road Transportation: Diesel	CO_2	L1, L2, T1, T2
1A3b	Road Transportation: Diesel	N_2O	T1
1A4a	Commercial: Gaseous Fuels	CO_2	L1, L2, T1
1A4a	Commercial: Liquid Fuels	CO_2	L1, T1
1A4b	Residential: Biomass	CH_4	T1
1A4b	Residential: Gaseous Fuels	CO_2	L1, L2, T1, T2
1A4b	Residential: Liquid Fuels	CO_2	L1, T1
1A4c	Agriculture and Forestry: Liquid Fuels	CO_2	L1
1B2	Oil and Natural Gas Energy Production	CH_4	L1, T1, T2
2A1	Cement production	CO_2	L1, L2, T1
2C3	Aluminium production	CO_2	T1, T2
2C3	Aluminium production	PFC	T1, T2
2F1	Refrigeration and air conditioning	HFC	L1, L2, T1, T2
2G	Other Product Manufacture and Use	N_2O	T2
2G	Other Product Manufacture and Use	SF_6	L1, T1
2	Indirect CO2 emissions	CO_2	T1, T2
3A	Enteric Fermentation	CH_4	L1, L2, T1
3B1–3B4	Manure management	CH_4	L1, L2
3B5	Indirect N2O emissions from manure management	N_2O	L1, L2, T2
3Da	Direct emissions from managed soils	N_2O	L1, L2
3Db	Indirect emissions from managed soils	N_2O	L1, L2, T1, T2
4A1	Forest land remaining Forest land	CO_2	L1, L2, T1, T2
4A2	Land converted to Forest	CO_2	L1, L2, T1, T2
4B1	Cropland remaining Cropland	CO_2	L1, L2, T1, T2
4C1	Grassland Remaining	CO_2	L2, T2
4C2	Land converted to Grassland	CO_2	L1, L2, T1, T2
4D1	Wetland remaining Wetland	CO_2	L2
4E2	Land converted to Settlements	CO_2	L1, L2
4G	Harvest Wood Products	CO_2 biog.	T1, T2
4III	Direct N2O from Disturbance	N_2O	L2
5A	Solid Waste Disposal	CH_4	L1, L2, T1, T2
5B	Biological Treatment of Solid Waste	CH_4	T1, T2
5D	Wastewater treatment and discharge	CH_4	L1, L2, T2
5D	Wastewater treatment and discharge	N_2O	L1, L2, T2

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3.4 National registry

3.4.1 General information

Name and contact information of the registry administrator

Swiss Federal Office for the Environment
Swiss Emissions Trading Registry
Climate Division, Mr. Marcel Kamber
CH–3003 Bern, Switzerland
Phone: +41 (0)58 462 05 66
Email: *emissionsregistry@bafu.admin.ch*
Registry: *https://www.emissionsregistry.admin.ch*
Web: *http://www.bafu.admin.ch/emissions-trading*

Cooperation with other Parties

Switzerland uses a registry software based on the Community Registry software, which was initially developed by the European Union in 2004. Further developments, updates and releases of the software are undertaken in cooperation with Dr. Lippke & Dr. Wagner GmbH. As of today, the same software is used by Monaco.

Description of the database structure and capacity of Switzerland's national registry

Information on the database structure and capacity of Switzerland's national registry is regarded as confidential.

Conformity to the technical standards for data exchange

In September 2015, the registry software successfully passed the CP2 Annex H test and therewith conforms to the technical specifications of data exchange standards (DES) for registry systems under the Kyoto Protocol, version 2.0.1.

Procedures employed to minimise and manage discrepancies and to correct problems

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

Internal incident and change management procedures were defined in cooperation with Dr. Lippke & Dr. Wagner GmbH, and the Swiss Federal Office of Information Technology, Systems and Telecommunication (FOITT).

Security measures

Information on security measures is regarded as confidential.

Information publicly accessible by means of the user interface

Non-confidential information is publicly available on the website of the Swiss emissions trading registry at *https://www.emissionsregistry.admin.ch*. The national allocation plan is accessible under 'Allocation' in the Public Information menu. Information made available to the public is conforming to the criteria defined in Annex E to decision 13/CMP.1:

- § 45 13/CMP.1: Report 'Accounts' at *https://www.emissionsregistry.admin.ch*;
- § 46 13/CMP.1: No report available as no ERUs were issued by Switzerland;
- § 47 13/CMP.1: Information on unit holding and transactions for each calendar year is available in the SEF Tables at *http://www.climatereporting.ch*;
- § 48 13/CMP.1: Report 'Accounts' at *https://www.emissionsregistry.admin.ch*.

The following information is considered as confidential, and thus not publicly available (Decision 13/CMP.1, paragraphs are indicated in parentheses):

- The representative identifier of the account holder (13/CMP.1, paragraph 45(d));

- The representatives name and contact information (13/CMP.1, paragraph 45(e));
- The total quantity of ERUs, CERs, AAUs and RMUs in each account at the beginning of the year (the total quantity is only available by account type) (Decision 13/CMP.1, paragraph 47(a));
- The identity of the transferring accounts from which ERUs, CERs, AAUs and RMUs were acquired by Switzerland's national registry (Decision 13/CMP.1, paragraph 47(d));
- The identity of the acquiring accounts to which ERUs, CERs, AAUs and RMUs were transferred from Switzerland's national registry (Decision 13/CMP.1, paragraph 47(f));
- Current holdings of ERUs, CERs, AAUs and RMUs in each account (Decision 13/CMP.1, paragraph 47(l)).

Internet address of the interface to Switzerland's national registry

On the website of Switzerland's national registry at *https://www.emissionsregistry.admin.ch*, the user interface is available.

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

Information on the data backup strategy is regarded as confidential.

Test procedures

Basic tests are performed by the application support provider Dr. Lippke & Dr. Wagner GmbH, on the international transaction log (ITL) DEVELOPER environment. The Annex H test during the registry initialisation process successfully tested the software of Switzerland's national registry against the ITL. New versions, updates or bug fixes of the registry software are tested by the registry administration team in the REGISTRY environment before implementation in the PRODUCTION environment. Major changes are tested including the REGISTRY environment of the ITL. If test end criteria are reached and security testing was successful, the new version or update is installed in the PRODUCTION environment.

3.4.2 Recent changes

Since Switzerland's sixth national communication and second biennial report, regular security and usability updates, as well as bug fixing took place.

3.4.3 Status of Switzerland's national registry as of 2017

Switzerland's national registry got fully operational with the international transaction log (ITL) on 4 December 2007. Tab. 12 shows the total quantities of Kyoto Protocol units in Switzerland's national registry related to the first commitment period 2008–2012 (CP1), Tab. 13 the total quantities of Kyoto Protocol units in Switzerland's national registry related to the second commitment period 2013–2020 (CP2), by account type at the end of 2016 (submission of SEF Tables in 2017).

Tab. 12 > Total quantities of CP1 Kyoto Protocol units in Switzerland's national registry by account type at the end of 2016.

Standard Electronic Format (SEF) Table 1

	Unit type					
Account type	**AAUs**	**ERUs**	**RMUs**	**CERs**	**tCERs**	**lCERs**
Party holding accounts	5'794'523	–	–	1'640'531	–	–
Entity holding accounts	–	–	–	181'123	–	–
Article 3.3/3.4 net source cancellation accounts	172'587	–	1'013'340	–		
Non-compliance cancellation accounts	–	–	–	–		
Other cancellation accounts	4'796'312	3'651'820	–	7'896'871	114'793	–
Retirement account	236'857'347	558'645	8'267'540	16'038'197	–	–
tCER replacement account for expiry	–	–	–	–	–	
lCER replacement account for expiry	–	–	–	–		
lCER replacement account for reversal in storage	–	–	–	–		–
lCER replacement account for non-submission of certification report	–	–	–	–		–
Total	**247'620'769**	**4'210'465**	**9'280'880**	**25'756'722**	**114'793**	**–**

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Tab. 13 > Total quantities of CP2 Kyoto Protocol units in Switzerland's national registry by account type at the end of 2016.

Standard Electronic Format (SEF) Table 1

	Unit type					
Account type	**AAUs**	**ERUs**	**RMUs**	**CERs**	**tCERs**	**lCERs**
Party holding accounts	–	–	–	15'297	–	–
Entity holding accounts	–	–	–	16'275'458	–	–
Retirement account	–	–	–	–	–	–
Previous period surplus reserve account	–					
Article 3.3/3.4 net source cancellation accounts	–	–	–	–		
Non-compliance cancellation account	–	–	–	–		
Voluntary cancellation account	–	–	–	854'839	–	–
Cancellation account for remaining units after carry-over	–	–	–	–	–	–
Article 3.1 ter and quater ambition increase cancellation account	–					
Article 3.7 ter cancellation account	–					
tCER cancellation account for expiry					–	
lCER cancellation account for expiry						–
lCER cancellation account for reversal of storage						–
lCER cancellation account for non-submission of certification report						–
tCER replacement account for expiry	–	–	–	–	–	
lCER replacement account for expiry	–	–	–	–		
lCER replacement account for reversal of storage	–	–	–	–		–
lCER replacement account for non-submission of certification report	–	–	–	–		–
Total	**–**	**–**	**–**	**17'145'594**	**–**	**–**

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4 Policies and measures[12]

This chapter describes policies and measures implemented or planned to be implemented in Switzerland in order to achieve the emission reduction commitments agreed on in the national and international context. Section 4.1 provides information related to the policymaking process in the context of environmental and climate policy, including the general framework of environmental legislation and some further background information on institutional arrangements at the domestic level. Section 4.2 focuses on policies and measures that are effective across sector boundaries. The subsequent sections are organised by sector and present individual mitigation actions (including their mitigation impacts) as listed in BR CTF table 3. Section 4.3 deals with (non-transport) policies and measures related to energy efficiency, reduced energy consumption, and renewable energy. Section 4.4 encompasses aspects of transport infrastructure, sustainable modes of transport, and vehicle emission standards. The remaining mitigation actions cover the following areas: Industrial processes and product use (section 4.5), agriculture (section 4.6), land use, land-use change, and forestry (section 4.6.5), and waste (section 4.8). Information on the costs, non-greenhouse gas mitigation benefits and interactions of Switzerland's policies and measures is provided in section 4.9. Sections 4.10 to 4.12 briefly address the modification of longer-term trends in greenhouse gas emissions, policies and measures no longer in place, and policies and measures leading to an increase in greenhouse gas emissions. Actions related to economic and social consequences of response measures (adverse effects) are addressed in section 4.13. The documentation of the quantified economy-wide emission reduction target as requested by the 'UNFCCC biennial reporting guidelines for developed country Parties' is presented in Annex B.3, including the relation to the national greenhouse gas mitigation targets. Information on the monitoring and evaluation of progress towards the quantified economy-wide emission reduction target as well as the corresponding institutional arrangements is presented in sections 4.1.2 and 4.1.3, respectively.

4.1 Policymaking process

This section provides specific information related to Switzerland's policymaking process in the context of environmental and climate policy. A general overview of the government structure – including background information on the general political organisation in Switzerland – is presented in section 2.1.

4.1.1 Fundamental settings regarding environmental and climate policy

The Federal Constitution of the Swiss Confederation forms the overarching framework for environmental and climate policy in Switzerland. The commitment to long-term preservation of natural resources is listed prominently in the opening paragraphs as one of the main aims (*Swiss Confederation*, 1999a, Article 2). In pursuit of this commitment, the Swiss government has established an Interdepartmental Sustainable Development Committee which defines 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. Further, by decision of the Swiss Federal Council, an interdepartmental committee on climate of the federal authorities ('IDA-Klima') was established as of 14 April 2008. The committee is responsible for the coordination between different policy areas and assures a coherent climate policy of the Swiss Confederation in compliance with the UNFCCC. The committee, led by the Swiss Federal Office for the Environment, thus coordinates the activities of all federal offices involved in climate policy. As stipulated in Article 39 of the second CO_2 Act (*Swiss Confederation*, 2011) and more generally also in Article 12 of the Ordinance on the Organisation of the Federal Department of the Environment, Transport, Energy and Communications (*Swiss Confederation*, 1999c), the Swiss Federal Office for the Environment is responsible for matters relating to climate protection. The related Ordinance on the Reduction of CO_2 Emissions (*Swiss Confederation*, 2012), in its chapter 11, details the responsibilities for the implementation of specific measures.

Strategies for sustainable development, long-term mitigation strategies and targets for greenhouse gas mitigation

The Swiss Federal Council set out its main policy focus areas for sustainable development in its sustainable development strategy 2016–2019 (*Swiss Federal Council*, 2016), adopted as part of the Swiss government's regular legislative

[12] In this chapter, the sections have partly been rephrased and complemented compared to the proposition in paragraph 74 and the annex of the 'Revision of the Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part II: UNFCCC reporting guidelines on national communications' (FCCC/SBI/2016/L.22). The reason for the conservative reorganisation is to structure the description of the different policies and measures (sections 4.2 to 4.8) and to provide additional information (sections 4.9 to 4.13).

planning cycle. This strategy represents an important contribution on the part of Switzerland to achieving the 2030 Agenda for Sustainable Development of the United Nations.

The sustainable development strategy 2016–2019, the fifth of its kind since 1997, centres around an action plan featuring measures that are grouped according to nine action areas, each covering a specific topic which is of central importance to the sustainable development of Switzerland. With a view to achieving the defined goals, the sustainable development strategy provides a model role for the Swiss Confederation, outlines horizontal (cross-sectoral) measures such as sustainability monitoring, sustainability assessments, the promotion of local sustainability processes and projects, and closer collaboration with other stakeholder groups. Finally, the sustainable development strategy sets out the institutional framework for its implementation.

One of the Swiss Federal Council's overarching objectives with regard to the incorporation of the sustainable development principle into the activities of the Swiss government is to combat global warming. The reduction of energy consumption, the increased use of renewable energies, and management of natural hazards form part of this endeavour. Switzerland's climate and energy policies are, thus, in line with the sustainable development strategy and are strongly coordinated. The third CO_2 Act, planned to come into effect in 2021, will be based in part on the Energy Strategy 2050 (for details regarding the Energy Strategy 2050 see section 4.3.1). The Swiss government is also engaged in elaborating and coordinating adaptation efforts, as reflected in the Swiss adaptation strategy (section 6.4) and the corresponding adaptation actions (section 6.5).

By ratifying the UNFCCC in 1993, the Kyoto Protocol in 2003, the Doha Amendment to the Kyoto Protocol in 2015, and the Paris Agreement in 2017, Switzerland internationally committed to contribute to the stabilisation of greenhouse gas emissions at a level that prevents dangerous anthropogenic interference with the climate system. The respective international targets, as well as the translation to Switzerland's national targets, are presented and discussed in Annex B.3.

Principles and instruments of Switzerland's environmental and climate policy

Deduced from the Federal Constitution of the Swiss Confederation, the principles and instruments of Switzerland's environmental policy are stipulated in the Federal Act on the Protection of the Environment (*Swiss Confederation*, 1983), in force since 1985 and revised several times since. The Environmental Protection Act is based on the following three main principles: (i) the principle of precaution, (ii) the control/limitation of ecological damage at the source, and (iii) the polluter pays principle. Consequently, Swiss environmental policy is addressing a wide spectrum of issues, ranging from pollution of air, water and soil, and exposure to noise, to protecting stratospheric ozone or reducing and managing waste. Several policy areas are linked directly or indirectly to the reduction of Switzerland's greenhouse gas emissions. Fiscal incentives are recognised as an essential instrument for promoting the efficient use of resources. The main instruments are the definition of legally binding emission limits, introduction of levies on substances or practices with negative environmental impacts as well as the obligation of environmental impact assessments for particular facilities and installations.

Switzerland's climate policy is based on the Federal Constitution of the Swiss Confederation, in particular Article 74 (environmental protection) and Article 89 (energy policy). The legal centrepiece supplementing the Environmental Protection Act and defining objectives, instruments, measures and general rules of implementation of climate policy on the needed level of detail is the Federal Act on the Reduction of CO_2 Emissions (CO_2 Act, see sections 4.2.2, 4.2.3, and 4.2.4). This Act also contains provisions related to enforcement and evaluation. The implementation of the CO_2 Act is further detailed in the Ordinance on the Reduction of CO_2 Emissions (CO_2 Ordinance), where, inter alia, specific responsibilities for the implementation of measures are assigned. Tab. 14 shows detailed references to enforcement and administrative procedures for some core policies and measures defined in the second CO_2 Act and the corresponding CO_2 Ordinance.

Apart from the Environmental Protection Act and the CO_2 Act, there are various other legal provisions that are related to environmental and climate issues. The Energy Act (*Swiss Confederation*, 1998a), the Forest Act (*Swiss Confederation*, 1991), the Spatial Planning Act (*Swiss Confederation*, 1979), the Agriculture Act (*Swiss Confederation*, 1998b), the Road Traffic Act (*Swiss Confederation*, 1958), the Heavy Vehicle Charge Act (*Swiss Confederation*, 1997a), the Mineral Oil Tax Act (*Swiss Confederation*, 1996) and the Ordinance on the Avoidance and Management of Waste

(*Swiss Confederation*, 2015) have as well components that contribute to environmental policy goals including greenhouse gas emissions reduction and reduction of greenhouse gas precursor gases.

Tab. 14 > Enforcement and implementation responsibilities for core provisions of the second CO_2 Act and the corresponding CO_2 Ordinance.

Instrument/measure	CO_2 Act	CO_2 Ordinance	Enforcement	Implementation level
Objectives	Article 3	Article 3	If a sector-specific interim target is not achieved, the Swiss Federal Department of Environment, Transport, Energy and Communications, after hearing the cantons and affected parties, shall request the Swiss Federal Council for additional measures.	Swiss Confederation
CO_2 levy on heating and process fuels	Articles 29–33	Articles 93–103	The CO_2 Ordinance defines a reduction pathway that needs to be followed (Article 94). If the targets set in the CO_2 Ordinance are not met, the CO_2 levy is increased automatically.	Swiss Confederation
Emissions trading scheme	Articles 15–21	Articles 40–65	Companies taking part in the emissions trading scheme have to cover their emissions with emission allowances (to a limited amount international carbon credits are also accepted). Emissions not covered entail a sanction of 125 Swiss francs per tonne of CO_2 equivalents.	Swiss Confederation
Negotiated reduction commitments (for exemption from the CO_2 levy)	Article 31	Articles 66–79	Companies have to commit to reduce their greenhouse gas emissions. If commitments are not fulfilled, a sanction of 125 Swiss francs is due per tonne of CO_2 equivalents that has been emitted in excess.	Swiss Confederation
National buildings refurbishment programme	Article 34	Articles 104–113	Annual reporting on effectiveness of implementation.	Cantons and contractual agreement between the Swiss Confederation and the cantons
Building codes of the cantons	Article 9	Article 16	Regulated at cantonal level. Cantons have to report annually to the Swiss Confederation on their activities.	Cantons
Obligation to offset emissions from gas-fired combined-cycle power plants	Articles 22–25	Articles 80–92	If the obligation to fully compensate the emissions is not fulfilled, the operators of gas-fired combined-cycle power plants have to pay a contractual sanction for non-compliance with the commitment.	Swiss Confederation
CO_2 emission regulations for newly registered vehicles	Articles 10–13	Articles 17–37	If targets are not met, importers of vehicles (passenger cars and light duty trucks) have to pay a sanction.	Swiss Confederation
Partial compensation of CO_2 emissions from motor fuel use	Articles 26–28	Articles 86–92	If the obligation to compensate is not fulfilled, a sanction of 160 Swiss francs per tonne of CO_2 must be paid. Additionally, the missing emission reductions must be covered by CERs.	Swiss Confederation

The website of the Swiss Federal Office for the Environment makes information regarding legislative arrangements and enforcement and administrative procedures publicly accessible[13]. In particular, the Swiss Federal Office for the Environment publishes recommendations on the implementation of the legal provisions in cases where more detailed information is necessary. These recommendations do not have legal force but are giving more precise instructions on the application of the legal instruments. For instance, in the context of the second CO_2 Act and the corresponding CO_2 Ordinance, the Swiss Federal Office for the Environment has published recommendations related to the implementation of compensation projects in Switzerland[14], the exemption from the CO_2 levy on heating and process fuels for energy intensive companies[15], and the emissions trading scheme[16].

In Switzerland, the CO_2 Act (Article 5 and 6) and the corresponding CO_2 Ordinance (Article 4 and Annex 2) provide the legal basis for the implementation and use of flexible mechanisms under the Kyoto Protocol. SwissFlex, the national secretariat for the flexible mechanisms[17], is the designated national authority under the Clean Development Mechanism and the designated focal point under the Joint Implementation. It was established in 2004 and announced to the UNFCCC in 2007. Activities relating to the implementation of the flexible mechanisms as well as enquiries concerning

13 https://www.bafu.admin.ch/bafu/en/home/topics/climate.html

14 http://www.bafu.admin.ch/uv-1315-d

15 http://www.bafu.admin.ch/uv-1316-d

16 http://www.bafu.admin.ch/uv-1317-d

17 Website of the Swiss national secretariat for the flexible mechanisms: https://www.bafu.admin.ch/bafu/en/home/topics/climate/services/swissflex--national-secretariat-for-the-flexibility-mechanisms.html

the mechanisms and the examination and approval of project proposals are coordinated by an interdepartmental working group. Besides the Swiss Federal Office for the Environment, the members of this group are drawn from the Swiss Federal Office of Energy, the Swiss State Secretariat for Economic Affairs, the Swiss Agency for Development and Cooperation, and the Swiss Federal Department of Foreign Affairs. SwissFlex publishes and regularly updates the list of letters of approval/authorisation issued under the Clean Development Mechanism[18] and under the Joint Implementation[19].

In view of the international dimension of environmental problems, Switzerland seeks to enhance and support international efforts to tackle problems at the 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 solve environmental problems in multilateral contexts.

4.1.2 Monitoring and evaluation of policies and measures

Regarding the monitoring of the overall progress achieved by Switzerland's policies and measures to mitigate greenhouse gas emissions over time (self-assessment), the national greenhouse gas inventories – which are annually submitted to the UNFCCC and also published on the website of the Swiss Federal Office for the Environment[20] – are fundamental. Further, Article 40 of the second CO_2 Act (section 4.2.3) obliges the Swiss Federal Council to periodically evaluate the effectiveness of single policies and measures, and to consider the necessity of additional measures. These evaluations, which need to take into account other climate-relevant parameters such as economic development, population growth and the expansion of traffic, have to be reported to the Swiss Parliament. However, apart from some exceptions (see below), the second CO_2 Act does not define the exact dates or periodicity of the assessments. In the following, the most significant monitoring approaches and ex-post evaluations (either completed or performed repeatedly) are presented.

Sectoral interim targets

Article 3 of the CO_2 Ordinance stipulates sectoral interim targets for the greenhouse gas emissions in 2015:

- Buildings sector: no more than 78 per cent of 1990 emissions;
- Transport sector: no more than 100 per cent of 1990 emissions;
- Industry sector: no more than 93 per cent of 1990 emissions.

The evaluation of the sectoral interim targets took place based on the greenhouse gas inventory published by the Swiss Federal Office for the Environment in April 2017. In contrast to the transport sector, the buildings sector and the industry sector achieved their interim targets[21].

CO_2 levy on heating and process fuels

In the context of the CO_2 Ordinance (Article 94), the Swiss Federal Council has defined intermediate reduction targets regarding the CO_2 emissions from heating and process fuels for the years 2012, 2014, and 2016 (see also section 4.2.5). If these targets are not met, the CO_2 levy on heating and process fuels is increased automatically to the levels laid down in the CO_2 Ordinance. The decision for an increase of the CO_2 levy on heating and process fuels is taken on the basis of the annual national CO_2 statistics which relies on the official national energy statistics published by the Swiss Federal Office of Energy each year (the CO_2 statistics also forms the basis for the upcoming greenhouse gas inventory). As the consumption of heating and process fuels strongly depends on temperature and solar radiation during the winter season, the corresponding CO_2 emissions are normalised regarding weather conditions before confrontation with the targets.

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18 2017: https://www.bafu.admin.ch/dam/bafu/en/dokumente/klima/fachinfo-daten/List_of_LoAs_2017.pdf
2006–2016: https://www.bafu.admin.ch/dam/bafu/en/dokumente/klima/statistik/Liste_2006-2016.zip

19 2007–2012: https://www.bafu.admin.ch/dam/bafu/en/dokumente/klima/fachinfo-daten/complete_list_ofloas2007-2012.pdf (as to date no AAUs were issued for the second commitment period of the Kyoto Protocol, no letters of approval/authorisation were issued under the Joint Implementation after 2012).

20 http://www.bafu.admin.ch/greenhouse-gases

21 https://www.newsd.admin.ch/newsd/message/attachments/48115.pdf

The Swiss Federal Office for the Environment has undertaken an evaluation of the CO_2 levy on heating and process fuels with the goal to estimate the impact of the CO_2 levy on heating and process fuels on emissions since its introduction using both a modelling approach and data collected from a firm-level survey (*FOEN*, 2015; *FOEN*, 2016). However, given that the CO_2 Act envisages numerous (and mutually reinforcing) instruments, interdependencies between these instruments are expected. Sorting out the mitigation impact of an individual policy and measure is, thus, very difficult, especially for instruments such as the CO_2 levy on heating and process fuels that have an impact in more than one sector.

CO_2 emission regulations for newly registered vehicles

The CO_2 emission regulations for newly registered vehicles (section 4.4.2) are enforced by a sanction mechanisms. Accordingly, compliance with the CO_2 emission regulations is monitored and evaluated on a case-by-case basis for small importers (in case the imported vehicle exceeds the CO_2 emission regulations a sanction has to be paid before the vehicle is licensed), or quarterly to annually for large importers. Data on the specific CO_2 emissions of newly registered vehicles are evaluated and published annually by the Swiss Federal Office of Energy.

Further, Article 37 of the CO_2 Ordinance requests that the Swiss Federal Department of Environment, Transport, Energy and Communications reports to the competent commissions of the Council of States and the National Council on the effectiveness of the emission regulations every three years, starting in 2016. Accordingly, the first report was presented in December 2016 (*DETEC*, 2016).

Partial compensation of CO_2 emissions from motor fuel use

According to chapter 7 of the CO_2 Ordinance, fossil fuel importers are bound to offset part of the CO_2 emissions from motor fuel sold in Switzerland (section 4.4.5). To implement this obligation, sales of motor fuels as well as the corresponding CO_2 emissions are monitored continuously by the Federal Customs Administrations.

The Swiss Federal Audit Office evaluated the activities related to the partial compensation of CO_2 emissions from motor fuel use and published the respective report – including a summary in English – in 2016 (*Swiss Federal Audit Office*, 2016).

National buildings refurbishment programme

Cantons have to report on measures implemented within the national buildings refurbishment programme (section 4.3.3) as well as on the development of corresponding CO_2 emissions from buildings on cantonal territory. The first reporting on CO_2 emissions from buildings in a standardised format will be made in 2018. The preparatory work for the detailed reporting by the cantons is currently ongoing.

An ex-post evaluation of the national buildings refurbishment programme is performed annually. Further, a report on the first five years of the programme, including the cumulative effects, was published in March 2016, as requested by Article 34 of the second CO_2 Act (*Swiss Federal Council*, 2016a).

The Swiss Federal Audit Office evaluated the activities related to the national buildings refurbishment programme and published the respective report – including a summary in English – in 2013 (*Swiss Federal Audit Office*, 2013).

Emissions trading scheme

The Swiss Federal Audit Office evaluated the activities related to the emissions trading scheme and published the respective report – including a summary in English – in 2017 (*Swiss Federal Audit Office*, 2017a).

Technology fund

The Swiss Federal Audit Office evaluated the activities related to the technology fund (see section 4.10) and published the respective report – including a summary in English – in 2017 (*Swiss Federal Audit Office*, 2017b).

Other monitoring processes

Several other measures require regular reporting of emissions or of compliance with specific commitments. They are therefore closely monitored on a regular basis. For instance, firms participating in the emissions trading scheme and firms with an individual (negotiated) reduction target that are exempt from the CO_2 levy are obliged to monitor their greenhouse gas emissions and to provide an annual report to the Swiss Federal Office for the Environment.

4.1.3 Institutional arrangements for the monitoring of greenhouse gas mitigation policy

No fundamental changes in domestic institutional arrangements, including legal, administrative and procedural arrangements have occurred since Switzerland's last submission. The Swiss Federal Office for the Environment, being responsible for matters relating to climate protection (see section 4.1.1), is generally also responsible for the monitoring of progress made with greenhouse gas mitigation policies and measures. In addition, the Swiss Federal Audit Office, in the framework of its activities as an independent inspecting authority, regularly inspects the implementation of greenhouse gas mitigation policies and measures. Institutional arrangements related to Switzerland's national greenhouse gas inventory system and the national registry are documented in section 3.3 and 3.4, respectively.

4.2 Cross-sectoral policies and measures

4.2.1 Overview

While policies and measures addressed in sections 4.3 to 4.8 may have side effects beyond their specific policy domain, the policies and measures presented in section 4.2 are clearly cross-sectoral in nature, i.e. they cannot be assigned to one of the 'classical' policy sectors.

Tab. 15 gives an overview of the most relevant cross-sectoral policies and measures. More details and background information on each policy and measure are presented below.

Tab. 15 > Summary of cross-sectoral climate policies and measures. The sector affected is 'cross-cutting' for all policies and measures presented in this table.

Name of policy or measure [a]	Greenhouse gas(es) affected	Objective and/or activity affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative, in kt CO_2eq) 2020
First CO_2 Act (1999) *	CO_2	Average reduction of CO_2 emissions from fossil fuel use by 10 per cent over the years 2008–2012 (relative to 1990).	Regulatory	Expired (replaced by second CO_2 Act)	First legal basis of Switzerland's climate policy including the implementation of the first commitment period of the Kyoto Protocol.	2000	FOEN	IE [b]
Second CO_2 Act (2011) *	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3	Reduction of all greenhouse gas emissions by 20 per cent by 2020 (relative to 1990).	Regulatory	Implemented	Current legal basis of Switzerland's climate policy including the implementation of the second commitment period of the Kyoto Protocol and containing provisions covering mitigation as well as adaptation.	2013	FOEN	IE [b]
Third CO_2 Act (2021)	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3	Decrease of total greenhouse gas emissions (relative to 1990) by (i) 50 per cent by 2030 (at least 30 per cent domestic and at most 20 per cent abroad) and (ii) 35 per cent in the mean over the years 2021–2030 (at least 25 per cent domestic and at most 10 per cent abroad).	Regulatory	Planned	Update of the CO_2 Act providing the legal basis of Switzerland's climate policy consistent with the Paris Agreement. While mostly covering the same policies and measures as the second CO_2 Act, the third CO_2 Act foresees a strengthening of the policies and measures in order to reach the more ambitious national and international targets.	2021	FOEN	IE [b]
CO_2 levy on heating and process fuels *	CO_2	Promote energy efficiency, less CO_2 intensive energy sources and reduced use of fossil heating and process fuels.	Economic, fiscal	Implemented (strengthening planned)	Surcharge on fossil heating and process fuels. Two thirds of the revenues are redistributed to households and businesses, up to one third goes into the national buildings refurbishment programme and – to a small extent – to a technology fund granting loan guarantees for the development of new low-emission technologies.	2008	FOEN	1'600 [c]
Emissions trading scheme *	CO_2, N_2O, PFCs	Reducing CO_2 emissions of emission-intensive industries using market-based mechanism.	Economic	Implemented (strength-	Emissions trading scheme based on the cap and trade principle, enabling the cost-	2008	FOEN	800

				ening planned)	effective achievement of climate-protection targets. Large greenhouse gas-intensive companies are required to participate, medium-sized companies may voluntarily participate. Companies included in the emissions trading scheme are exempt from the CO_2 levy on heating and process fuels.			
Negotiated reduction commitments (for exemption from the CO_2 levy) *	CO_2, N_2O, PFCs	Emission reduction targets agreed with companies exempt from the CO_2 levy on heating and process fuels.	Regulatory	Imple-mented (strength-ening planned)	Binding agreements with eligible small and medium-sized companies. Emission reduction targets take the technological potential and economic viability of measures into account. Targets are calculated from the starting point along a simplified or individual linear reduction course to the endpoint in the year 2020. Alternatively, economically viable measures (measures target) can be determined.	2008	FOEN, SFOE	400

[a] Policies and measures marked with an asterisk (*) are included in the 'with measures' projection.

[b] The first, second and third CO_2 Acts are the legal framework for various measures. While the expected mitigation impacts of individual policies and measures are presented along with these policies and measures, the total mitigation impacts of the CO_2 Acts correspond to the objectives indicated in the third column.

[c] For the purposes of estimating the mitigation impact, the CO_2 levy on heating and process fuels was fixed at 36 Swiss francs per tonne of CO_2 for the period 2010–2015. For 2016–2020, it was assumed that the CO_2 levy on heating and process fuels would be raised to 72 Swiss francs per tonne of CO_2.

IE, included elsewhere
FOEN, Swiss Federal Office for the Environment; SFOE, Swiss Federal Office of Energy

4.2.2 First CO_2 Act (1999)

The first CO_2 Act (*Swiss Confederation*, 1999b) entered into force in May 2000. It formed the legal framework for the implementation of Switzerland's emissions reduction commitment under the Kyoto Protocol by limiting CO_2 emissions from fossil fuel use for heating and transport to 10 per cent below 1990 levels over the period 2008–2012. The overall target was further divided into a reduction target of 15 per cent on heating and process fuels and eight per cent on motor fuels. These targets were set to assure compliance with the target under the Kyoto Protocol, assuming that the aggregate level of other greenhouse gas emissions remained unchanged compared to 1990.

The primary instruments to reach the targets for the period 2008–2012 were:

- Voluntary actions in various areas;
- A subsidiary CO_2 levy on heating and process fuels;
- Measures in other policy areas (waste, agriculture, F-gases) that are relevant to climate change mitigation;
- An emissions trading scheme (cap and trade);
- The complementary use of flexible mechanisms under the Kyoto Protocol.

Estimate of mitigation impact

The expected mitigation impact of the first CO_2 Act corresponds to its objective, i.e. an average reduction by 10 per cent of CO_2 emissions from fossil fuel use over the years 2008–2012 relative to 1990. However, as the first CO_2 Act formed the legal framework for various measures, the mitigation impact is indicated in Tab. 15 and BR CTF table 3 as 'included elsewhere' (i.e. under the policies and measures presented below).

4.2.3 Second CO_2 Act (2011)

The second CO_2 Act (*Swiss Confederation*, 2011) is the current centrepiece of Swiss climate policy. Fully revising the first CO_2 Act, it entered into force on 1 January 2013 and covers the period from 2013–2020. Apart from defining objectives it forms the foundation for several policies and measures to reach the set targets. Some policies and measures developed or initiated in the context of the first CO_2 Act – such as the CO_2 levy on heating and process fuels, the national buildings refurbishment programme, and the CO_2 emission regulations for newly registered vehicles – are continued.

The national reduction target of the second CO_2 Act stipulates the reduction of domestic greenhouse gas emissions by at least 20 per cent by 2020 compared to the 1990 level (see Annex B.3). In contrast to the first CO_2 Act, all gases covered by the Kyoto Protocol are addressed. The second CO_2 Act sets incentives for increasing use of renewable energies, improvement of energy efficiency and development of innovative low-emission technologies. In addition, it gives the Swiss government the responsibility to coordinate measures aimed at adaptation to the impacts of climate change at the national level.

The reduction target of –20 per cent by 2020 compared to the 1990 level is shared between the building, industry and transport sectors, but also tackles emissions from agriculture and of synthetic greenhouse gases. For 2015, the CO_2 Ordinance sets interim targets which correspond to reductions of 22 and seven per cent for the buildings and industry sectors, respectively, as well as zero emissions growth for the transport sector compared to the 1990 level. An evaluation of sectoral achievement of the interim targets was performed in 2017. While the buildings sector and the industry sector both reached their targets, emissions in the transport sector were four per cent higher than in 1990. Only indicative sectoral targets exist regarding reductions by 2020 (by 40 per cent for the buildings sector, by 15 per cent for the industry sector, and by 10 per cent for the transport sector, all compared to the 1990 level).

Planned strengthening

The second CO_2 Act is currently under revision, details of the planned strengthening are presented in section 4.2.4.

Estimate of mitigation impact

The expected mitigation impact of the second CO_2 Act corresponds to its objective, i.e. to a reduction of greenhouse gas emissions of 20 per cent by 2020 relative to the 1990 level. However, as the second CO_2 Act forms the legal framework for various measures, the mitigation impact is indicated in Tab. 15 and BR CTF table 3 as ‘included elsewhere’ (i.e. under the policies and measures presented below).

4.2.4 Third CO_2 Act (2021)

The third CO_2 Act will replace the second CO_2 Act and cover the period 2021–2030. It translates Switzerland’s commitments under the Paris Agreement into national law and defines reduction targets for greenhouse gas emissions (see discussion of the estimate of mitigation impact below) as well as the corresponding instruments. Since the Swiss Parliament has already approved Switzerland’s international emission reduction target under the Paris Agreement in 2017, the focus now lies on adopting the corresponding instruments to reach the target. Accordingly, the drafting of the third CO_2 Act is ongoing, as of autumn 2017 the feedbacks from the public consultation of a draft version from 2016 are implemented under the aegis of the Swiss Federal Office for the Environment. The Swiss Federal Council will send the finalised draft to the Swiss Parliament at the end of 2017, where the debate is planned to begin in 2018. The draft predominantly proposes the continuation and strengthening of the main instruments, with the following cornerstones (subject to parliamentary discussion):

- The CO_2 levy on heating and process fuels shall continue to be an important pillar of Swiss climate policy. The maximum possible level of the CO_2 levy on heating and process fuels proposed is 210 Swiss francs per tonne of CO_2. As in the current legislation under the second CO_2 Act, the CO_2 levy on heating and process fuels will augment automatically if defined intermediate targets were missed;
- The emissions trading scheme shall be continued and will deliver the most of the mitigation effort from industry. Importantly, the emissions trading schemes of Switzerland and the European Union are planned to be linked (see section 4.2.6 for details);
- The negotiated reduction commitments (for exemption from the CO_2 levy) has proven to be a useful instrument to cut emissions at the level of companies. It shall continue with little changes;
- A subsidiary ban for heating systems using fossil fuels was proposed in the public hearing of a draft of the third CO_2 Act at the end of 2016. However, given the rather sceptical feedbacks, the latest draft of the third CO_2 Act proposes a limit of specific emissions (in CO_2 per square metre energy reference area) for buildings instead should defined intermediate mitigation targets be missed in 2026/2027;

- The partial compensation of CO_2 emissions from motor fuel use shall continue. Until 2030, the compensation level will rise up to no more than 90 per cent of total emissions from motor fuels. At least 15 per cent shall be compensated in Switzerland, the rest under Article 6 of the Paris Agreement;
- CO_2 emission regulations for newly registered vehicles shall be continued and strengthened in line with the European Union.

Estimate of mitigation impact

The expected mitigation impact of the third CO_2 Act corresponds to its objective, i.e. a reduction of total greenhouse gas emissions (relative to 1990) by (i) 50 per cent by 2030 (at least 30 per cent domestic and at most 20 per cent abroad) and (ii) 35 per cent in the mean over the years 2021–2030 (at least 25 per cent domestic and at most 10 per cent abroad). As the third CO_2 Act will form the legal framework for the strengthening of various policies and measures currently implemented under the second CO_2 Act, its mitigation impact is indicated in Tab. 15 and BR CTF table 3 as 'included elsewhere' (i.e. under the policies and measures presented below).

4.2.5 CO_2 levy on heating and process fuels

By increasing the price of fossil heating and process fuels, the CO_2 levy sets an incentive to use fossil fuels more efficiently, to invest in low carbon technologies, and to switch to low-carbon or carbon-free energy sources. The CO_2 levy was introduced in January 2008 at an initial rate of 12 Swiss francs per tonne of CO_2. The CO_2 ordinance foresees an automatic increase of the rate to a maximum of 120 Swiss francs per tonne of CO_2 in case CO_2 emissions from heating and process fuels exceed the intermediate targets shown in Tab. 16.

Tab. 16 > Intermediate targets set out in Article 94 of the CO_2 ordinance to the second CO_2 Act, including corresponding increases of the CO_2 levy in case of non-compliance with the intermediate targets (the intermediate targets set out in Article 3 of the CO_2 ordinance to the first CO_2 Act are not shown here[22]). The attainment of the targets is evaluated based on the CO_2 statistics which is annually published at the beginning of July and which contains CO_2 emissions from heating and process fuels from the previous year. Accordingly, the relevant CO_2 emissions from heating and process fuels for the year 2016 are available as of July 2017, but will only be included in the greenhouse gas inventory submitted to the UNFCCC in 2018.

As of 1 January 2014: • Increase to 60 Swiss francs per tonne of CO_2 if the CO_2 emissions from heating and process fuels in 2012 exceed 79 per cent of 1990 emissions. ⇨ The rate of the CO_2 levy was increased to 60 Swiss francs per tonne of CO_2.
As of 1 January 2016: • Increase to 72 Swiss francs per tonne of CO_2 if the CO_2 emissions from heating and process fuels in 2014 exceed 76 per cent of 1990 emissions; • Increase to 84 Swiss francs per tonne of CO_2 if the CO_2 emissions from heating and process fuels in 2014 exceed 78 per cent of 1990 emissions. ⇨ The rate of the CO_2 levy was increased to 84 Swiss francs per tonne of CO_2.
As of 1 January 2018: • Increase to 96 Swiss francs per tonne of CO_2 if the CO_2 emissions from heating and process fuels in 2016 exceed 73 per cent of 1990 emissions; • Increase to 120 Swiss francs per tonne of CO_2 if the CO_2 emissions from heating and process fuels in 2016 exceed 76 per cent of 1990 emissions. ⇨ The rate of the CO_2 levy was increased to 96 Swiss francs per tonne of CO_2.

As a basic principle, proceeds from the CO_2 levy on heating and process fuels are refunded to the Swiss population (on a per capita basis) and to the Swiss economy (in proportion to wages paid). However, following a parliamentary decision in June 2009, up to a third (or a maximum of 300 million Swiss francs per year up to the end of 2017 and a maximum of 450 million Swiss francs as of 2018) of the revenues from the CO_2 levy is earmarked to finance the national buildings refurbishment programme (see section 4.3.3). This programme is partly co-funded out of cantonal budgets and co-managed by the Swiss government and the cantons. Additionally, 25 million Swiss francs per year are invested in a technology fund to promote innovative technologies that reduce greenhouse gas emissions and the consumption of resources, support the use of renewable energy and increase energy efficiency.

Planned strengthening

The Swiss Federal Council proposes to increase the maximum rate to 210 Swiss francs per tonne of CO_2 as part of the current revision of the CO_2 Act. As under the current legislation, the levy will be increased step-wise depending on the evolution of greenhouse gas emissions from heating fuels.

[22] https://www.admin.ch/opc/de/classified-compilation/20070960/201205010000/641.712.pdf

Estimate of mitigation impact

The CO_2 levy is expected to lead to a reduction of 1.6 million tonnes of CO_2 in 2020. For the purposes of estimating the mitigation impact, the CO_2 levy on heating and process fuels was fixed at 36 Swiss francs per tonne of CO_2 for the period 2010–2015. For 2016–2020 it was assumed that the CO_2 levy on heating and process fuels would be raised to 72 Swiss francs per tonne of CO_2. The estimations are based on model-based simulations that were conducted as an input for the message of the Swiss Federal Council on the Second CO_2 Act (*Ecoplan*, 2009*)*. The proposed increase of the maximum rate to 210 Swiss francs per tonne of CO_2 is projected to reduce another 1.3 million tonnes of CO_2 in 2030 (compared to a scenario where the rate is held constant at its current maximum level of 96 Swiss francs per tonne of CO_2).

4.2.6 Emissions trading scheme

Switzerland introduced its emissions trading scheme in 2008 in order to give companies – especially those industries with substantial CO_2 emissions resulting from the use of heating and process fuels as well as from cement production – the flexibility in contributing to CO_2 reduction goals under the same rules as their international competitors (at the same time being exempt from the CO_2 levy on heating and process fuels). The emissions trading scheme is based on the cap and trade principle. For the period 2013–2020, Switzerland’s emissions trading scheme has been aligned with the emissions trading scheme of the European Union with a view to link both systems. Notable amendments included the mandatory nature of the emissions trading scheme for large, greenhouse gas-intensive companies and partial auctioning of emission allowances. Rules for allocation of free emission allowances were harmonised and based on the same benchmarks of emissions performance as in the European Union.

Planned strengthening

For the period 2021–2030, the emissions trading schemes of Switzerland and the European Union are planned to be linked, after further developments to ensure compatibility of the two systems. Most importantly, this requires identical sectoral coverage. Therefore, Switzerland will have to include aircraft operators and gas-fired combined-cycle power plants in its emissions trading scheme. The maximal amount of available emission allowances (cap) will be reduced at 2.2 per cent per year instead of 1.74 per cent per year. The technical negotiations between Switzerland and the European Union on the linking of their emissions trading schemes have been completed in January 2016. The required bilateral agreement has been signed on 23 November 2017. It will enter into force as soon as both parties have ratified the treaty. This process of ratification, which also includes the approval of amendments to Swiss legislation to include aircraft operators and gas-fired combined-cycle power plants in the emissions trading scheme, is currently pending in the Swiss Parliament.

Estimate of mitigation impact

Based on the rate of reduction of the cap of 1.74 per cent per year and considering actual emissions covered by the emissions trading scheme, the mitigation impact of the emissions trading scheme until 2020 is estimated to be approximately 0.8 million tonnes of CO_2. Under the planned strengthening, the increase of the rate of reduction to 2.2 per cent per year from 2021 on will lead to an additional mitigation impact of one million tonnes of CO_2 in 2030.

4.2.7 Negotiated reduction commitments (for exemption from the CO_2 levy)

Companies with substantial CO_2 emissions may apply for exemption from the CO_2 levy without participation in the emissions trading scheme, provided they commit to emission reductions and they fulfil the requirements laid out in the CO_2 Ordinance. Companies have to elaborate emission reduction targets, which take into account the technological potential and economic viability of measures. The emissions reduction targets of companies are calculated from the starting point along a linear reduction course to the endpoint in the year 2020, either based on a simplified determination of the reduction course or an individual reduction course including a systematic analysis. As a further option, for companies that emit no more than 1’500 tonnes of CO_2 equivalents per year, economically viable measures (measures target) can be determined in a standardised procedure instead of a reduction course. The elaboration of negotiated reduction commitments and their implementation is assisted by two organisations mandated by the government (Swiss Energy Agency of the Economy and Cleantech Agency Switzerland, see section 9.2).

Planned strengthening

The current mechanism with negotiated reduction commitments for companies with substantial CO_2 emissions has proven to be a valuable instrument. As part of the current revision of the CO_2 Act, the Swiss Federal Council proposes its continuation with several adjustments aiming to reduce administrative costs and overlaps with cantonal instruments.

Estimate of mitigation impact

For 2020, the estimated mitigation impact of the negotiated reduction commitments (for exemption from the CO_2 levy) is estimated at about 400 thousand tonnes of CO_2 equivalents (Tab. 15 and BR CTF table 3). This estimation is based on the sum of reduction commitments of exempt companies, i.e. on total reductions needed to meet their negotiated targets. The additional mitigation impact of the continuation of the instrument beyond 2020 can be roughly estimated at 200 thousand tonnes of CO_2 equivalents by 2030, which corresponds to a 10 per cent decrease of total emissions of exempt companies. This estimation is very uncertain, because the details of the design and implementation of the instrument are subject to ongoing discussions.

4.3 Energy

4.3.1 Overview

Energy policy was anchored in the Federal Constitution of the Swiss Confederation in 1990, when an energy article was added. This article stipulates that the Swiss government and the cantons are obliged to use their competences to ensure an adequate, broad-based, secure, economic 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, including the ability to find compromise solutions that meet all criteria.

The energy article in the Federal Constitution of the Swiss Confederation is elaborated further in the Energy Act, the Nuclear Energy Act and the Electricity Supply Act. In addition to legal instruments and related measures, the energy policies of the Swiss government and the cantons are also based on ‘energy perspectives’ (models and scenarios of future energy production and consumption), ‘strategies’ (goal-oriented policy packages), implementation programmes focussing on information and promotion, and the periodic evaluation of energy-related measures at the municipal, cantonal and federal level.

Following the reactor disaster of Fukushima in 2011 the Swiss Federal Council and the Swiss Parliament decided on Switzerland’s progressive withdrawal from nuclear energy sources. This decision, together with further far-reaching changes in the international energy environment, requires an upgrading of the Swiss energy system. For this purpose the Swiss Federal Council has developed the Energy Strategy 2050.

On September 2013, the Swiss Federal Council submitted the first set of measures in the Energy Strategy 2050 (*Swiss Federal Council*, 2013a) to the Swiss Parliament. The Swiss Federal Council wishes to significantly develop the existing potential for energy efficiency and to exploit the potential of hydropower and the new renewable energies (sun, wind, geothermal, biomass). The set of measures entails a total revision of the Energy Law as well as changes in various other laws, e.g. the CO_2 Act. The Swiss Parliament approved the draft in a final vote on September 2016. The referendum request against the first bundle of measures was successful. In the referendum on 21 May 2017, the Swiss electorate approved the new Energy Act thus paving the way for a change in the national energy policy. The Act will take effect on 1 January 2018.

The Energy Strategy 2050 sets a number of priorities to assure the future energy supply, such as reduction in energy consumption, broadening of the portfolio of energy sources, expansion and restructuring of the electricity transmission grid as well as energy storage. As part of the Energy Strategy 2050, emphasis is placed on increased energy savings (energy efficiency), the expansion of hydropower and implementation of new renewable energies. The new Energy Act sets guidelines for energy and electricity consumption and for production of new renewable sources and for hydropower. Adherence to these guidelines will be among the topics and indicators which will be the focus of the monitoring procedure incorporated in Energy Act 2050 that will commence once the Act goes into effect. In addition and if necessary, fossil fuel-based electricity production (mainly gas-fired combined-cycle power plants for peak supply, but also combined heat and power production for baseload in winter) as well as enhanced imports are options foreseen in the strategy.

Within the context of the Energy Strategy 2050, priority areas particularly relevant to climate policy goals are:

- **Reduction in energy consumption:** The new Energy Act contains reference values of –16 per cent energy consumption per person and –3 per cent electricity consumption per person until 2020 and of –43 per cent energy consumption per person and –13 per cent electricity consumption per person until 2035 compared to 2000. On this basis, the energy strategy shall contribute to achieve the long-term goals of Switzerland's climate policy – to reduce greenhouse gas emissions to 1 to 1.5 tonnes of CO_2 equivalents per year and person by 2050. The government intends to encourage the economical use of energy in general and of electricity in particular. Enhanced efficiency measures include minimum requirements for appliances (best practice, energy label) and other regulations, bonus malus mechanisms (efficiency bonus), measures to raise public awareness (strengthening of the SwissEnergy programme, described below) and measures regarding the production of heat;
- **Broadening of electricity supply:** Hydropower and new renewable electricity generation should be bolstered in particular. Their share in the current energy mix needs to be expanded substantially. This is the main aim of the feed-in remuneration (electricity network surcharge), raising funds for promotional measures. However, in order to meet demand, fossil fuel-based electricity generation may need to be expanded by constructing gas-fired combined-cycle power plants intended to provide peak load, but also combined heat and power plants for base load in winter. The government is retaining its climate policy objectives (see section 4.3.6), therefore emissions caused by new fossil fuel-based power plants must be compensated;
- **Expansion and restructuring of electricity transmission grid and energy storage:** The increasing share of intermittent power production by renewable energies (wind, solar) requires the expansion and restructuring of transmission grids and of the pool of power plants to ensure temporary power balancing as well as the necessary storage and reserve capacities. 'Smart grids' are important prerequisites for future domestic production infrastructures and electricity exchange. They allow direct interaction between consumers, the network and power producers and offer great potential with regard to optimising the electricity system, delivering energy savings and, consequently, bringing down costs;
- **Strengthening energy research:** An action plan on 'Coordinated Energy Research Switzerland' was created as a consequence of the Swiss decision to phase out nuclear energy. It aims at building up capacities in energy research and strengthening thematic focal points in seven clearly defined fields of action. Within the framework of the Energy Strategy 2050, the Swiss Parliament adopted the 'Coordinated Energy Research' action plan for the period from 2013 to 2016 as a supplement to the existing energy research programme. This action plan is supporting the implementation of the Energy Strategy 2050 by providing additional research capacity at universities and colleges of technology in the area of application-oriented energy research. For the implementation of this action plan, eight specialised competence centres were created (Swiss Competence Centres for Energy Research SCCER, see section 8.1.1).

The Swiss Federal Council submitted the Climate and Energy Incentive System (KELS) to the Swiss Parliament as the second stage of Energy Strategy 2050. Neither chamber advocated any of the proposals aimed at establishing a constitutional article stipulating use of an incentive tax on energy.

The monitoring procedure mentioned in Energy Strategy 2050 will reveal whether further measures will be required in the field of energy efficiency. There will be an opportunity to discuss how to guarantee the long-term security of electricity supplies within the debate about the design of the electricity market after 2020. The market design should be compatible with Swiss climate targets, complete liberalisation of the market and with an agreement with the European Union on electricity supplies.

Currently, the Swiss Parliament is debating another proposal dealing with the modernisation and expansion of the grid. The idea behind the electricity grid strategy (SSN) is to establish new legislative conditions for the development of the grid. The aim of the proposal is to ensure the prompt needs-oriented development of Switzerland's electricity grids to guarantee the security of the electricity supply. In the main the proposal is not in dispute and the few differences in opinion are being reconciled.

Tab. 17 gives an overview of the most climate-relevant policies and measures in the energy sector. The following sections provide more details and background information on each policy and measure.

Tab. 17 > Summary of policies and measures in the energy sector. The sector affected is 'energy' for all policies and measures presented in this table.

Name of policy or measure [a]	Greenhouse gas(es) affected	Objective and/or activity affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative, in kt CO_2eq) 2020
SwissEnergy programme *	CO_2	Promotion of energy efficiency and the increased use of renewables.	Information, education	Implemented	Major policy instrument engaging cantons, municipalities, industry, as well as environmental and consumer associations for awareness raising and the promotion of increased energy efficiency and the enhanced use of renewable energy.	2001	SFOE	NE [b]
National buildings refurbishment programme *	CO_2	Refurbishment of existing buildings envelope and Incentives for renewable energy, energy recuperation and optimisation of building technology.	Economic	Implemented (strengthening planned)	The programme increases the energy efficiency of buildings and promotes the use of renewable energies in the buildings sector. Financed by one third of the revenue from the CO_2 levy on heating and process fuels, with additional funds provided by the cantons.	2010	SFOE, FOEN, cantons	1'120
Building codes of the cantons *	CO_2	Stringent energy consumption standards for new buildings.	Regulatory	Implemented (strengthening planned)	A set of common energy and insulation standards (model ordinances) to reduce energy consumption of buildings agreed on by the cantonal energy directors. Implementation of the further tightening of standards by 2018 has been agreed in 2011.	1992	Cantons, in coordination with SFOE	1'760
Negotiated commitments on energy efficiency *	CO_2	Exemption from electricity network surcharges under the Energy Act.	Economic, voluntary/negotiated agreements	Implemented	Full or partial refund of electricity network surcharges (raised for the promotion of renewable energies) to energy-intensive companies if they commit to enhance energy efficiency in a target agreement. The target agreements need to follow the guidance provided by the Swiss government and have to be elaborated in collaboration with two specialised organisations.	2014	SFOE	NE [b]
Obligation to offset emissions from gas-fired combined-cycle power plants *	CO_2	Avoid new large sources of CO_2 from electricity or heat generation.	Regulatory	Implemented (strengthening planned)	Fossil thermal power plants with a capacity larger than 100 megawatts obtain planning permission only if their CO_2 emissions are fully compensated. Under the second CO_2 Act, at least half of the compensation has to be achieved domestically.	2008	FOEN	NA [c]
Negotiated reduction commitment of municipal solid waste incineration plant operators	CO_2	Contribution to emission reduction by municipal solid waste incineration plant operators through energy efficiency measures and metal recuperation.	Regulatory	Implemented	Agreement committing the association of municipal solid waste incineration plant operators to establish a monitoring system and to reduce net CO_2 emissions. Implementation of the agreement exempts municipal solid waste incineration plant operators from participation in the emissions trading scheme.	2014	FOEN	200 [d]

[a] Policies and measures marked with an asterisk (*) are included in the 'with measures' projection.

[b] See the respective sections (4.3.2 and 4.3.5) for more information regarding the mitigation impact.

[c] It is currently uncertain when (and if) new gas-fired combined-cycle power plants will be realised in Switzerland. In any case, the obligation to offset emissions from gas-fired combined-cycle power plants aims at ensuring their climate-neutral operation (partly using international carbon credits).

[d] Agreed (net) emission reduction commitment is 200 thousand tonnes of CO_2 equivalents below 2010 emissions by 2020. The recuperation of metals may lead to (indirect) reductions of greenhouse gas emissions outside Switzerland.

NA, not applicable; NE, not estimated
FOEN, Swiss Federal Office for the Environment; SFOE, Swiss Federal Office of Energy

4.3.2 SwissEnergy programme

In 2001, the Swiss Federal Council launched the 'SwissEnergy' programme, in line with the Energy Act and the CO_2 Act that came into force in 1999 and 2000, respectively. It aims at reducing fossil fuel use and CO_2 emissions as required by the CO_2 Act and contains targets for electricity generation and heat production from renewable sources. The SwissEnergy programme represents a major policy instrument for awareness raising and promoting an increase in energy efficiency and the enhanced use of renewable energy (see section 9.2). Measures are mostly voluntary in nature, supporting the effect of regulatory measures. Running initially from 2001 to 2010, the programme has been extended to 2020.

SwissEnergy is managed by the Swiss Federal Office of Energy. Projects are normally run in close cooperation with cantons, municipalities, and industry, as well as environmental and consumer associations. Programme results are subject to detailed monitoring and verification. To bolster the implementation of the Energy Strategy 2050, Swiss Energy's funding was increased, reaching 45 million Swiss francs in 2014 and 55 million Swiss francs in 2015. Additional funding is to be sourced from third parties (trade and industry, cantons and municipalities).

In recent years, several tasks formerly vested with SwissEnergy have become a legal obligation: promotion of renewables has shifted from a programme-type activity supplementing a modest and inadequate feed-in tariff to a comprehensive feed-in system, whose enforcement and continuity is guaranteed by law. Many minimum efficiency performance standards, previously introduced in the form of voluntary agreements (cars, some appliances) or codes of conduct (some energy-using products), are now legally mandated and aligned with the standards of the European Union. Hence, the role of SwissEnergy is shifting towards that of a facilitator for the above mentioned regulations and laws.

Estimate of mitigation impact

The SwissEnergy programme covers a number of fields each requiring the use of very different – and very specific – instruments and means of communication. The focus of the programme is on soft measures (information, consulting, training and continuing education, quality assurance), therefore the mitigation impact cannot be quantified for lack of methodology. In addition, the SwissEnergy programme provides advice about implementation of regulations and promotional programmes and is primarily responsible for ensuring that enough trained people are available and that measures are publicised. These are necessary activities, but their mitigation impact cannot be looked at in isolation from the measures being applied. For all these reasons, the mitigation impact of the SwissEnergy programme is reported as 'not estimated' in Tab. 17 and BR CTF table 3.

4.3.3 National buildings refurbishment programme

In order to increase the refurbishment rate of buildings and to promote the use of renewable energies in the buildings sector, a third of the revenues from the CO_2 levy on heating and process fuels were earmarked for this purpose in the framework of the first CO_2 Act. In 2009, the Swiss Parliament adopted the national buildings refurbishment programme (operational since 1 January 2010). The programme was collectively developed by the cantons, represented by the Conference of Cantonal Energy Directors and the federal administration (Swiss Federal Office of Energy, Swiss Federal Office for the Environment). The cantons are responsible for its implementation. The duration of the programme is limited to ten years. A mid-term evaluation has been submitted to the Swiss Parliament in 2016. Some numbers on the cost-effectiveness of the programme on the basis of the most recent annual reporting (*EnDK*, 2015) are given below.

With the revision of the CO_2 Act in 2011, the Swiss Parliament increased the maximum amount earmarked for the national buildings refurbishment programme from 200 million to 300 million Swiss francs per year. Available funds are linked to the actual level of the CO_2 levy. With the increases of the CO_2 levy at the beginning of 2014 and 2016, more financial means are available to promote measures to reduce greenhouse gas emissions from buildings.

Until 2016, the national buildings refurbishment programme was divided into two distinct parts: (i) part A, refurbishment of existing building envelope and (ii) part B, promotion of renewable energy, energy recuperation and optimisation of building technology. This segregation of tasks was abolished as a result of reorganisation of the programme in 2017.

For refurbishment of existing buildings envelope and use of renewable energy, energy recuperation and optimisation of building technology up to 15 per cent of total investment costs are sponsored by the programme. In 2015, about four million square metres of building surface were refurbished with the support of the programme. The main focus was on roofs and facades. Also high contributions to CO_2 reduction came from the installation of wood-based heating systems, including district heating. Other important elements were waste heat utilisation, heat pumps and solar collectors. The cumulative effect of the programme since its inception in 2010 till 2015 amounts to 18.6 million tonnes of CO_2 (taking account of the entire lifespan of the measures).

Average costs per tonne of CO_2 reduced was 64 Swiss francs (combined funds from the federal and the cantonal level). Beyond the national buildings refurbishment programme, several cantons provide financial support to measures such as promotion of photovoltaics and consulting of building owners. However, there is no systematic overarching evaluation of the quantitative effect of these measures on CO_2 emissions.

After the adoption of the new Energy Act in May 2017, more funding will be available to the national buildings refurbishment programme as of 1 January 2018 and the maximum amount earmarked for the national buildings refurbishment programme will increase from 300 million to 450 million Swiss francs per year. The time limitation set for the programme of 2019 will also be abolished.

Planned strengthening

Within the framework of Switzerland's climate policy for the years after 2020, the Swiss Federal Council proposes to extend the partial earmarking of funds until 2025.

Estimate of mitigation impact

A model which allots a CO_2 mitigation impact to each measure realised (e.g., per square metre of insulation) was used to calculate the mitigation impact of the national buildings refurbishment programme. For the calculation, dead-weight effects were also taken into consideration and assumptions were made concerning the funds to be allotted. The model, taking into account the investements available up to 2020, provides a mitigation impact of 1.12 million tonnes of CO_2 equivalents by 2020 (Tab. 17 and BR CTF table 3).

4.3.4 Building codes of the cantons

The cantons are responsible to decree any regulations in the buildings sector. Under the second CO_2 Act they are required to define standards for the continuous reduction of CO_2 emissions in new and existing buildings (Article 9).

In order to harmonise the building codes throughout Switzerland, the cantons, under the guidance of the Conference of Cantonal Energy Directors, agreed on model ordinances. Model ordinances were first established in 1992 and have been updated periodically since (i.e. in 2000, 2008, and 2014, see *EnDK*, 2014).

Planned strengthening

According to a declaration of intent issued by the general assembly of the members of the Conference of Cantonal Energy Directors in 2011, cantons will by 2018 integrate the 2014 version of the model ordinances into cantonal legislation in order to become effective by 2020 at the latest. Minimum requirements of this version are: New buildings must be autonomous with regard to their own heat demand and produce a reasonable share of their electricity demand, the use of electricity for heating and warm water production is prohibited, the refurbishment of existing buildings, and the switch to renewables are to be promoted increasingly.

Estimate of mitigation impact

The mitigation impact of the building codes of the cantons on greenhouse gas emissions mainly results from insulation requirements for building refurbishment and new constructions. The estimate of 1.76 million tonnes of CO_2 equivalents by 2020 indicated in Tab. 17 and BR CTF table 3 is based on assumptions about the energy reference area, rate of refurbishment, heat consumption before and after renovation, and heat consumption of new buildings (used as input into the computable general equilibrium model of *EPFL and Infras* (2016) and *EPFL* (2017) for the calculation of projections, see chapter 5).

4.3.5 Negotiated commitments on energy efficiency

The Energy Act foresees financial contributions for the promotion of renewable energies. The contributions are financed by means of electricity network surcharges, which presently amount to 0.015 Swiss francs per kilowatt-hour at the most. Energy-intensive companies can be granted a full or partial refund of the electricity network surcharges, provided they comply with certain conditions, inter alia, a commitment to enhancing energy efficiency in a target agreement with the Swiss government.

As a result of the adoption of the Energy Strategy 2050, two changes to requirements enter into force as of January 2018, leading to a higher number of companies entitled to a refund:

- Increase in the grid surcharge from 1.5 cents to 2.3 cents per kilowatt-hour;
- Inclusion of the grid surcharge paid in energy costs.

It is assumed that many more companies will meet the minimum requirements as a result of these changes.

Estimate of mitigation impact

The influence on CO_2 emissions cannot be estimated, because it is not yet clear how many companies would make target agreements to increase energy efficiency. Accordingly, the mitigation impact of the negotiated commitments on energy efficiency is indicated as 'not estimated' in Tab. 17 and BR CTF table 3.

4.3.6 Obligation to offset emissions from gas-fired combined-cycle power plants

Currently, no gas-fired combined-cycle power plants are in operation in Switzerland, and it is unclear whether there will be a need for such power plants to cover future electricity demand. Nevertheless, since 2008, gas-fired combined-cycle power plants with a capacity larger than 100 megawatts obtain planning permission only if their CO_2 emissions are fully compensated. Compared to the first CO_2 Act, the possibility to use flexible mechanisms under the Kyoto Protocol to compensate for CO_2 emissions has been raised from 30 to 50 per cent under the second CO_2 Act, i.e. at least half of the compensation has to be achieved domestically.

Planned strengthening

With the planned linking of the Swiss emissions trading scheme with the one of the European Union, gas-fired combined-cycle power plants shall be implemented in the emissions trading scheme. As in the European Union, there will be no free allocation for producing electricity. Therefore, future gas-fired combined-cycle power plants in Switzerland will have to compensate their emissions by buying emission allowances in the emissions trading scheme.

Estimate of mitigation impact

It is currently uncertain when (and if) gas-fired combined-cycle power plants will be realised in Switzerland. Accordingly, the mitigation impact of the obligation to offset emissions from gas-fired combined-cycle power plants is indicated in Tab. 17 and BR CTF table 3, for 2020, as 'not applicable'. However, the policy and measure will ensure the climate-neutral operation of gas-fired combined-cycle power plants in any case (partly using international carbon credits).

4.3.7 Negotiated reduction commitment of municipal solid waste incineration plant operators

Greenhouse gas emissions from waste incineration plants have been increasing to about two million tonnes of CO_2 equivalents (roughly four per cent of the national total) by 2015, mainly due to growth of the economy and the population. In the context of national climate mitigation commitments, municipal solid waste incineration plant operators are expected to contribute to emission reduction efforts. In 2014, the Swiss Federal Department of Environment, Transport, Energy and Communications concluded an agreement with the Swiss Association of municipal solid waste incineration plants. This agreement commits the association to establish a monitoring system and to reduce net CO_2 emissions by 200 thousand tonnes by 2020, compared to 2010 levels, and to reduce cumulative net emissions over the period 2010–2020 by one million tonnes. Since the potential for direct emission reductions at the incineration plants is limited, improvements in the efficiency of the use of the heat generated and avoided emissions through the recuperation of metals are taken into account (bottom ash of the municipal solid waste incineration plants containing on average about 10 per cent scrap iron and significant amounts of non-iron metals such as aluminium, copper, brass etc.). Note, however, that the recuperation of metals may also lead to (indirect) reductions of greenhouse gas emissions outside Switzerland, i.e. the direct impact on Switzerland's total greenhouse gas emissions is difficult to estimate. Implementation of the agreement exempts municipal solid waste incineration plant operators from participation in the emissions trading scheme. The association was also obliged to establish a monitoring system to track progress towards the goals set in the agreement, and to hand in a report on an annual basis that described the results of the monitoring process.

The agreement between the Swiss Federal Department of Environment, Transport, Energy and Communications and the Swiss Association of municipal solid waste incineration plants is valid until 2021. If still possible under future legal frameworks, negotiations on a possible follow-up agreement covering the period until 2030 will be taken up in due time.

Estimate of mitigation impact

The expected mitigation impact of the agreement corresponds to its objectives, i.e. 200 thousand tonnes of CO_2 equivalents by 2020 (Tab. 17 and BR CTF table 3). However, the agreement does not include a reduction target for the emissions from waste incineration plants, implying that these emissions might still increase, but rather builds on improvements in the efficiency of the use of energy and the avoidance of emissions through increased recuperations of metals (potentially leading to indirect reductions of greenhouse gas emissions outside Switzerland).

4.4 Transport

4.4.1 Overview

Switzerland has developed an integrated strategy for transport, seeking better coordination between transport modes, spatial planning, and taking into account environmental and sustainability concerns. While several measures are designed to reduce specific energy consumption or to address CO_2 emissions from the transport sector, many are part of the general transport policy approach that involves reducing unnecessary motorised mobility, shifting traffic from road to more environmentally friendly modes, and improving intermodal transport chains and interconnectivity.

The latest projections (*ARE*, 2016) 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 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-motorised 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 by developing the Agglomeration Programme (see below). For over 20 years, the coordination of pedestrian and hiking networks has been laid down in the Federal Constitution of the Swiss Confederation. As a reaction to a popular petition and to strengthen non-motorised transport, the Swiss Federal Council formulated a counter-proposal to lay down cycle networks in a similar manner. The referendum on this proposal will be held in 2019.

Switzerland has an excellent rail infrastructure that is permanently maintained, modernised and improved. The first phase of a major expansion of rail transport capacity, RAIL 2000, was opened on 12 December 2004. It marked a milestone for Swiss public transport, as rail service levels increased by 12 per cent from one day to the next (more trains and faster connections between Swiss cities). As a follow-up of RAIL 2000, a new Federal Act on the Future Development of Rail Infrastructure (*Swiss Confederation*, 2009) was enacted in 2009 to further modernise and expand the Swiss rail network. At present, work is progressing on the New Rail Link through the Alps (NRLA) and other projects for expanding rail capacity by 2025 are under way. By also improving connections to the European high-speed rail network, Swiss transport policy encourages the modal shift of short-distance international traffic from air to rail.

In the past, financing of the major rail infrastructure projects was secured on the basis of the temporary ‘FinÖV’, a public transport fund, which drew revenues from the heavy vehicle charge. As from 1 January 2016, subsequent to a popular vote in 2014, operation, maintenance and extension of rail infrastructure are financed through a single, open-ended ‘Rail Infrastructure Fund’.

Funding for development and maintenance of road infrastructure is provided through the ‘Infrastructure Fund for Agglomeration Transport, the National Road/Motorway Network and Major Roads in Mountain and Peripheral Regions’, which was launched in 2007 and is running until 2027. Out of this fund, Switzerland runs an Agglomeration Programme aimed at providing financial resources (3.44 billion Swiss francs) for infrastructure projects that promote public and non-motorised transport in sub-urban regions and agglomerations. In 2018, the Infrastructure Fund will be replaced by the newly adopted and unlimited ‘Fund for the National Motorway Network and Agglomeration Transport’.

The two-lane Gotthard road tunnel connecting Northern Switzerland to the Ticino and Italy was opened in 1980. After 35 years of operation it needs major refurbishment. The Swiss Federal Council and the Swiss Parliament have proposed to construct a second tunnel. This would allow for closing of the first tunnel during refurbishment works without lengthy interruption of this important traffic link. In addition, two tunnels would lead to safer operating conditions in the future. A referendum on this proposal was held in February 2016 and approved. The referendum was motivated by concerns that the two tunnels will be opened to four-lane traffic once refurbishment of the first tunnel is completed, leading to a conflict with the intention of Article 84 of the Federal Constitution of the Swiss Confederation (section 4.4.6). The second road tunnel is scheduled to open in 2027.

As the share of emissions from Switzerland’s domestic aviation is very small, Switzerland’s aviation policy is focused on international aviation, and, thus, mainly targets bunker fuels. Switzerland joined the International Civil Aviation Organisation in 1947 and the European Civil Aviation Conference in 1955. Under the air transport agreement between Switzerland and the European Union, which came into effect on 1 June 2002, Switzerland adopted European civil aviation legislation that was in force when the agreement was concluded and regularly adapts the agreement to new legislation entering into force in the European Union. In 2006, Switzerland joined the European Aviation Safety Agency (EASA). Switzerland’s aviation legislation and policy is therefore shaped by the regulations of the International Civil Aviation Organisation and European Civil Aviation Conference, as well as by developments within the European Union. Switzerland’s foreign relations are further governed by bilateral and multilateral agreements; bilateral aviation agreements were concluded with more than 130 countries. The reduction of aircraft fuel consumption is strongly driven by market forces. In Switzerland, the CO_2 emissions per passenger kilometre for the whole aircraft fleet have been reduced by 42 per cent between 1990 and 2015, therefore showing an average improvement of 1.7 per cent per year during this period. Switzerland expects this number to even improve during the next decade, by fleet renewal, efficiency improvement packages and production cut-off triggered by the new standard. The international orientation of Switzerland’s aviation policy is reflected in the policies and measures presented in section 4.4.8, 4.4.9 and 4.4.10.

Tab. 18 gives an overview of the climate-relevant policies and measures of the transport sector, while the following sections provide more details and background information on each policy and measure.

Tab. 18 > Summary of policies and measures in the transport sector. The sector affected is ‘Transport’ for all policies and measures presented in this table.

Name of policy or measure [a]	Greenhouse gas(es) affected	Objective and/or activity affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative, in kt CO_2eq) 2020
CO_2 emission regulations for newly registered vehicles *	CO_2	Reduction of average fuel consumption and CO_2 emissions from new passenger cars and light duty trucks.	Regulatory	Implemented (strengthening planned)	CO_2 emission targets for newly registered vehicles in line with regulations of the European Union. The target by 2020 for passenger cars (fleet average) has been set at 95 grams of CO_2 per kilometre, for light commercial vehicles at 147 grams of CO_2 per kilometre. Vehicle importers have to pay a sanction if the individually specified target is not met.	2012	SFOE, FEDRO	1’700 [b]
Energy label for new motor vehicles *	CO_2	Raise visibility of cars with low average fuel consumption and CO_2 emissions.	Information, regulatory	Implemented (continuation planned)	Mandatory label displayed at the point of sale providing information on the fuel consumption (litres per 100 kilometre) and CO_2 emissions (in grams of CO_2 per kilometre) of every passenger car.	2003	SFOE	IE [c]
Climate Cent *	CO_2, CH_4, N_2O	Compensation of transport emissions (i) through funding of mitigation projects within Switzerland and (ii) by use of international carbon credits.	Voluntary agreement	Expired (implemented from 2005 to 2012)	Voluntary agreement with a private sector initiative in place of a CO_2 levy on fossil motor fuels. Obligation (i) to offset two million tonnes of CO_2 during the first commitment period of the Kyoto Protocol (2008–2012)	2005	Climate Cent Foundation	NA [d]

					through investments in domestic emission reduction projects and (ii) to purchase a total of 16 million international carbon credits. Financed by a surcharge of 0.015 Swiss francs per litre on motor fuels.			
Partial compensation of CO_2 emissions from motor fuel use *	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3	Domestic mitigation projects as compensatory measure (instead of a CO_2 levy on motor fuels).	Regulatory	Implemented (strengthening planned)	Obligation for importers to offset part of the CO_2 emissions from motor fuel use through investments in domestic emission reduction projects. Financed by a surcharge on imported fuels not exceeding 0.05 Swiss francs per litre of fuel. The share of CO_2 emissions to be offset is gradually increased from 2 to 10 per cent by 2020.	2013	Foundation for Climate Protection and Carbon Offset, FOEN	1'500
Heavy vehicle charge *	CO_2	Reduction of transalpine road traffic, increase of transport rates on rail, limit increase in heavy vehicles on the road.	Fiscal	Implemented	Charges applied to passenger and freight transport vehicles of more than 3.5 tonnes gross weight, aiming at a shift of transalpine transport from road to rail. The level of the charge depends on the maximum weight and emission standards of the individual vehicle.	2001	ARE, FEDRO	140
Mineral oil tax reduction on biofuels and natural gas *	CO_2	Promotion of low carbon motor fuels.	Fiscal	Implemented	Tax reduction of 0.4 Swiss francs per litre of petrol equivalent for natural and liquefied petroleum gas (LPG). Complete tax exemption for biogas and other fuels from renewable sources if certain (ecological and social) criteria are met. Tax revenue losses are compensated by increasing tax rates on liquid fossil motor fuels.	2008	FCA, in collaboration with FOEN and SECO	220
Inclusion of aviation in the emissions trading scheme	CO_2	Limit/offset CO_2 emissions from international aviation.	Regulatory, economic	Planned	Inclusion of (international) aviation into the emissions trading scheme. Implementation is contingent on the linking of the emissions trading schemes of the European Union and Switzerland.	NA [e]	FOCA, FOEN	NA [f]
CO_2 emissions standard for aircraft	CO_2	Reduction of average fuel consumption and CO_2 emissions from new and in-production aircraft.	Regulatory	Adopted	CO_2 emission targets for new aircraft designs from 2020, for in-production aircraft from 2023 and production cut-off from 2028.	2020	FOCA	NA [f]
Carbon offsetting and reduction scheme for international civil aviation (CORSIA)	CO_2	Carbon neutral growth of international civil aviation as of 2020.	Regulatory	Planned	Emissions from international civil aviation above 2020 levels will have to be offset by operators. Applicable standards and recommended practices are currently being developed by the International Civil Aviation Organisation.	2021	FOCA, FOEN	NA [f]

[a] Policies and measures marked with an asterisk (*) are included in the 'with measures' projection.

[b] This estimate presupposes an average fuel consumption of new passenger cars of 95 grams of CO_2 per kilometre.

[c] The mitigation impact of the energy label for new motor vehicles is included in the mitigation impact of the CO_2 emission regulations for newly registered vehicles.

[d] Total domestic reductions achieved by the Climate Cent Foundation during the first commitment period (2008–2012) was 2.7 million tonnes of CO_2 equivalents. The ongoing mitigation impact of Climate Cent Foundation projects after 2012 is contained in the subsequent measure 'Partial compensation of CO_2 emissions from motor fuel use'. Total contribution of international carbon credits acquired by the Climate Cent Foundation during the first commitment period (2008–2012) was 16.0 million tonnes of CO_2 equivalents.

[e] A prerequisite for the inclusion of aviation in the emissions trading scheme is the linking of the emissions trading schemes of Switzerland and the European Union. However, because the process of ratification of the required bilateral agreement is currently pending in the Swiss Parliament, the start year of implementation is not yet known (see also section 4.2.6).

[f] The mitigation impact of these adopted/planned measures will develop after 2020 (preparatory measures may be implemented beforehand).

IE, included elsewhere; NA, not applicable
ARE, Swiss Federal Office for Spatial Development; FCA, Swiss Federal Customs Administration; FEDRO, Swiss Federal Roads Office; FOCA, Swiss Federal Office of Civil Aviation; FOEN, Swiss Federal Office for the Environment; SECO, Swiss State Secretariat for Economic Affairs; SFOE, Swiss Federal Office of Energy

4.4.2 CO_2 emission regulations for newly registered vehicles

Because a voluntary agreement signed in 2002 by the Association of Swiss Automobile Importers to reduce the specific fuel consumption of first-time registration cars was insufficient, the Swiss Parliament amended the CO_2 Act in 2011 to include CO_2 emission targets for newly registered vehicles. The prescriptions came into effect in July 2012 and are based on the European Union regulation. In the first phase from 2012 through 2015, a fleet average target of 130 grams of CO_2 per kilometre applied. The fleet average emission in 2015 was 135 grams of CO_2 per kilometre and therefore slightly exceeded the target. Most vehicle importers reached their individual targets, penalty payments for those importers with excess emissions totalled 12.6 million Swiss francs. The Swiss Federal Council intends to follow the European Union regulation proposals for further decarbonising road traffic. Targets of 95 grams of CO_2 per kilometre by 2020 for new passenger cars and of 147 grams of CO_2 per kilometre by 2020 for light commercial vehicles are part of the first bundle of measures of the Energy Strategy 2050 (section 4.3.1), which was adopted on 21 May 2017 and will enter into force as of 1 January 2018.

Planned strengthening

For the period from 2025 onwards, the Swiss Federal Council has proposed to further decrease the emission reduction targets in line with the European Union.

Estimate of mitigation impact

The mitigation impact is estimated at 1.7 million tonnes of CO_2 equivalents per year by 2020 (Tab. 18 and BR CTF table 3). This mitigation impact is calculated by comparing a scenario where the new vehicle fleet attains the efficiency target of 130 grams of CO_2 per kilometre with only little delay to a scenario where only autonomous fuel efficiency improvements are assumed in the absence of any regulations. The additional mitigation impact for the period after 2025 can currently not be estimated, because the emission reduction targets for this period are not yet defined[23].

4.4.3 Energy label for new motor vehicles

Since 2003, the compulsory energy label for newly sold cars informs customers at the point of sale about fuel consumption and specific CO_2 emissions. It classifies cars into one of seven energy efficiency classes from A to G using well-to-wheel energy consumption. Evaluation criteria are adapted at yearly intervals to follow technological development in the automotive sector. The energy label supports the efforts with regard to the CO_2 emission regulations for newly registered vehicles (section 4.4.2).

Estimate of mitigation impact

The energy label for new motor vehicles is a purely informative measure for car buyers. An estimate from 2005 found a positive impact on energy efficiency. However, there is no recent quantitative estimate. Surveys demonstrate that energy efficiency and low fuel consumption are important criteria for the purchase of new cars and the energy label is known among a majority of car buyers. A positive overall qualitative impact on energy efficiency is expected. In any case, the mitigation impact of the energy label for new motor vehicles is included in the mitigation impact of the CO_2 emission regulations for newly registered vehicles (section 4.4.2), and, thus, reported as ‘included elsewhere’ in Tab. 18 and BR CTF table 3.

4.4.4 Climate Cent

When implementing the first CO_2 Act in 1999 (section 4.2.2), the Swiss Federal Council dispensed with the introduction of a CO_2 levy on motor fuels. Instead, it entered into a voluntary agreement with the Climate Cent Foundation, a private sector initiative, in 2005. The agreement contained the obligation to account for annual emission reductions of 3.2 million tonnes of CO_2 equivalents through the purchase of international carbon credits (CERs, ERUs) and 0.4 million tonnes of CO_2 equivalents through investments in domestic emission reduction projects, respectively, during the

[23] An earlier proposition that was discussed in the European Union aimed at reducing the emission reduction targets for new passenger cars to 68 to 78 grams of CO_2 per klilometre and for new light commercial vehicles to 105 to 120 grams of CO_2 per kilometre. A reduction to the lower ends of these ranges (68 and 105 grams of CO_2 per kilometre, respectively) would lead to an additional mitigation impact of 300 thousand tonnes of CO_2 by 2030. While this proposition is no longer valid, it was used in the WAM scenario (see section 5.3.1) as a proxy for the quantification of the mitigation impact of a further strengthening of the CO_2 emission regulations for newly registered vehicles.

period 2008–2012. The so-called 'Climate Cent', setting a surcharge of 0.015 Swiss francs per litre on motor fuels, was in effect from October 2005 to August 2012.

As of 2013, the Climate Cent was replaced by the legally binding obligation for importers of fossil motor fuels to compensate part of the emissions linked to fossil motor fuel use (section 4.4.5). Excess revenues amounting to 150 million Swiss francs, collected by the Climate Cent Foundation until 2012, are to be used by the foundation for the acquisition of international carbon credits. These will be handed over to the government to meet obligations under the international climate regime, as detailed in an agreement between the Climate Cent Foundation and the Swiss Confederation (*Climate Cent Foundation and Swiss Confederation*, 2013).

Estimate of mitigation impact

The Climate Cent was implemented from 2005 to 2012. The ongoing mitigation impact of projects of the Climate Cent Foundation after 2012 is contained in the subsequent measure partial compensation of CO_2 emissions from motor fuel use (section 4.4.5). During the first commitment period of the Kyoto Protocol (2008–2012), the international carbon credits acquired by the Climate Cent Foundation accounted for 16.0 million tonnes of CO_2 equivalents, while domestic reductions achieved by the Climate Cent Foundation during the same time period accounted for 2.7 million tonnes of CO_2 equivalents (*Climate Cent Foundation*, 2013). As the Climate Cent has expired, the mitigation impact for 2020 is indicated as 'not applicable' in Tab. 18 and BR CTF table 3.

4.4.5 Partial compensation of CO_2 emissions from motor fuel use

Based on the second CO_2 Act (section 4.2.3), as of 2014, fossil fuel importers are bound to offset part (at most 40 per cent) of the CO_2 emissions from motor fuel use through investments in domestic emission reduction projects. The offset is financed by a surcharge on imported fuels which shall not exceed 0.05 Swiss francs per litre of fuel. The Swiss Federal Council determined the share of CO_2 emissions from motor fuels to be offset by fuel importers as follows:

- Two per cent in 2014–2015;
- Five per cent in 2016–2017;
- Eight per cent in 2018–2019;
- 10 per cent in 2020.

The revenues and climate change abatement measures are managed by the follow-up organisation to the Climate Cent Foundation, the Foundation for Climate Protection and Carbon Offset (KliK). By the end of 2015, KliK was budgeting for the compensation of a cumulative total of 6.5 million tonnes of CO_2 equivalents for the years 2013 to 2020, achieved by national projects and programmes, as well as the purchase of eligible domestic carbon credits (*KliK*, 2016). The budget estimate corresponds to a surcharge of 0.01 to 0.02 Swiss francs per litre of fossil motor fuel.

For domestic emission reduction projects in order to fulfil the mandatory compensation of CO_2 emissions from motor fuel use, the Swiss Federal Office for the Environment may issue tradable attestations. Domestic emission reduction projects must be registered in advance and the emission reductions achieved must be accounted for annually in a monitoring report. Attestations can only be issued for voluntary measures that go beyond legal requirements and are not already otherwise supported. Those with compensation obligations can initiate domestic emission reduction projects themselves – in a slightly different form – but cannot receive attestations for them. Domestic emission reduction projects cover a variety of different technological areas such as energy efficiency on the supply and demand side, renewable energy, fuel switch, transport, avoidance of emissions of CH_4, N_2O and F-gases, biological sequestration, and others. A detailed list of domestic emission reduction projects in these various technological areas is available on the website of the Swiss Federal Office for the Environment[24], where the expected and actual emission reductions from currently registered domestic emission reduction projects are presented as well[25].

24 https://www.bafu.admin.ch/bafu/en/home/topics/climate/info-specialists/climate-policy/compensation-for-co2-emissions/list-of-registered-compensation-projects.html

25 https://www.bafu.admin.ch/bafu/de/home/themen/klima/daten-indikatoren-karten/daten/kompensationsprojekte.html

Planned strengthening

It is planned to continue and strengthen the partial compensation of CO_2 emissions from motor fuel use in the framework of the third CO_2 Act (4.2.4), which is planned to enter into force as of 2021. While consultation on various levels on the final arrangements are still ongoing, the initial proposal by the Swiss Federal Council contains the following cornerstones: (i) the Swiss Federal Council determines the share of CO_2 emissions from motor fuels to be offset by fuel importers at a maximum of 90 per cent and (ii) the Swiss Federal Council determines the share of emissions to be compensated domestically at a minimum share of 15 per cent.

Estimate of mitigation impact

On average over the second commitment period of the Kyoto Protocol (2013–2020), five per cent of CO_2 emissions from motor fuels need to be offset by fuel importers domestically. By 2020, the respective share is 10 per cent, which is expected to correspond to about 1.5 million tonnes of CO_2 equivalents (Tab. 18 and BR CTF table 3). After 2020, the mitigation impact is considered to increase substantially, depending on the pending final decision on the share of emissions from motor fuels to be compensated by importers of motor fuels.

4.4.6 Heavy vehicle charge

Switzerland's freight transport policy is based on Article 84 of the Federal Constitution of the Swiss Confederation (as amended in 1994) which requires transalpine freight transport to shift from road to rail. This goal is to be reached by the so-called heavy vehicle charge, in combination with measures to improve competitiveness of international rail transport. The heavy vehicle charge has been applied to passenger and freight transport vehicles of more than 3.5 tonnes of gross weight since 2001. The fee level is calculated according to three criteria: (i) kilometres travelled on Swiss roads, (ii) vehicle specific maximum authorised gross weight, and (iii) pollutants according to EURO classes. The heavy vehicle charge was implemented in three stages between 2001 and 2008, accompanied by increases in the admissible maximum weight for trucks (40 tonnes instead of 28 tonnes). As of 2017, the charge has been increased, depending on the vehicle class by 11 to 18 per cent (EURO 3/III now at 3.10 Swiss francs per hundred tonne kilometres, EURO 4/IV and Euro 5/V now at 2.69 Swiss francs per hundred tonne kilometres, and EURO 6/VI now at 2.28 Swiss francs per hundred tonne kilometres).

Estimate of mitigation impact

A significant renewal of the truck fleet in the year before the introduction of the heavy vehicle charge was prompted by the fact that the charge depends on the maximum weight and on emission standards of the individual vehicle. The heavy vehicle charge results in a positive overall environmental balance, in particular thanks to reduced emissions of air pollutants and greenhouse gases from road freight transport. According to model calculations for the year 2005 (*ARE*, 2007), air quality has improved by 10 per cent (particle emissions) and 14 per cent (nitrogen oxides), respectively, and CO_2 emissions have decreased by six per cent compared to a scenario without the introduction of the heavy vehicle charge (and with a weight limit of 28 tonnes). In the absence of more recent estimates, it is assumed that the heavy vehicle charge persistently led to a reduction of CO_2 emissions from road freight transport by six per cent compared to a scenario without its introduction. Applied to the projected emissions of the road freight transport, this assumption suggests a mitigation impact of the heavy vehicle charge of 140 thousand tonnes of CO_2 in 2020 (Tab. 18 and BR CTF table 3).

4.4.7 Mineral oil tax reduction on biofuels and natural gas

The amendment of the Mineral Oil Tax Act of 1 July 2008 provides tax incentives for low carbon fuels. A tax reduction of 0.4 Swiss francs per litre of petrol equivalent is granted for natural and liquefied petroleum gas (LPG). Complete tax exemption for biogas and other fuels from renewable sources is granted if certain criteria are met. In March 2014, the Swiss Parliament decided to tighten these criteria by amending the Mineral Oil Tax Act as well as the Environment Protection Act. The ecological criteria are: (i) a minimum of 40 per cent greenhouse gas reduction based on life cycle analysis (LCA), (ii) a net environmental burden not significantly exceeding the one of fossil fuels, and (iii) the cultivation of biofuels must not endanger biodiversity, in particular rainforests. Minimum requirements for socially acceptable production conditions are: social legislation applicable at the production location of raw materials and fuels is respected; at least the fundamental conventions of the International Labour Organisation (ILO) are complied with; cultivation of biofuels has to be realised on legally acquired soils. Tax revenue losses are compensated by increasing tax rates on liquid fossil motor fuels. In contrast to other countries, Switzerland has no quotas for biofuels.

The mineral oil tax reduction on biofuels and natural gas will expire in June 2020. As for now, there is no plan to continue with this policy and measure. However, with the third CO_2 Act the CO_2 reduction potential of biofuels should be connected with the mandatory partial compensation of CO_2 emissions from motor fuel use (see section 4.4.5). Importers of motor fuels should be bound to compensate five per cent of their emissions by bringing biofuels on the market.

Estimate of mitigation impact

Until 2020, the mitigation impact of the mineral oil tax reduction on biofuels is estimated at 1.5 per cent of the emissions of the transport sector. This corresponds to roughly 220 thousand tonnes of CO_2 (Tab. 18 and BR CTF table 3).

4.4.8 Inclusion of aviation in the emissions trading scheme

Switzerland plans to link its emissions trading scheme with the emissions trading scheme of the European Union. This would imply that the linked emissions trading scheme also includes the Swiss aviation sector (see section 4.2.6 for details).

Estimate of mitigation impact

The mitigation impact will follow the cap-and-trade principle of the new common emissions trading scheme, where the calculation of the cap for the aviation activities covered by the Swiss emissions trading scheme is planned to be based on aviation activities of the year 2018. Due to the planned linking of the Swiss emissions trading scheme with the emissions trading scheme of the European Union, the effective reductions of greenhouse gas emissions may be realised outside Switzerland. For 2020, the mitigation impact is reported as ‘not applicable’ in Tab. 18 and BR CTF table 3, because it is currently open when the mitigation impact of this planned measure will become visible.

4.4.9 CO_2 emissions standards for aircraft

Switzerland helped in the process for the adoption of the first CO_2 emissions standard for civil aircraft by the International Civil Aviation Organisation, which is the world’s first global design certification standard governing CO_2 emissions. In Switzerland, the standard will be applicable to Swiss registered new relevant aircraft type designs from 2020. It will also apply to relevant aircraft type designs already in production as of 2023. Those in-production aircraft which by 2028 do not meet the standard will no longer be able to be produced unless their designs are sufficiently modified. The measure is currently adopted.

Estimate of mitigation impact

Because the CO_2 emissions standard for aircraft will develop its mitigation impact after 2020, the mitigation impact for 2020 is reported as ‘not applicable’ in Tab. 18 and BR CTF table 3.

4.4.10 Carbon offsetting and reduction scheme for international civil aviation (CORSIA)

In 2017 the International Civil Aviation Organisation assembly decided to introduce the so-called carbon offsetting and reduction scheme for international aviation (CORSIA). Under this scheme the CO_2 emissions of international air transport which exceed the levels of the year 2020 will have to be offset by the air traffic operators. Already in 2017, Switzerland has announced its willingness to participate in the scheme together with the 43 other member states of the European Civil Aviation Conference. Applicable standards and recommended practices for the scheme are currently being prepared by the International Civil Aviation Organisation. The pilot phase (from 2021 through 2023) and first phase (from 2024 through 2026) would apply to states that have volunteered to participate in the scheme.

Estimate of mitigation impact

Emissions of international civil aviation activities exceeding 2020 levels covered by the scheme will be offset (carbon neutral growth on the basis of 2020). As the pilot phase is planned to start in 2021, the mitigation impact of this measure will develop after 2020 and is reported, for 2020, as ‘not applicable’ in Tab. 18 and BR CTF table 3.

4.4.11 Further relevant measures

This section provides a brief overview of further measures with limited direct impact on greenhouse gas emission levels, e.g. measures that may indirectly contribute to climate policy goals (e.g. by reducing precursor gas emissions) and measures focussing on non-greenhouse gas emissions that may have favourable side effects on climate change mitigation.

Further measures to promote rail transport

The ongoing general refurbishment and extension of the rail network, including two new base tunnels (Lötschberg, St Gotthard) will increase capacity and shorten travel times. This will increase competitiveness of rail and thus support the shift from road to rail envisaged as part of Switzerland's transport policy.

To further increase productivity and competitiveness of rail transport, Switzerland, in accordance with the relevant European Union directive, has been progressively implementing reforms (Railway Reform). This improves interoperability and the quality of transnational transport. Measures also 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 Germany and Italy), Switzerland is subsidising such services. Thanks to sustained support to truck-on-train transport, a further shift towards combined transport is expected. Total funding for the modal shift from road to rail amounts to more than 1.6 billion Swiss francs from 2009 to 2018.

The land transport agreement between Switzerland and the European Union secures the Swiss policy and the modal shift efforts in the European context. The European Union respects the Swiss policy objectives and the necessary measures taken (in particular the heavy vehicle charge). Efforts are under way 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 European Union, and Switzerland.

Greenhouse gas emissions from marine bunker fuels

As a landlocked country, Switzerland operates only a small fleet of ships at the international level. Consequently, greenhouse gas emissions from marine bunker fuels are negligible (see Tab. 3) and only include emissions from fuel sold within the borders of Switzerland for international transport on the Lake Geneva, Lake Constance, and the Rhine. Nevertheless, in the framework of its membership to the International Maritime Organisation (IMO), Switzerland supports the introduction and further strengthening of obligations to reduce greenhouse gas emissions from international navigation. Switzerland ratifies, as a basic principle, all environmentally relevant international agreements related to international navigation and implements them, as required, in domestic legislation. On the basis of Article 9 of the Maritime Navigation Act, the compliance with international agreements and domestic legislation is enforced by inspections by the Swiss Maritime Navigation Office or by classification societies accredited by Switzerland.

Air pollution control 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 (installation of CRT particle filters). The annual cantonal motor vehicle tax depends on different parameters such as vehicle weight and engine capacity, which provides an incentive to buy and use cars that are more fuel efficient. Moreover, many cantons have adopted rebate and feebate regimes for cars, based on criteria such as the energy label category, fuel or drivetrain type, and specific CO_2 emissions.

Euro emission standards

Switzerland is following the European path of reducing air pollutants (NO_x, non-methane hydrocarbons, total hydrocarbons, CO, and particulate matter) by introducing stricter Euro emission standards for new vehicles. Since 2015, the Euro 6/VI standard is mandatory for new vehicles. With regard to reducing particulate matter and diesel soot emissions, particle filter trap systems have been introduced for various types of vehicles.

Gothenburg Protocol

In 2005, Switzerland ratified the Gothenburg Protocol to abate acidification, eutrophication and ground-level ozone (under the Geneva Convention on Long-range Transboundary Air Pollution, United Nations Economic Commission for Europe). 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 emissions of indirect greenhouse gases. The Gothenburg Protocol was revised in 2012. The revised version also addresses particulate matter (PM2.5) and black carbon. It contains national emission reduction commitments for sulphur dioxide, nitrogen oxides, ammonia, volatile organic compounds and particulate matter to be achieved by 2020. The obligations of the revised Gothenburg Protocol include the application of best available techniques and emission limit values for industrial and mobile sources, as well as for agriculture. Accordingly, the impact of the Gothenburg Protocol is not limited to the transport sector.

4.5 Industrial processes and product use

4.5.1 Overview

Most greenhouse gas reduction policies and measures in the industry sector are implemented under the CO_2 Act and control CO_2 emissions from fossil fuel use. These policies and measures are presented together with the cross-sectoral policies and measures (section 4.2). The main instruments affecting greenhouse gas emissions from industry are (i) the CO_2 levy on heating and process fuels (section 4.2.5), (ii) the emissions trading scheme (section 4.2.6), and (iii) the negotiated reduction commitments (for exemption from the CO_2 levy) (section 4.2.7).

However, emissions of F-gases and precursor gases – such as NMVOCs – are not tackled by the CO_2 Act. Instead, specific policies and measures have been developed on the basis of the Environmental Protection Act and specified in the Ordinance on Chemical Risk Reduction (*Swiss Confederation*, 2005a), the Ordinance on Air Pollution Control (*Swiss Confederation*, 1985), as well as in the Ordinance on the Incentive Tax on Volatile Organic Compounds (*Swiss Confederation*, 1997). NMVOCs are used as solvents in numerous industries, are contained in many products such as paints, varnishes and various cleaning solutions, and are emitted by industrial processes, product use and by incomplete fuel combustion. If these compounds become airborne, they contribute (together with nitrogen dioxide) to the excessive formation of ground-level ozone (summer smog). In addition, NMVOCs completely oxidise in the atmosphere within days and are, thus, a source of indirect CO_2 emissions. In order to reduce NMVOC emissions, Switzerland has three policies and measures in place: (i) the international exhaust gas regulations for motor vehicles, which are fully implemented in Swiss regulations and where Switzerland is highly involved in the development (section 4.5.3), (ii) the Ordinance on Air Pollution Control for stationary sources (section 4.5.4), and (iii) the NMVOC incentive fee to reduce diffuse emissions of NMVOCs (section 4.5.5). Regarding the reduction of F-gas emissions, provisions relating to substances stable in the atmosphere (HFCs, PFCs, SF_6, and NF_3) are in place (section 4.5.2).

The policies and measures of the industrial processes and product use sector are summarised in Tab. 19 and detailed in the following sections.

Tab. 19 > Summary of policies and measures in the industry sector. The sector affected is 'industry/industrial processes and product use' for all policies and measures presented in this table.

Name of policy or measure [a]	Greenhouse gas(es) affected	Objective and/or activity affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative, in kt CO_2eq) 2020
Provisions relating to substances stable in the atmosphere (HFCs, PFCs, SF_6, NF_3) *	All F-gases	Reduction in use and emissions of F-gases.	Regulatory	Implemented (strengthening planned)	Regulations relating to, inter alia, compressed gas containers, plastic foams, solvents containing PFCs, HFCs or HFEs, refrigerants, extinguishing agents, and SF_6 in electrical distribution equipment.	2003	FOEN, cantons	HFCs: 811 [b] PFCs: 1 [b] SF_6 and NF_3: 83 [b]
International exhaust gas regulations (NMVOC) *	Indirect CO_2	Improvement of air quality through O_3 abatement.	Regulatory	Implemented	Limits for NMVOC emissions of motor vehicles, also leading to a reduction of indirect CO_2 emissions.	1974	FEDRO	200
Ordinance on Air Pollution Control *	Indirect CO_2	Improvement of air quality through O_3 abatement.	Regulatory	Implemented	Limits for NMVOC emissions of stationary installations, also leading to a reduction of indirect CO_2 emissions.	1986	FOEN, cantons	IE [c]
NMVOC incentive fee *	Indirect CO_2	Improvement of air quality through O_3 abatement.	Economic	Implemented	Market-based instrument to reduce NMVOC emissions, also leading to a reduction of indirect CO_2 emissions.	2000	FCA	380

[a] Policies and measures marked with an asterisk (*) are included in the 'with measures' projection.

[b] Values according to *Carbotech* (2015).

[c] The estimate of mitigation impact is included under the 'NMVOC incentive fee'.

IE, included elsewhere
FCA, Swiss Federal Customs Administration; FEDRO, Swiss Federal Roads Office; FOEN, Swiss Federal Office for the Environment

4.5.2 Provisions relating to substances stable in the atmosphere (HFCs, PFCs, SF_6, NF_3)

The three main lines of action in the area of F-gases are: (i) to limit the use of these substances to those applications where there is no alternative at the current state of technology, (ii) when such substances are used, to reduce emissions as far as possible, and (iii) where feasible, to engage in voluntary binding agreements with industry (as implemented in an agreement developed by the industry on SF_6 in high-voltage equipment and other sectors in 2002, revised in 2014).

Under the generic name of 'substances stable in the atmosphere', the Ordinance on Chemical Risk Reduction, in its Annex 1.5, provides for measures to control emissions of persistent substances with high global warming potential values (HFCs, PFCs, SF_6, NF_3, HFEs). Section 5 of Annex 1.5 states that containers and switchgear containing such substances must be labelled, inter alia, with the following text in at least two official languages: 'Contains fluorinated greenhouse gases covered by the Kyoto Protocol'.

Because emissions resulting from installations/systems working with refrigerants dominate total F-gas emissions, regulations most importantly aim at reducing emissions from such installations/systems. However, further regulations relating to substances stable in the atmosphere are in place.

Refrigerants

The regulatory system in force since December 2013 contains a partial ban – depending on cooling capacity and sector of use – on marketing of refrigeration, air conditioning and heat pumps of fixed installations operating with F-gases. To ensure the transparency and proportionality of the 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 cantonal authorities and the sector concerned.

Compressed gas containers

In the area of compressed gas containers, emissions of F-gases (mainly HFCs) can only be limited by restrictions on use. Applications for which exemptions are inevitable are: (i) compressed gas containers for cleaning live electrical and electronic equipment, (ii) medical and pharmaceutical applications, in particular metered dose inhalers, and (iii) spray foam (polyurethane) in certain situations where safety is critical. For other applications where these substances may 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 on Aerosol Dispensers (*Swiss Confederation*, 2005) prohibits the use of HFCs or PFCs in most spray cans. According to Annex 4 of this ordinance, in spray cans containing cosmetics and household products only the use of HFC-152a as a propellant is allowed.

Plastic foams

The measures currently implemented in Switzerland (restrictions on use, disposal by incineration and recycling) to limit emissions of F-gases from plastic foams on the one hand and the general tendency of this industry sector in Europe on the other hand have led to the situation where foams without fluorinated gases account for practically the entire Swiss market. F-gases (mainly HFCs) may only be used in plastic insulating foams and under severe restraints: (i) if they offer significant advantages in thermal insulating efficiency in case of spatial constraints and (ii) where non-flammability is required, in agreement with the current state of technology. Rapidly advancing technology requires that 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 containing HFCs, PFCs or HFEs

Solvents containing HFCs, PFCs or HFEs are currently used almost exclusively by the electronic and precision industry, in cases where sound alternative technology is not available. To reduce emissions, consumer goods containing such solvents have been banned.

Extinguishing agents

Since 1996, the supply and import of extinguishing agents made of F-gases 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 only authorised in equipment that operates at more than one kilovolt and is hermetically sealed or constantly monitored. This is governed by a voluntary agreement established in 2013 by the high-voltage industry[26]. The level and the volume of annual emissions are limited to one per cent of the total amount used, and to an absolute maximum value of annually four tonnes (until 2012, limit is decreasing to 3.6 tonnes in 2020). Further, recovery of SF_6 from decommissioned equipment must be guaranteed.

Other application sectors

The use of PFCs and SF_6 in tyres, insulating windows and sport shoes is banned since 2003. SF_6 as protecting gas in magnesium and aluminium smelting was banned after 31 December 2016. 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 I of the Ordinance concerning Lists Regarding the Movement of Toxic Waste, 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.

Planned strengthening

In the course of 2019, a revision of the Ordinance on Chemical Risk Reduction is foreseen to enter into force. This revision is expected to include further restrictions for the use of substances stable in the atmosphere. In particular, restrictions are planned in the domain of refrigerants, including lower cooling capacity thresholds for several applications, above which the use of HFCs will be banned. Additional constraints are foreseen for the use of HFCs in non-stationary appliances where alternative technologies are available. Furthermore, a licensing system for the import and export of substances stable in the air will be implemented, in agreement with the requirements stipulated in the so-called Kigali Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer, once this Amendment is ratified by Switzerland.

The planned revisions respond, on the one hand, to the advances in the state of technology that allow to restrict a broader range of applications currently operating with substances stable in the atmosphere. On the other hand, the restrictions shall ensure that Switzerland will fulfil its commitments towards the Montreal Protocol and – after ratification – the Kigali Amendment. The amendment, which was adopted in October 2016, defines a phase-down schedule for each developed country which will lead to a reduction of 85 per cent of production and consumption of HFCs by 2036, relative to each country's 2011–2013 baseline period.

Estimate of mitigation impact

For estimating the mitigation impact, emission scenarios were calculated with and without existing policies and measures (*Carbotech*, 2015, see also 5.3.2). The emission scenarios cover metal production, electrical equipment, refrigerants, solvents, aerosols, foam blowing, electrical equipment, and others. The dominating sector is refrigeration, contributing roughly 80 per cent in total emissions of substances stable in the atmosphere (expressed in thousand tonnes of CO_2 equivalents). Input data for projecting the development of this key sector are the statistics available on currently installed stationary equipment, as well as assumptions on future market growth and leakage rates during operation and disposal. As shown in Tab. 19 and BR CTF table 3, the emission modelling suggests a total mitigation impact of 895 thousand tonnes of CO_2 equivalents by 2020 (see also Tab. 27 and Fig. 64), thereof 811 thousand tonnes of CO_2 equivalents within the refrigeration sector.

26 https://www.bafu.admin.ch/bafu/en/home/topics/climate/info-specialists/climate-policy/sector-agreements/freiwillige-branchenloesung-fuer-sf6.html

4.5.3 International exhaust gas regulations (NMVOC)

The first international exhaust gas regulations for motor vehicles started in 1974 and limited the total hydrocarbon emissions for gasoline passenger cars and for light commercial vehicles to 5.1 to 8.2 grams per kilometre. Numerous subsequent regulations followed. The implementation of the three-way catalytic converter led to much lower emissions of NMVOCs from gasoline vehicles. Also for diesel vehicles emission limit values have been introduced.

Estimate of mitigation impact

In 1990, the NMVOC emissions of road traffic amounted to 88 thousand tonnes. In 2020, it is expected to drop below 10 thousand tonnes of NMVOC. Without measures since 1990, it is assumed that the emission factors would have remained constant, resulting in emissions of 70 thousand tonnes of NMVOC in 2020. Lowering NMVOC emissions by 60 thousand tonnes results in lower indirect CO_2 emissions. By 2020, the estimated greenhouse gas mitigation impact is about 200 thousand tonnes of CO_2 equivalents (Tab. 19 and BR CTF table 3), based on a carbon content of NMVOC of 90 per cent for emissions from combustion engines (diesel and gasoline mostly contain hydrocarbons and have a very low content of oxygen, sulphur, nitrogen etc.)[27].

4.5.4 Ordinance on Air Pollution Control

The Ordinance on Air Pollution Control is based on the Environmental Protection Act and entered into force in 1986. It contains – beside other prescriptions – emission limits for NMVOCs for stationary installations. It also prescribes that emissions shall be captured as fully and as close to the source as possible and shall be removed in such a way as to prevent excessive ambient air pollution levels. Furthermore, it gives the possibility to the authorities to limit emissions preventively as far as technically and operationally feasible and economically acceptable.

Estimate of mitigation impact

The estimate of mitigation impact is included under the NMVOC incentive fee (section 4.5.5), and, thus, reported as ‘included elsewhere’ in Tab. 19 and BR CTF table 3.

4.5.5 NMVOC incentive fee

The NMVOC incentive fee is defined in the Ordinance on the Incentive Tax of Volatile Organic Compounds, which is also based on the Environmental Protection Act and which entered into force in 1997. The incentive fee has been levied since 1 January 2000, amounting to two Swiss francs per kilogram of NMVOC emitted into the air. Since 2003 the fee is three Swiss francs per kilogram of NMVOC. As a market-based instrument in the field of environmental protection, it creates a financial incentive to further reduce NMVOC emissions.

Estimate of mitigation impact

The total anthropogenic NMVOC emissions in Switzerland without road traffic (see section 4.5.4) are projected to drop from 210 thousand tonnes in 1990 to about 64 thousand tonnes in 2020. Using real activity data and keeping the emission factors constant from 1990 onwards, the emissions rise up to 238 thousand tonnes of NMVOC in 2020. The reduction of 173 thousand tonnes of NMVOC is the result of the combination of the Ordinance on Air Pollution Control and the NMVOC incentive fee. Using a carbon content of NMVOC of 60 per cent, about 380 thousand tonnes of CO_2 equivalents result as a greenhouse gas mitigation impact due to the reduction of indirect CO_2 emissions[28].

4.6 Agriculture

4.6.1 Overview

Article 104 of the Federal Constitution of the Swiss Confederation forms the basis for agricultural policy in Switzerland. It mentions sustainability as one of the guiding principles. The Agriculture Act, which came into force in 1999,

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[27] In the greenhouse gas inventory, the oxidation factors used to calculate CO_2 emissions from road traffic are assumed to be 100 per cent. Accordingly, indirect CO_2 emissions resulting from the atmospheric oxidation of NMVOCs are already included under direct CO_2 emissions in this case (see section 3.2.4 for more details). The values related to indirect CO_2 emissions provided in chapter 3 and chapter 5 (section 5.3.6) strictly avoid double counting.

[28] In this estimate, fossil and biogenic NMVOC emissions are included. In contrast to the estimates presented here, the values related to indirect CO_2 emissions provided in chapter 3 and 5 (section 5.3.6) only consider fossil carbon and strictly avoid double counting. However, in 1990 almost 80 per cent of NMVOC emissions resulted from the use of solvents anyway.

provides a framework for sustainable development in the agriculture sector. In its Article 2, as amended in 2014, it stipulates that the Swiss Confederation shall, inter alia, take measures to promote the sustainable use of natural resources and animal-friendly and climate-friendly production.

Greenhouse gas emissions in agriculture strongly depend on the portfolio of activities chosen by farmers. An important parameter influencing this decision is the relative economic profit achievable by the different activities. Their attractiveness depends on the price level of agricultural goods and services as well as on the mode and level of agricultural subsidies. Agricultural policy, as it is designed in Switzerland, influences both, prices of agricultural products and subsidies and is therefore an important factor determining the amount of greenhouse gas emissions.

With the revision of Switzerland's agricultural policy since the beginning of the 1990s, support for agriculture has been gradually reduced and decoupled from production. Between 1990 and 2010 total financial aid (price support and budgetary subsidies) was reduced from just over eight billion to 5.6 billion Swiss francs. Furthermore, the proportion of linked financial aid (price support through restrictions on import and other contributions towards market price support including export subsidies) decreased by around 50 per cent over the same period. As compensation, direct payments decoupled from production volume have been considerably increased by 80 per cent.

Tab. 20 gives an overview of the climate-relevant policies and measures in the agriculture sector, while the following sections provide more details and background information on each policy and measure. The values for the mitigation impact of each policy and measure in the agriculture sector are rough estimates.

Tab. 20 > Summary of policies and measures in the agriculture sector. The sector affected is 'agriculture' for all policies and measures presented in this table.

Name of policy or measure [a]	Greenhouse gas(es) affected	Objective and/or activity affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative, in kt CO_2eq)
								2020
Proof of ecological performance to receive direct payments *	CH_4, N_2O, CO_2	Incentives related to ecological goals.	Economic	Implemented	Direct payments are contingent on appropriate soil nutrient balance, suitable proportion of ecological compensation areas, crop rotation system, soil protection, selective application of crop protection agents, and animal husbandry in line with legal provisions.	Early 1990s	FOAG	700
Resource programme (subsidies for a more efficient use of natural resources)	CH_4, N_2O, CO_2	Promotion of efficient use of natural resources.	Economic	Implemented	Subsidising measures for more efficient use of natural resources such as nitrogen, phosphorous and energy, protection and sustainable use of soils, and biodiversity. To qualify for subsidies, measures must go beyond legal requirements or the criteria for other funding programmes.	2008	FOAG	NE [b]
Climate strategy for agriculture	CH_4, N_2O, CO_2	Long-term mitigation and adaptation in the sector.	Information, research	Implemented (strengthening planned)	Declaration of intent to reduce emissions by one third by 2050 compared to 1990 with technical, operational and organisational measures and by another third with measures influencing food consumption and production. Framework for the development, testing and implementation of specific future measures in mitigation and adaptation.	2011	FOAG	NE [c]
Further development of the direct payments system (orientation towards targets) *	CH_4, N_2O, CO_2	More targeted use of the direct payments system.	Economic	Implemented (strengthening planned)	Abolition of unspecific direct payments (livestock subsidies, general acreage payments). Additional funds for environment-friendly production systems and for the efficient use of resources, e.g., increase in nutrient efficiency and ecological set-aside areas, reduction of ammonia emissions.	2014	FOAG	200

[a] Policies and measures marked with an asterisk (*) are included in the 'with measures' projection.

[b] The mitigation impact of the resource programme (subsidies for a more efficient use of natural resources) achieved by 2020 cannot be estimated due to the lack of specific information. However, the main mitigation impact will evolve after 2020 as projects with a focus on the reduction of greenhouse gas emissions just started.

[c] Because the measures so far introduced in the framework of the climate strategy for agriculture aim at the exchange and transfer of knowledge, no methodological approaches are available to quantify the mitigation impact.

NE, not estimated
FOAG, Swiss Federal Office for Agriculture

4.6.2 Proof of ecological performance to receive direct payments

Direct payments are tied to ecological standards, i.e. farmers are eligible for payments only if they fulfil the so called proof of ecological performance. This is the case when the nutrient balance is maintained, a suitable proportion of farmland is managed as ecological compensation area, 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. Since direct payments are an essential part of the income for most famers, the diffusion of the proof of ecological performance is widespread.

Estimate of mitigation impact

It is assumed that introduction of the proof of ecological performance was the main driver for the reductions in agricultural greenhouse gas emissions in the 1990s (about 700 thousand tonnes of CO_2 equivalents). However, price signals for animal products as well as other developments like progress in breeding under a milk quota system certainly also have contributed to the decrease in livestock populations. Therefore, the estimation represents an upper limit.

4.6.3 Resource programme (subsidies for a more efficient use of natural resources)

On the basis of an amendment to the Agriculture Act in 2008, a new instrument called resource programme was introduced. Through this programme, the Swiss Confederation is subsidising measures for the more efficient use of natural resources in the agriculture sector. Target areas are resources such as nitrogen, phosphorous and energy, protection and sustainable use of soils, and biodiversity. 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 introductory phase, but that will run without further payments afterwards. Therefore payments are restricted to six years. The specified targets and measures, as well as the spatial dimension and the participation of the farms can vary considerably between the projects. Until 2015, 24 regional bottom-up projects were initiated and half of them already completed. Two thirds of the projects deal with ammonia emission reduction, the others contain measures with the aim to improve soil fertility, biodiversity or energy efficiency. In 2016, three new initiatives started. Two of them focus mainly on the reduction of agricultural greenhouse gas emissions, one is about the use of antibiotics in livestock production. The requirements for projects eligible under the resource programme were slightly revised in 2014. More emphasis is given to innovation and accompanying research. With that, the variety of projects should be enhanced and the transfer of know-how beyond the project improved.

Estimate of mitigation impact

The mitigation impact of the projects which focus on other aspects than the reduction of greenhouse gas emissions cannot be estimated due to the lack of specific information. The two projects on the mitigation of greenhouse gas emissions which started in 2016 have the potential to reduce farm emissions by 10 per cent on nearly 20 per cent of Swiss farms. However, their main mitigation impact will evolve after 2020. Consequently, the mitigation impact for the resource programme (subsidies for a more efficient use of natural resources) is reported as 'not estimated' in Tab. 20 and BR CTF table 3.

4.6.4 Climate strategy for agriculture

The climate strategy for agriculture was published in 2011 by the Swiss Federal Office for Agriculture (*FOAG*, 2011). This strategy is a declaration of intent, guiding agriculture and food production in Switzerland in their efforts to reduce greenhouse gas emissions and adapt to a changing climate. It sets out common guidelines and long-term targets and identifies priorities and possible areas where action can be taken. Greenhouse gas emissions by the agriculture sector are to be reduced by at least one-third by 2050 (compared to 1990 levels) through technical and organisational measures. Further reductions are aspired by influencing production structures as well as consumption patterns. At the same time, agricultural production (nutritional energy) as well as other public and ecological services are to be maintained. Implementing activities in the context of the climate strategy for agriculture include: intensification of agricultural research, development of appropriate legal framework and empowerment of the stakeholders concerned.

Since the publication of the climate strategy for agriculture a platform in the fields of renewable energy, energy efficiency and climate change mitigation was supported with financial aid from the government. The aim of the platform is to facilitate the exchange and transfer of knowledge between research, advisory services, industry and farmers. Congresses and workshops are organised, mitigation options identified and tools developed.

Planned strengthening

It is planned that the reduction target for the agriculture sector set out by the climate strategy for agriculture is made mandatory by including it in the third CO_2 Act (section 4.2.4).

Estimate of mitigation impact

The climate strategy for agriculture aims at setting out long-term targets to be reached with deduced policies and measures and has, thus, a positive mitigation impact. However, because the measures so far introduced in the framework of the climate strategy for agriculture aim at the exchange and transfer of knowledge, no methodological approaches are available to quantify the mitigation impact. Accordingly, the mitigation impact is reported as ‘not estimated’ in Tab. 20 and BR CTF table 3.

4.6.5 Further development of the direct payments system (orientation towards targets)

In 2013 the Swiss Parliament adopted the present, quadrennial programme for agriculture, the agricultural policy 2014–2017. The key element of this policy is the further development of the direct payments system. Measures with unspecified aims are replaced by specific tools. Subsidies for livestock are converted to subsidies for ensuring food security, dependent on land use. The funds freed by the abolishment of the general acreage subsidy are used, inter alia, for new direct payment types for environmentally-friendly production systems and for the efficient use of resources. Concretely, payments are effected for e.g. organic farming, grassland-based ruminant production, and precise application of fertiliser and plant protection agents, conservative soil cultivation. The legal framework of agricultural policy 2014–2017 has been designed in a way that enables the inclusion of further elements under the new direct payment types by adjusting the corresponding ordinance.

Planned strengthening

Under the direct payments type ‘efficient use of resources’ another two elements have been proposed: (i) payments for differentiated feeding of pigs according to age and (ii) nutritional needs and payments for reduced use of plant protection agents in vine and sugar beet.

Estimate of mitigation impact

In a simplified way it can be assumed that, by 2020, the mitigation impact of the further development of the direct payments system corresponds to the difference between the WEM and the WOM scenario (see section 5.3.3 and Tab. 28), i.e. about 200 thousand tonnes of CO_2 equivalents.

4.7 Land use, land-use change and forestry

4.7.1 Overview

There is a long tradition of forest protection in Switzerland. The first Forest Act came into force in 1876. It only covered the Alpine region and its aim was to put a halt to deforestation, to secure the remaining forest area, to manage it in a sustainable way, and to promote afforestation. The Forest Act of 1902 covered the whole country. The forest acts resulted in an increase of the forested area in Switzerland from 0.7 million hectares in the mid-19th century to over 1.3 million hectares today (*FOEN and WSL*, 2015). Switzerland’s total forest area is still increasing, although the changes in forest area vary significantly from region to region. The strongest increase in forest area can be observed in the Alps and in the Southern Alps. The forest area in the Central Plateau is virtually stable.

Due to the age structure, large fractions of the Swiss forest are mature for harvesting. Consequently, the levels of harvesting should rise in the near future. On one hand, this contributes to avoiding episodic large quantities of greenhouse gas emissions originating from decay, should the excessive accumulation of carbon stocks be disturbed by drought, fires, storms, or insect attacks. On the other hand, as the forest, its products and services could be broadly affected by climate change there is need to support forests to adapt to climate change. Adaptation processes in forests are best induced through regeneration.

In Switzerland, the climate-related goal of forest policy is to adapt forests by increasing resilience to climate change and – taking into account the high growing stock – to reduce CO_2 emissions by substituting other materials or fossil fuels rather than enhancing sink capacity. The highest possible substitution effect can be achieved through the principle of cascaded use of wood. With the planned step-by-step phasing out of nuclear energy as part of Switzerland's Energy Strategy 2050 (see section 4.3.1), renewable energy sources will play a central role. This is likely to lead to a more intensive use of energy wood and an increase in timber harvesting.

The most recent changes in the Federal Act on Forest (in force since 1 January 2017) follow this goal and strengthen the measures concerning adaptation and mitigation of climate change. Furthermore, new instruments for the prevention and abatement of harmful organisms have been defined.

Among others, mitigation of climate change is a major objective of the Forest Act and the Forest Policy 2020, which form both part of the legislative arrangements and administrative procedures. At the same time, by applying sustainable forest management practices in Swiss forests, complete use of the wood harvesting potential and conservation of biodiversity are envisaged. The objective of mitigating climate change includes the optimisation of the climate protection services of Swiss forest (*FOEN*, 2007). These climate protection services comprise (i) the sequestration of carbon in the forest, (ii) the carbon fixation in long-living harvested wood products, and (iii) the substitution of fossil fuels by using fuel wood (energetic substitution) or by replacing energy-intensive construction materials like steel by wood (material substitution). The climate protection services ensure sustainable use of the natural resource 'wood'.

Tab. 21 gives an overview of the most climate-relevant policies and measures in the land use, land-use change and forestry sector, while the following sections provide more details and background information on each policy and measure.

Tab. 21 > Summary of policies and measures regarding land use, land-use change and forestry sector. The sector affected is 'forestry/LULUCF' for all policies and measures presented in this table.

Name of policy or measure [a]	Greenhouse gas(es) affected	Objective and/or activity affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative, in kt CO_2eq) 2020
Forest Act (sustainable forest management and forest area conservation) *	CO_2	Limiting harvest to size of growth increment in forests, obligation to compensate for any deforestation.	Regulatory	Implemented	Ban on clear-cutting, no deforestation unless it is replaced by an equal area of afforested land or an equivalent measure to improve biodiversity.	First implemented in 1876, main revisions/ extensions in 1902 and 1993	FOEN, cantons	NE [b]
Wood Action Plan *	CO_2	Ecologically and economically effective use of wood.	Information, education, research	Implemented	Policy package implementing Forest Policy 2020 (see above) in the area of better use of the wood harvest potential (the Wood Action Plan is thus meant to help implementing the Forest Policy 2020). Focal areas comprise optimised cascaded use of wood, climate-appropriate building and refurbishment and communication, knowledge transfer and cooperation.	2009	FOEN	IE [c]
Measures within Forest Policy 2020 *	CO_2	Promote the use of wood and the substitution of carbon intensive resources.	Information	Implemented	Improvement of conditions for an efficient and innovative forestry and wood industry. Targets for the consumption of sawn timber and timber products and for CO_2 emission reductions through enhanced use of wood. Long-term target of	2011	FOEN, cantons	1'200

					a CO_2 balance between forest sink, wood use and wood substitution effects. Given the current age structure of Swiss forests, this implies aiming at increased harvesting rates over the coming years.			
Forest Act (most recent changes) *	CO_2	Promote the use of wood and the substitution of carbon-intensive resources.	Regulatory, Information	Imple-mented	New legal base for Wood Action Plan (see above) and new legal instrument to promote the use of sustainably produced timber for the construction of federal buildings.	2017	FOEN, cantons	NE [b]

[a] Policies and measures marked with an asterisk (*) are included in the 'with measures' projection.

[b] See the respective sections (4.7.3 and 4.7.5) for a qualitative discussion of the mitigation impact.

[c] The respective effects are included under the measures within Forest Policy 2020. Reductions result from substitution of other materials or fossil fuels (and thus impact emissions outside the land use, land-use change and forestry sector). While these indirect reductions are not included in the modelling of emissions (see section 5.3.4), the figures here do not reflect the corresponding reduction of carbon storage by the forest.

IE, included elsewhere; NE, not estimated
FOEN, Swiss Federal Office for the Environment

4.7.2 Forest Act (sustainable forest management and forest area conservation)

The Forest Act, as revised in 1993, reaffirms the long-standing Swiss tradition of preserving both forest area and forests as natural ecosystems. It prescribes sustainable forest management, prohibits clear-cutting, and bans deforestation unless it is replaced by an equal area of afforested land or an equivalent measure to improve biodiversity. At an average increment of 10.4 million cubic metres per year, 1.5 million cubic metres remain unlogged annually (values for survey periods of NFI3/2004–2006 and NFI4/2009–2013; *FOEN and WSL*, 2015) – mainly in forests that are difficult to access and in forest reserves. The federal authorities would like to increase Switzerland's annual wood harvest since the forests' sustainable potential for supplying domestic construction and energy wood is not being exploited completely. Specific measures aiming, inter alia, at the better exploitation of the existing potential of wood as a renewable resource are described in the sections below.

Estimate of mitigation impact

There are no quantitative estimates, but the impact is positive (see qualitative evaluation in sections 4.7.3 and 4.7.5).

4.7.3 Wood Action Plan

With the Wood Resource Policy (first initiated in 2008, updated in 2014 and 2017; *FOEN/SFOE/SECO*, 2017), the Swiss Confederation formulated a separate Wood Action Plan, which is coordinated with the Forest Policy 2020, climate policy, energy policy and regional policy. As the lead agency in this process, the Swiss Federal Office for the Environment actively promotes the cooperation between these sectoral policy areas, the Swiss forestry and timber sector, and the cantons. The aim of the Wood Resource Policy is to ensure that wood from Swiss forests is supplied, processed and used in a way that is sustainable and resource efficient. By this means, it makes a major contribution to forest, climate and energy policy. With its three priority areas of 'optimised cascade use', 'climate-appropriate building and refurbishment' and 'communication, knowledge transfer and cooperation', the Wood Action Plan serves the implementation of the Wood Resource Policy (*FOEN/SFOE/SECO*, 2017). Upon evaluation of the first (2009–2012) and second phase (2013–2016), the Wood Resource Policy has been updated and the Wood Action Plan extended until 2020.

In 2017, a new programme phase of the Wood Action Plan started (2017–2020). Its focus and relationship to other policy instruments is described above.

Estimate of mitigation impact

There are no quantitative estimates available, but the overall mitigation impact of the Wood Action Plan is positive. The promotion of the 'optimised cascaded use of domestic wood' increases the carbon stored in the pool of harvested wood products.

4.7.4 Measures within Forest Policy 2020

The Forest Policy 2020, which was approved by the Swiss Federal Council in 2011, is a strategic document built on the Forest Act of 1993 and designed to trigger improvements to it. The Forest Policy 2020 ensures sustainable forest management while creating favourable conditions for an efficient and innovative forestry and wood industry. The policy sets out eleven strategic objectives. It identifies five objectives that pose the greatest challenges: (i) exploiting the potential sustainable wood supply, (ii) contributing to mitigation of, and enhancing resilience to, climate change, (iii) maintaining the protective forest services, (iv) increasing biodiversity by conserving forests as near-natural ecosystems, and (v) conservation of the forest area in its spatial distribution.

The policy contains a comprehensive set of strategic and specific measures, indicators and target values that go with every objective. Some examples related to mitigation are (i) under the Forest Policy 2020, the consumption of sawn timber and timber products should be increased by 20 per cent by 2020 compared to 2006 levels, (ii) at the same time, the substitution effect through enhanced use of wood should be increased by 1.2 million tonnes of CO_2 per year by 2020 compared to 1990, and (iii) in the long term, a sustainable equilibrium between forest sink, wood use and wood substitution effects is sought.

Estimate of mitigation impact

According to the Forest Policy 2020, the mitigation impact by substitution is estimated at 1.2 million tonnes of CO_2 equivalents in 2020 (see page 62 in *FOEN*, 2013). For a qualitative evaluation see sections 4.7.3 and 4.7.5.

4.7.5 Forest Act (most recent changes)

In 2017 a renewal of the Forest Act entered into force. Article 28a ‘Precautionary measures against climate change’ is the first legal provision in a federal sector law that explicitly addresses the issue of adaptation to climate change. With this law the Swiss government financially supports adaptation measures with the aim to increase the adaptive capacity of Switzerland’s forests (see also section 6.2.7). Further, the revised Forest Act allows for taking measures to combat invasive species outside of protective forests. Non-native pests – such as the Asian longhorned beetle, whose numbers have recently increased – will be controlled. The law also foresees measures to promote timber which was produced sustainably and in close-to-nature silvicultural systems. A goal of these measures to promote timber is reducing CO_2 emissions through the use of harvested wood products. Starting in 2017, the Swiss government is required, if suitable, to use wood in its own building projects that complies with the above mentioned criteria.

Estimate of mitigation impact

There are no quantitative estimates available, but overall the mitigation impact of the Forest Act is positive:

- In the medium to long term, mitigation cannot be sustained without adaptation: Adaptive forest management in Switzerland aims to avoid major emissions from collapsing forest stands that are not adapted to climate change. The Forest Act prescribes to prepare Swiss forests for future climate conditions by adaptation measures. This means that short-time emissions from forest management can be expected, but positive long-term removals may compensate them. Swiss forests are often characterised by high carbon stocks. To convert these old forests into more stable younger forests, a decrease in biomass is necessary and net emissions may occur if the harvested biomass is not entirely transformed into harvested wood products. Further, specific forest stand types might need a change in species composition because of changing climate and corresponding changing stand characteristics. This exchange in tree species composition is typically spread over decennia. Emissions from these measures are expected to be moderate or small;
- By combating invasive species, emissions from tree mortality caused by insect diseases can be avoided;
- The more active promotion of wood use (e.g., there is a respective commitment for the construction of federal buildings) has a positive mitigation impact because the pool of harvested wood products will be increased.

4.8 Waste

4.8.1 Overview

In general, waste disposal in Switzerland is financed on the basis of the polluter pays principle. In 2011, around 80 per cent of the Swiss residents financed their waste disposal entirely or in part through volume-based charges, and the remaining 20 per cent financed it through taxation or payment of a flat fee. As a matter of principle, all waste should undergo material recycling or thermal treatment. If this is technically not possible or economically not viable, the waste is landfilled following suitable treatment. Since 2000, no untreated municipal solid waste may be landfilled; the capacity of the waste incineration plants was increased accordingly.

The main strategy to reduce emissions from waste incineration is to increase the recycling quantities. Well-developed recycling services exist for many types of waste. In 2015, 53 per cent of the total municipal solid waste was collected separately and recycled (see section 2.9, Tab. 1). The corresponding figure for 2002 was 46 per cent. Recycling rates are particularly high (more than 90 per cent) for glass, aluminium packaging, and waste-paper (see section 2.9, Fig. 36).

Tab. 22 gives an overview of the climate-relevant policies and measures of the waste sector, which are detailed in the following sections. The negotiated reduction commitment of municipal solid waste incineration plant operators is presented in detail together with the policies and measures of the energy sector (section 4.3.7), as their emissions are accounted for in the energy sector.

Tab. 22 > Summary of policies and measures regarding waste management. The negotiated reduction commitment of municipal solid waste incineration plant operators is presented together with the policies and measures of the energy sector (section 4.3.7). The sector affected is 'waste management/waste' for all policies and measures presented in this table.

Name of policy or measure [a]	Greenhouse gas(es) affected	Objective and/or activity affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative, in kt CO_2eq) 2020
Ban on landfilling of combustible waste *	CH_4	Avoid emissions from solid waste disposal sites, use waste as an energy source.	Regulatory	Implemented	Prohibition on landfilling of combustible waste.	2000 [b]	FOEN	177
Ordinance on the Avoidance and Management of Waste *	CO_2	Optimisation of energy recovery by municipal solid waste incineration plants.	Regulatory	Implemented	Mandatory minimal energy recovery rate.	2016	FOEN	28

[a] Policies and measures marked with an asterisk (*) are included in the 'with measures' projection.

[b] Regulations regarding the installation of technical equipment for the collection and removal of landfill gas were already established in the 1990s.

FOEN, Swiss Federal Office for the Environment

4.8.2 Ban on landfilling of combustible waste

Since 2000, disposal of combustible solid wastes on landfills is banned. All Swiss waste incineration plants use the combustion heat they produce to generate electricity or to supply district heating networks and industrial facilities. Today, Swiss waste incineration plants supply around two per cent of Switzerland's total energy consumption. As a consequence of the ban on landfilling, CH_4 emissions from solid waste disposal sites have declined substantially. In addition, regulations regarding landfilling established in the 1990s led to the installation of technical equipment for the collection and removal of landfill gas (*Consaba*, 2016).

Estimate of mitigation impact

The mitigation impact of the ban on landfilling of combustible waste is estimated by comparing the 'with existing measures' (WEM) and 'without measures' (WOM) scenarios as used for Switzerland's projections of greenhouse gas emissions (for methodological details see section 5.3.5). Accordingly, it is assumed that the mitigation impact of the ban on landfilling of combustible waste corresponds to 177 thousand tonnes of CO_2 equivalents in the year 2020 (this estimate does not include the different evolutions of biogas production which leads to further differences between the two scenarios for the waste sector).

4.8.3 Ordinance on the Avoidance and Management of Waste

In Switzerland, the disposal of waste is regulated by the Ordinance on the Avoidance and Management of Waste (*Swiss Confederation*, 2015). As of 1 January 2016, this ordinance replaced the former Technical Ordinance on Waste. The new ordinance aims in particular at the sustainable use of renewable and non-renewable raw materials, inter alia by promoting closed-loop material flows. At the same time, the reduction of environmental pollution by means of separation and appropriate treatment of hazardous substances and proper disposal of all kinds of waste is to be further improved. The reliability of the waste removal system as a whole is to be strengthened by ensuring adequate structures for collection, transport and treatment of the different types of waste.

The most relevant goal with a direct impact on greenhouse gas emissions of the Ordinance on the Avoidance and Management of Waste is the optimisation of the energy recovery by municipal solid waste incineration plants. This is done by the prescription of a mandatory minimal energy recovery rate of 55 per cent of the energetic content of the waste incinerated (mandatory as of 1 January 2026). All 30 Swiss municipal solid waste incineration plants are supplying energy either in form of electricity or heat for district heating. Whereas many municipal solid waste incineration plants show recovery rates far above the minimal regulatory requirements, there are a few plants which need further technical investments in order to meet the minimal recovery rate.

Estimate of mitigation impact

According to a conservative scenario, municipal solid waste incineration plants with an insufficient recovery rate have to raise their energy efficiency in order to meet the mandatory requirements. Applied to the actual situation in 2016, an additional minimal recovery of 107 gigawatt-hours is needed that all municipal solid waste incineration plants fulfil the legal requirements. Assumed that this additional energy is supplied as heat for district heating and, therefore, replaces fossil heating fuels, a reduction of 28 thousand tonnes of CO_2 can be obtained. On the one hand, this is a very conservative assumption, because an energetic optimisation of a municipal solid waste incineration plant will usually aim at higher energy recovery rate than required by the Ordinance on the Avoidance and Management of Waste. On the other hand, there is a transition period until 2026, i.e. the full mitigation impact may develop after 2020 (but the value of 28 thousand tonnes of CO_2 is still provided as the best estimate for the mitigation impact for 2020 in Tab. 22).

4.9 Costs, non-greenhouse gas mitigation benefits and interactions of policies and measures

Although encouraged by the UNFCCC reporting guidelines on national communications to report on costs, non-greenhouse gas mitigation benefits and interactions of policies and measures, gaining this information is very challenging and Switzerland is not in a position to comprehensively report this information for every single policy and measure. However, information for selected policies and measures as well as a discussion of the challenges regarding the reporting of this information is provided in the following.

Costs of policies and measures

Evaluation of the costs of policies and measures is particularly challenging, e.g. because the definition of costs is ambiguous and because many policies and measures are closely interlinked. Accordingly, Switzerland does not evaluate its policies and measures regarding costs on a regular basis, and no consistent methodology to estimate costs of all individual policies and measures exists. However, for selected policies and measures, the following information is available:

- The economy-wide cost of the CO_2 levy has been analysed in detail (*FOEN*, 2016b). A hypothetical increase of the maximum rate of the CO_2 levy to 210 Swiss francs per tonne of CO_2 would lead to a reduction of gross domestic product of around 0.4 per cent in 2030, compared to a scenario where the rate is held constant at 96 Swiss francs per tonne of CO_2;
- The planned linking of the emissions trading schemes of Switzerland and the European Union would increase Switzerland’s gross domestic product by approximately 0.04 per cent in 2030, compared to a scenario where the two emissions trading schemes are operated separately. The inclusion of aircraft operators in the emissions trading scheme would slightly reduce the growth rate of value added of the aviation sector, but this effect would most probably not fully counteract the overall positive impact of the linking;
- The remaining policies and measures are expected to have only a minor or even negligible impact on the overall economy. Additionally, possible secondary benefits of the reduction of emissions (such as lower health costs, lower dependency on fossil fuels, impacts on innovation etc.) are not included in the calculations above. While these benefits are difficult to quantify, it is likely that the overall economic impact of the proposed measures would be positive if their benefits were also considered;
- The costs for the emission reductions outside Switzerland will depend strongly on the corresponding prices. Currently, reductions abroad are a relatively cheap mitigation option when compared to reductions in Switzerland. However, costs for reductions abroad are likely to increase in the future when developing countries will have to fulfil their commitments under the Paris Agreement.

Non-greenhouse gas mitigation benefits of policies and measures

As indicated above, non-greenhouse gas mitigation benefits of policies and measures are generally difficult to estimate. The main benefits come from the reduction of other air pollutants and the corresponding decrease of health and damage costs. Until 2020, these benefits (mainly due to the CO_2 levy on heating and process fuels) are estimated to be 100 million to 200 million Swiss francs per year (*Econcept*, 2008). The dependency on fossil fuels from abroad could be reduced by around 2.7 per cent if the objective of reducing greenhouse gas emissions by 20 per cent by 2020 relative to 1990 is reached. For any other secondary benefits, no robust quantifications are available.

Interactions of policies and measures

Around three quarters of Switzerland's greenhouse gas emissions result from fossil fuel use. Energy and climate policy are therefore closely linked. The main objective of the Energy Strategy 2050 (increasing energy efficiency and the use of renewable energy) also contributes to the mitigation of CO_2 emissions. However, due to the implementation of the Energy Strategy 2050, it is possible that the production of electricity from fossil sources may increase, which would have a negative impact on Switzerland's CO_2 emissions. Fossil thermal power plants are therefore obliged to fully compensate their emissions. The first bundle of measures of the Energy Strategy 2050 also includes measures that require adjustments of the CO_2 Act, most notably the strengthening of the CO_2 emissions regulations for passenger cars from 130 to 95 grams of CO_2 per kilometre, the exemption from the CO_2 levy of operators of fossil combined heat and power plants, and the increase of the maximum amount earmarked for the national buildings refurbishment programme from 300 million to 450 million Swiss francs per year. As detailed in section 5.2.1, *EPFL and Infras* (2016) and *EPFL* (2017) estimate that in the energy sector the combined effects of policies and measures are responsible for about 12 per cent of the aggregate effect of currently implemented and adopted policies and measures.

4.10 Modification of longer-term trends in greenhouse gas emissions

Switzerland's policies and measures described in section 4.2 to 4.8 are generally set out to modify the short-term and longer-term trends in anthropogenic greenhouse gas emissions and removals (obviously aiming at reducing net emissions of greenhouse gases). In line with the general objectives of the Convention, they aim at promoting efficiency improvements in the energy, transport and waste sectors, give preference to the sustainable use of renewable resources in agriculture and forestry, and set incentives for the use of climate-friendly substances in the industry sector. The modification of the longer-term trend in greenhouse gas emissions achieved by Switzerland's policies and measures becomes obvious when comparing the 'with existing measures' (WEM) and 'without measures' (WOM) scenarios as presented in chapter 5 (and in particular in Fig. 62). Further, emission trends will be modified by measures where the immediate effect on greenhouse gas emission levels is not a priority, but where longer-term contributions to a low-emission economy and society are targeted. Some examples of particular interest are:

- **Masterplan Cleantech**: In 2011, the Swiss government published the Masterplan Cleantech for Switzerland (*OPET*, 2011). This strategy aims at improving resource efficiency and promoting renewable energies. It encourages cooperation among companies, research centres, cantons and the Swiss Confederation. Under its heading, promotional programmes for research and innovation, knowledge and technology transfer, education and advanced training, and export promotion are topics receiving particular attention. The evaluation of the first years of the Masterplan Cleantech shows a highly positive picture, as it is estimated that the clean technology sector contributed an estimated gross value added of 49 billion Swiss francs and employed 530 thousand persons in 2013[29];
- **Technology fund**: In the context of the second CO_2 Act, a technology fund, financed with 25 million Swiss francs per year from the revenue of the CO_2 levy, was established in 2013. This fund provides for loan guarantees for innovative companies in order to ease access to capital for investments in developing new low-emission technologies;
- **Information, training and advisory services**: As of 2013, the second CO_2 Act requests the Swiss Confederation and the cantons to support measures for the integration of elements relevant regarding climate change in

[29] For details see *https://www.admin.ch/gov/de/start/dokumentation/medienmitteilungen.msg-id-57171.html* and *http://www.swisscleantech.ch*.

communication, education and professional training programmes at all levels. This includes improving knowledge about mitigation of greenhouse gas emissions as well as adaptation to climate change.

4.11 Policies and measures no longer in place

The climate policies and measures developed over the past years are well-established. As described under the respective sections, some of the measures implemented have been adapted and strengthened over time. Most measures listed in Switzerland's sixth national communication – which was updated with Switzerland's second biennial report – are still part of the national portfolio. Nevertheless, BR CTF table 3 has been updated to better reflect the nature, status and practical relevance of certain policies and measures.

As mentioned in previous reports, several policies and measures are still in place but no longer listed in BR CTF table 3, due to their nature (legal or strategic frameworks mentioned in the sectoral introductory paragraphs, from which more specific polices and measures emanate) or due to their rather weak link to the achievement of mitigation commitments (policies and measures mainly impacting precursor gases). These measures are, however, briefly described in textual form in section 4.4.11.

4.12 Policies and measures leading to an increase in greenhouse gas emissions

No significant changes have occurred since Switzerland's sixth national communication with regard to Switzerland's commitment under Article 4, paragraph 2(e)(ii), of the UNFCCC to identify and periodically update the policies and practices that encourage activities that lead to greater levels of anthropogenic greenhouse gas emissions than would otherwise occur. In brief, the decision to not replace nuclear power plants at the end of their service life will require other options for power generation, among other likely also gas-fired combined-cycle power plants (see section 4.3.1). While this will potentially lead to additional greenhouse gas emissions, operators of gas-fired combined-cycle power plants are obligated to fully offset the respective emissions (section 4.3.6). Further, as detailed in section 4.13, there are a few tax exemptions and reductions at the federal level providing limited support to users of fossil fuels: Farmers, foresters, fishermen and the fuel use of snow cats are exempt from the mineral oil tax that is normally levied on sales of mineral oils, while public transport companies benefit from a reduced rate. The reasoning for these tax exemptions are to avoid putting a strain on the production within the agriculture sector, to avoid levying taxes which are earmarked for expenditures related to road traffic from users of non-road vehicles (such as snow cats), or to avoid levying taxes from companies which are subsidised because they render services for the public benefit.

4.13 Economic and social consequences of response measures (minimising adverse effects)

Detailed information on the assessment of the economic and social consequences of response measures are requested by paragraph 13 of the revised UNFCCC reporting guidelines on national communications (FCCC/SBI/2016/L.22). Further, paragraph 36 of the guidelines for the preparation of information under Article 7 of the Kyoto Protocol (FCCC/CP/2001/12/Add.3, Annex) requests information on how Parties strive to implement policies and measures under Article 2 of the Kyoto Protocol in such a way as to minimise adverse effects, including the adverse effects of climate change, effects on international trade, and social, environmental and economic impacts on other Parties, especially developing country Parties and in particular those identified in Article 4, paragraphs 8 and 9, of the Convention, taking into account Article 3 of the Convention.

In the following, Switzerland reports the requested information, thereby addressing the actions mentioned in Decision 31/CMP.1, paragraph 8 (FCCC/KP/CMP/2005/8/Add.4). Further information regarding financial support for any economic and social consequences of response measures is provided in section 7.1.5.

Context

Switzerland strives to design climate change policies and measures in a way as to ensure a balanced distribution of mitigation efforts by implementing climate change response measures in all sectors and for different gases. Indirectly, this approach is deemed to minimise also potential adverse impacts on concerned actors (including developing countries). Given Switzerland's size and share in international trade (mainly with the European Union), it is not assumed that Swiss climate change policies have any significant adverse economic, social or environmental impacts in developing countries. Additionally, the policies and measures are very much compatible and consistent with those of the European Union in order to avoid trade distortion, non-tariff barriers to trade and to set similar incentives. All major legal reform projects in Switzerland are to be accompanied by impact assessments, inter alia including evaluation of trade-related issues. This approach strives for climate change response measures which are least trade distortive and do not create unnecessary barriers to trade. Consistently, Switzerland notifies all proposed non-tariff measures having a potential impact on trade to the World Trade Organisation.

Impact assessments of legal reform projects are accompanied by a broad internal and external consultation process, inter alia inviting competent and potentially affected actors to provide advice on economic, social and environmental aspects of proposed policies and measures. The open public consultation process, together with regular policy dialogues with other countries guarantee that domestic and foreign stakeholders can raise concerns and issues related to new policy initiatives, including those concerns about possible adverse impacts on other countries.

Progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions and subsidies in all greenhouse gas emitting sectors, taking into account the need for energy price reforms to reflect market prices and externalities

Environmental policy in Switzerland, including climate change policies, is guided by the polluter pays principle, as enshrined in the Federal Act on the Protection of the Environment (*Swiss Confederation*, 1983). Accordingly, the internalisation of external costs and adequate price signals are key aspects of Switzerland's climate change policy. Regarding greenhouse gas emissions, market-based instruments – such as e.g. the Swiss emissions trading scheme (section 4.2.6), the supplemental use of international carbon credits from the Clean Development Mechanism (Annex B.3.6) or the CO_2 levy on heating and process fuels (section 4.2.5) – are important measures to put a price on emissions of greenhouse gases that are then reflected in market prices and thus internalizing externalities.

Regarding fiscal incentives, tax and duty exemptions and subsidies, price-based measures are recognised as essential instruments for promoting the efficient use of resources and to reduce market imperfections. In 2001, Switzerland introduced a heavy vehicle charge (section 4.4.6). It is applied to passenger and freight transport vehicles of more than 3.5 tonnes gross weight. The impact of the heavy vehicle charge was most clearly reflected by changes in traffic volume (truck-kilometres), but also in reduced air pollution, a renewal of the heavy vehicle fleet and an increase of load per vehicle, i.e. fewer trucks transported more goods. Two thirds of the revenues are used to finance major railway infrastructure projects (such as the base tunnels through the Alps, see section 2.7), and one third is transferred to the cantons.

In 2008, Switzerland introduced the CO_2 levy on heating and process fuel to 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 (section 4.2.5). Companies, especially those with substantial CO_2 emissions from use of heating and process fuels, may apply for exemption from the CO_2 levy on heating and process fuels, provided the company commits to emission reductions (section 4.2.7). The company has to elaborate an emission reduction target based on the technological potential and economic viability of various measures within the company. While the proceeds from the CO_2 levy on heating and process fuels were initially to be fully refunded to the Swiss population (on a per capita basis) and to the Swiss economy (in proportion to wages paid), a parliamentary decision of June 2009 earmarked a third of the revenues from the CO_2 levy on heating and process fuels for CO_2 relevant measures in the buildings sector (section 4.3.3). As of 1 January 2018, the funds for the national buildings refurbishment programme are limited to a maximum of 450 million Swiss francs per year (previously 300 million Swiss francs per year).

As analysed in detail in two studies, the overall economic impact of the Swiss climate policy is considered to be very small (*Ecoplan*, 2009; *FOEN*, 2010).

In general, Switzerland does not subsidise fossil fuels. However, depending on the definition, there are some policies in place that may be regarded as fossil fuel subsidies, but these policies are only applicable to small amounts of fossil fuels consumed in Switzerland. At the federal level, a few tax exemptions and reductions provide limited support to users of fossil fuels. Farmers, foresters, fishermen and the fuel use of snow cats are exempt from the mineral oil tax that is normally levied on sales of mineral oils, while public transport companies benefit from a reduced rate. These mineral oil tax exemptions in the specific sectors are listed in appendix 3 of the Swiss Federal Council's subsidy report (*Swiss Federal Council*, 2008). Moreover, the mineral oil tax refunds in the agriculture sector are currently subject to an examination by the Swiss Federal Audit Office and the report is planned to be published in 2017[30]. Some vehicles are also exempt from the performance-related heavy vehicle charge, e.g. agricultural vehicles, vehicles used for the concessionary transport of persons or vehicles for police, fire brigade, oil and chemical emergency unit, civil protection and ambulances.

Worldwide subsidies for fossil fuels are estimated at 300 billion to 500 billion US dollars per year, depending on the level of energy prices. This huge market distortion does not only produce severe fiscal problems for the countries concerned, it also poses a major obstacle for enhanced investments in energy efficiency measures and renewable energies. Switzerland as a founding member of the Friends of Fossil Fuels Subsidy Reform supports the gradual and sustained phasing out of fossil fuel subsidies and the reduction of unnecessary market distortions. Furthermore, Switzerland contributes to the World Bank development project ESMAP (Energy Sector Management Assistance Program). This programme offers technical assistance for states that want to reform their fossil fuel subsidies. The 2016 Annual Report of ESMAP is also supported by Switzerland and provides the analytical basis for the implementation of such reforms.

Removing subsidies associated with the use of environmentally unsound and unsafe technologies

Switzerland does not subsidise the use of environmentally unsound and unsafe technologies.

Cooperating in the technological development of non-energy uses of fossil fuels, and supporting developing country Parties to this end

Switzerland does not support any activities linked to the technological development of non-energy uses of fossil fuels in developing countries.

Cooperating in the development, diffusion, and transfer of less-greenhouse-gas-emitting advanced fossil fuel technologies, and/or technologies, relating to fossil fuels, that capture and store greenhouse gases, and encouraging their wider use; and facilitating the participation of the least developed countries and other non-Annex I Parties in this effort

Switzerland is an active participant in the negotiations for a plurilateral Environmental Goods Agreement (EGA) at the World Trade Organisation with the aim to liberalise environmental goods, including the diffusion and transfer of less-greenhouse-gas-emitting advanced fossil fuel technologies.

Furthermore, Switzerland is supporting the improvement and refit of inefficient gas-fired power plants in developing countries and advocates the use of the most efficient technologies available. Several Swiss universities conduct research in the field of carbon capture and storage and cooperate with other research institutions, companies and universities primarily in Europe and northern America to further develop the technology. Currently, Switzerland is not supporting any least developed countries and other developing countries in the development of fossil fuel-fired power plants with carbon capture and storage technology, because Switzerland is of the view that the technology is not sufficiently mature and cost effective yet.

Strengthening the capacity of developing country Parties for improving efficiency in upstream and downstream activities relating to fossil fuels, taking into consideration the need to improve the environmental efficiency of these activities

Switzerland supports through different projects the enhancement of efficiency in industrial production, i.e. ‘cleaner production’. These cleaner production projects promote eco-efficient means of production and better working conditions attained through technological improvements and behavioural changes in both management and staff in industrial companies and services. The resulting rise of economic and environmental efficiency and improved competitiveness is gained through the systematic optimisation of energy use, processing of raw material, more efficient use of resources and thus better protection of the environment.

30 See annual programme of the Swiss Federal Audit Office (‘Prüfung der Rückerstattung der Mineralölsteuer in der Landwirtschaft’, 17500): *https://www.efk.admin.ch/images/stories/efk_dokumente/publikationen/Jahresprogramme/2017/CDF_prg_2017_de.pdf*.

Furthermore, there is a rising awareness and demand by consumers for environmentally sound products. In order to alleviate potential adverse economic impacts of corresponding national measures, Switzerland promotes and supports the development of international standards, especially with regard to the sustainable use of natural resources (including agricultural commodities), e.g. through the creation of sustainability standards, financial incentives and favourable framework conditions in developing countries.

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

Most developing and transition countries have, in recent years, taken important steps towards trade liberalisation, in order to align their trade policies with international trade agreements. The Swiss State Secretariat for Economic Affairs supports these efforts, because a multilaterally acknowledged and respected set of regulations for international transactions not only strengthens trade as such, but also creates more potent and legally secure markets to the benefit of all players.

The measures taken by the Swiss State Secretariat for Economic Affairs are aimed at creating the necessary conditions for earning additional income in the beneficiary countries and thereby contribute directly to the alleviation of poverty. The Swiss State Secretariat for Economic Affairs is focusing on three areas of intervention along the value chain: (i) enabling framework conditions for trade, (ii) international competitiveness, and (iii) improving market access.

Regarding market access, trade between developing and industrial countries is often insufficiently developed respectively not diversified enough. On one hand, in some developing countries there is still a lack of necessary production capacities, quality standards, transport infrastructure and know-how; on the other hand, tariff and non-tariff barriers to trade make direct access to markets more difficult.

Switzerland promotes access to Swiss markets by granting preferential tariffs on products from developing and emerging countries. In addition, the Swiss State Secretariat for Economic Affairs runs programmes for promoting imports to Switzerland and the rest of Europe. Easing market entry for products from disadvantaged countries is an important contribution to the promotion and diversification of trade, the increase of export revenues and thus to the economic development of the partner countries. Switzerland supports developing and transition countries in the following areas:

- Generalised system of preferences;
- Swiss Import Promotion Program[31];
- Promotion and strengthening of private voluntary social and environmental standards based on international multi-stakeholder approaches, such as Better Cotton, 4C (Common Code for the Coffee Community), Roundtable for Sustainable Biofuels, etc.

Finally, Switzerland is a strong supporter of the Extractive Industries Transparency Initiative. Switzerland acts based on the firm conviction that an efficient use of natural resources is an important driving force for sustainable economic growth, contributing to sustainable development and poverty reduction. The sustainable management of natural resources – as supported by the Extractive Industries Transparency Initiative principle and criteria including regular publication and audit of revenues – is key to mobilise the funds for diversification strategies.

Changes compared to the latest submission

There are no fundamental changes compared to the last submission.

[31] www.sippo.ch

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5 Projections and total effect of policies and measures

In this chapter, Switzerland's greenhouse gas emission projections under the following three scenarios are reported:

- The 'with existing measures' (WEM) scenario, encompassing currently implemented and adopted policies and measures. The WEM scenario thus reflects the current state of legislation, also taking into account the stipulated strengthening of existing policies and measures (i.e. any strengthening foreseen under current legislation);
- The 'without measures' (WOM) scenario, excluding all implemented, adopted and planned policies and measures to the extent possible. However, autonomous diffusion of technological progress takes place also under the WOM scenario, leading to a gradual improvement of energy efficiency (which is obviously slower than under the WEM scenario);
- The 'with additional measures' (WAM) scenario, encompassing implemented, adopted and planned policies and measures. The WAM scenario thus reflects the long-term target scenarios of the Swiss government, taking into account – in addition to all measures considered under the WEM scenario – the planned strengthening of existing policies and measures as well as new policies and measures that have not yet been put in concrete terms but are planned in order to reach the set targets.

Section 5.1 presents Switzerland's total greenhouse gas emissions projected under the WEM, WOM and WAM scenarios from 1990 to 2030, disaggregated by sector and by gas. The projections are presented relative to actual and unadjusted inventory data for the preceding years (*FOEN*, 2017a). An overview of measures considered under the different scenarios and details about the historical and projected key underlying assumptions driving the emission scenarios are provided. In section 5.2, the assessment of the aggregate effect of policies and measures is discussed. Information on the methodology applied as well as the underlying assumptions specific to each sector are presented in section 5.3.1 for the energy sector (including transport), in section 5.3.2 for the industrial processes and product use sector, in section 5.3.3 for the agriculture sector, in section 5.3.4 for the land use, land-use change and forestry sector, in section 5.3.5 for the waste sector, in section 5.3.6 for indirect CO_2 emissions, and in section 5.3.7 for international transport. Section 5.3.8 and section 5.3.9 present major changes since Switzerland's last submission and information on the sensitivity analysis, respectively.

5.1 Projections

5.1.1 Policies and measures considered under the WEM, WOM and WAM scenarios

Tab. 23 gives an overview of the policies and measures considered under the different scenarios; details regarding each policy and measure are discussed in chapter 4.

Tab. 23 > Policies and measures considered under the WEM, WOM and WAM scenarios (policies and measures marked with a dot are considered under the respective scenario). The bifurcation points for the WEM and WOM scenarios are shown in Tab. 29. Under the WAM scenario, some measures are be strengthened compared to the WEM scenario.

Measure	Section in chapter 4	Sector	WEM	WOM	WAM	Remark
First CO2 Act (1999)	4.2.2	Cross-sectoral	●		●	
Second CO2 Act (2011)	4.2.3	Cross-sectoral	●		●	
Third CO2 Act (2021)	4.2.4	Cross-sectoral			●	Planned policy and measure.
CO2 levy on heating and process fuels	4.2.5	Cross-sectoral	●		●	WAM strengthened compared to WEM.
Emissions trading scheme	4.2.6	Cross-sectoral	●		●	WAM strengthened compared to WEM.
Negotiated reduction commitments (for exemption from the CO2 levy)	4.2.7	Cross-sectoral	●		●	
SwissEnergy programme	4.3.2	Energy	●		●	The Swiss Federal Office of Energy refrains from estimating the mitigation impact of the SwissEnergy programme (for explanations see section 4.3.2). In contrast, *EPFL and Infras* (2016) include this policy and measure for the calculation of greenhouse gas emission projections.
National buildings refurbishment programme	4.3.3	Energy	●		●	WAM strengthened compared to WEM.
Building codes of the cantons	4.3.4	Energy	●		●	WAM strengthened compared to WEM.
Negotiated commitments on energy efficiency	4.3.5	Energy	●		●	

Obligation to offset emissions from gas-fired combined-cycle power plants	4.3.6	Energy	●		●	
Negotiated reduction commitment of municipal solid waste incineration plant operators	4.3.7	Energy				This policy and measure points at the net emissions of municipal solid waste incineration plants, i.e. it is expected that emission reductions are achieved mainly by indirect savings thanks to the additional production of electricity and heat as well as the recovery of metals from the bottom ash. In particular the latter may indirectly reduce greenhouse gas emissions outside Switzerland. For these reasons, the policy and measure is not considered for the projections (all scenarios).
CO2 emission regulations for newly registered vehicles	4.4.2	Transport	●		●	WAM strengthened compared to WEM.
Energy label for new motor vehicles	4.4.3	Transport	●		●	
Climate Cent	4.4.4	Transport	●		●	
Partial compensation of CO2 emissions from motor fuel use	4.4.5	Transport	●		●	WAM strengthened compared to WEM.
Heavy vehicle charge	4.4.6	Transport	●		●	
Mineral oil tax reduction on biofuels and natural gas	4.4.7	Transport	●		●	
Inclusion of aviation in the emissions trading scheme	4.4.8	Transport			●	Planned policy and measure.
CO2 emissions standards for aircraft	4.4.9	Transport				Not explicitly included in the emission perspectives.
Carbon offsetting and reduction scheme for international civil aviation (CORSIA)	4.4.10	Transport			●	Planned policy and measure.
Provisions relating to substances stable in the atmosphere (HFCs, PFCs, SF6, NF3)	4.5.2	IPPU	●		●	WAM strengthened compared to WEM.
International exhaust gas regulations (NMVOC)	4.5.3	IPPU	●		●	Relevant for indirect CO_2 emissions.
Ordinance on Air Pollution Control	4.5.4	IPPU	●		●	Relevant for indirect CO_2 emissions.
NMVOC incentive fee	4.5.5	IPPU	●		●	Relevant for indirect CO_2 emissions.
Proof of ecological performance to receive direct payments	4.6.2	Agriculture	●	●	●	Because the bifurcation point of the WEM and WOM scenarios of this measure is 2011 (Tab. 29), most of the mitigation impact provided in section 4.6.2 and Tab. 20 is reflected in all scenarios (as the mitigation impact reported in Tab. 20 is mostly achieved in the early 1990s).
Resource programme (subsidies for a more efficient use of natural resources)	4.6.3	Agriculture			●	
Climate strategy for agriculture	4.6.4	Agriculture			●	
Further development of the direct payments system (orientation towards targets)	4.6.5	Agriculture	●		●	
Forest Act (sustainable forest management and forest area conservation)	4.7.2	LULUCF	●		●	
Wood Action Plan	4.7.3	LULUCF	●		●	
Measures within Forest Policy 2020	4.7.4	LULUCF	●		●	
Forest Act (most recent changes)	4.7.5	LULUCF	●		●	
Ban on landfilling of combustible waste	4.8.2	Waste	●		●	
Ordinance on the Avoidance and Management of Waste	4.8.3	Waste	●		●	

IPPU, industrial processes and product use; LULUCF, land use, land-use change and forestry

5.1.2 Key underlying assumptions

To provide a general overview of the drivers of Switzerland's greenhouse gas emission scenarios, Tab. 24 shows key underlying assumptions used for the modelling of the WEM, WOM and WAM scenarios (the information provided corresponds to the information in BR CTF table 5). Population is assumed to increase considerably over the coming decades. This is also reflected in energy reference area and transport growth. Switzerland's gross domestic product, another parameter strongly influencing energy consumption and greenhouse gas emissions, is also assumed to increase considerably over the coming decades. While for historical years the heating degree days reflect the observed natural variability of meteorological conditions (mainly during winter), a smooth trend is assumed for projected years reflecting the expected average meteorological conditions. Accordingly, for future years the greenhouse gas emissions scenarios are based on average meteorological conditions, but may vary substantially from year to year (see section 6.2.8 for more details).

Tab. 24 > Historical and projected key underlying assumptions used for the modelling of Switzerland's greenhouse gas emission projections (relevant for all scenarios). See section 6.2.8 for more details about heating degree days.

Key underlying assumptions	Historical							Projected		
	1990	1995	2000	2005	2010	2011	2015	2020	2025	2030
Population (31 December, million inhabitants)	6.75	7.06	7.20	7.46	7.86	7.96	8.33	8.76	9.16	9.54
Gross domestic product (prices 2015, billion Swiss francs)	443	445	499	537	599	609	646	701	750	799
IEA crude oil price (prices 2015, US dollars per barrel)	36.5	25.1	37.6	60.5	84.9	78.1	51.0	82.0	104.5	127.0
European Union import price for natural gas (prices 2015, US dollars per Mbtu)	4.2	2.9	4.3	6.9	8.2	8.0	7.0	7.3	9.2	11.1
Energy reference area (relative to 1990, per cent)	100	111	126	136	147	149	158	170	178	186
Heating degree days	3'203	3'397	3'081	3'518	3'586	3'484	3'075	3'244	3'154	3'064
Passenger transport (billion vehicle kilometres)	42'649	44'131	45'613	48'281	50'949	51'782	55'114	56'618	58'628	60'471
Number of passenger cars (1000 vehicles)	2'985	3'229	3'545	3'861	4'076	4'152	4'458	4'689	4'824	4'893
Number of other vehicles (1000 vehicles)	1'046	985	1'030	1'099	1'177	1'207	1'326	1'360	1'389	1'420

EPFL and Infras (2016); *EPFL* (2017); *Infras* (2017)

5.1.3 Results

Tab. 25 and Tab. 26 provide a general overview of the projections of Switzerland's greenhouse gas emissions under the WEM, WOM and WAM scenarios, detailed by sector and by gas (the tables complement the results presented in BR CTF table 6). For a direct comparison with Switzerland's emissions reduction targets, the total emissions presented in the tables and figures of this chapter are composed as follows:

- Emissions of all greenhouse gases from the sectors 1 'Energy', 2 'Industrial processes and product use', 3 'Agriculture' and 5 'Waste' are included;
- Emissions from sector 6 'Other' are excluded;
- Indirect CO_2 emissions are included (for details see section 3.2.4 and Annex B.3.3), with the exception of indirect CO_2 emissions from sector 6 'Other', as this sector is not included at all in Switzerland's emission reduction targets;
- While greenhouse gas emissions and removals from land use, land-use change and forestry are accounted for by an activity-based approach at the end of the commitment period (see Annex B.3.5), they are excluded from the totals presented in this chapter. However, the evolutions for the different scenarios for sector 4 'Land use, land-use change and forestry' are reported separately and briefly discussed;
- Greenhouse gas emissions from international transport are excluded, but to increase transparency, they are reported separately and briefly discussed;
- To be fully consistent with Switzerland's emission reduction target, the values for Switzerland's base year emissions should actually be taken from the update to Switzerland's second initial report (*FOEN*, 2016d, see also FCCC/IRR/2016/CHE). However, to simplify matters (and because the differences are negligible), relative evolutions in this chapter are provided with regard to the emissions in 1990 according to Switzerland's most recent greenhouse gas inventory submission.

The evolution of total greenhouse gas emissions under the WEM, WOM and WAM scenarios as relevant for Switzerland's emission reduction targets is displayed in Fig. 62, while the various panels in Fig. 63 and Fig. 64 present the disaggregation by sector and gas, respectively. To provide more details for the energy sector and to allow for a distinction of the contribution of transport[32], the evolution of the different source categories of sector 1 'Energy' (1A1, 1A2, 1A3, 1A4, 1A5, and 1B) under the WEM, WOM and WAM scenarios is shown in Fig. 65 and Fig. 66. Finally, Fig. 67 shows the evolution of indirect CO_2 emissions. In brief, the three scenarios (emissions as relevant for Switzerland's emission reduction targets) are characterised as follows:

[32] In BR CTF table 6, 'energy' consists of the greenhouse gas emissions from the source categories 1A1, 1A2, 1A4, 1A5 and 1B (which are targeted with the policies and measures presented in section 4.3), while 'transport' consists of the greenhouse gas emissions from source category 1A3 (which are targeted with the policies and measures presented in section 4.4).

- **'With existing measures' (WEM) scenario:** By 2020 and 2030, Switzerland's total greenhouse gas emissions under the WEM scenario are projected to decrease to 85.6 per cent and 77.7 per cent of the emissions in 1990, respectively. While the source category covering residential and commercial/institutional buildings (1A4) dominated total emissions in 1990, its emissions gradually decreased and are projected to continue on a decreasing pathway, reaching a reduction of 31.7 per cent by 2020 compared to 1990 (Fig. 66). Emissions from transport (1A3), on the other hand, increased considerably (by 13.6 per cent) between 1990 and 2008, exceeding emissions from residential and commercial/institutional buildings by 2007. Emissions from the transport sector are largely driven by passenger cars. Only recently, efforts to reduce specific vehicle emissions seem to become effective. Accordingly, thanks to the CO_2 emission regulations for newly registered vehicles stipulated in the second CO_2 Act (section 4.4.2), as well as thanks to the autonomous technological progress, greenhouse gas emissions from the transport sector are projected to decrease over the coming years. The emission reduction projected to be achieved by 2020 is 10.8 per cent compared to the highest level in 2008, meaning that emissions from the transport sector are still 1.3 per cent above the emissions in 1990. Emission reductions from the source categories covering residential and commercial/institutional buildings (1A4) as well as transport (1A3) dominate the projected evolution of total greenhouse gas emissions under the WEM scenario. Emissions from other source categories remain about stable and/or are of minor importance, with the exception of the F-gases, where projections suggest the peaking of emissions before 2020 and a decline thereafter (Fig. 64);
- **'Without measures' (WOM) scenario:** Under the WOM scenario, policies and measures are excluded as of the bifurcation points indicated in Tab. 29, i.e. with a few exceptions as early as 1990. Consequently, emissions under the WOM scenario show an increasing tendency until around 2010, followed by a slow decrease to 4.0 per cent above the emissions in 1990 by 2020 and to 0.3 per cent below the emissions in 1990 by 2030. This decreasing trend after about 2010 is a result of autonomous technological progress improving the greenhouse gas efficiency also in the absence of (domestic) policies and measures. Under the WOM scenario (as under the WEM scenario), the source categories covering residential and commercial/institutional buildings (1A4) and transport (1A3) are mainly responsible for the general decrease in total greenhouse gas emissions in the coming years, to some extent also the manufacturing industry (1A2; see Fig. 65 and Fig. 66). In contrast, emissions from energy industries (1A1) are projected to increase, in particular in 2019 and 2029, i.e. at the time when nuclear power plants are decommissioned and assumed to be replaced by gas-fired combined-cycle power plants (Fig. 68)[33]. Accordingly, greenhouse gas emissions from energy industries (1A1) exceed, by 2030, the emissions in 1990 by about 3.9 million tonnes of CO_2 equivalents. A continuously increasing trend is also projected for emissions from the industrial processes and product use sector, which, driven by emissions of HFCs, increase to 29.1 per cent above the emissions in 1990 by 2020 and to 31.9 per cent above the emissions in 1990 by 2030;
- **'With additional measures' (WAM) scenario:** By 2030, Switzerland's total greenhouse gas emissions under the WAM scenario are projected to decrease to 65.2 per cent of the emissions in 1990. Compared to the WEM scenario, emissions decrease faster, as new policies and measures are introduced and existing policies and measures are strengthened beyond the strengthening already stipulated under current legislation (i.e., under the WEM scenario). While the energy sector (in particular the source categories covering residential and commercial/institutional buildings as well as transport) is mainly responsible for the additional emission reductions, contributions also come from the agriculture sector and from the reduction of emissions of F-gases within the industrial processes and product use sector (Fig. 66).

Regarding **land use, land-use change and forestry**, the difference between the WEM and the WOM scenarios results from differing forest management practices, because all other parameters are identical for all scenarios (see section 5.3.4). Under the WEM scenario, harvesting is assumed to increase, making the land use, land-use change and forestry sector a net source, with differences between the WEM and the WOM scenarios of 1.7 million to 2.1 million tonnes of CO_2 equivalents over the period from 2020 to 2030. However, the low harvesting rates assumed under the WOM scenario lead to an unsustainable forest stand in the long run and, amongst other effects, jeopardise the capacity of forests to adapt to climate change. Therefore, despite the positive (short-term) effect with regard to carbon sequestration, the WOM scenario is not considered a viable policy option. In more detail, the following emissions and removals

[33] In contrast, under the WEM scenario nuclear power plants are replaced by gas-fired combinded-cycle power plants only to a minor extent (Fig. 68). Accordingly, the respective increases in emissions are hardly visible in total emissions of the energy sector, but emerge when looking at emissions of source category 1A1 separately (Tab. 25 and Fig. 65).

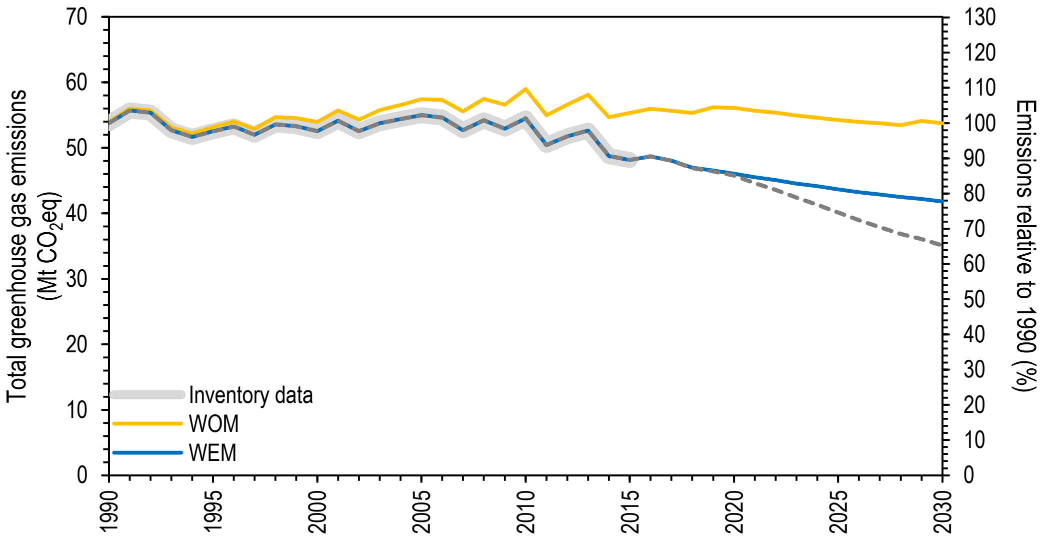
from the land use, land-use change and forestry sector are projected under the different scenarios (see Tab. 35 for underlying assumptions):

- Under the WEM scenario, forest management leads to net emissions in the order of 0.1 million tonnes of CO_2 equivalents per year in the period from 2020 to 2030. The combined effects of afforestation, deforestation and forest management activities lead to total net emissions in the order of 0.2 million to 0.3 million tonnes of CO_2 equivalents in the period from 2020 to 2030. In total, the land use, land-use change and forestry sector produces net emissions of 0.9 million to 1.0 million tonnes of CO_2 equivalents per year in the period from 2020 to 2030 (Tab. 25);
- Under the WOM scenario, forest management leads to net removals of –1.5 million to –2.0 million tonnes of CO_2 equivalents in the period from 2020 to 2030. The forest category as a whole (i.e. afforestation, deforestation and forest management activities) acts as a net sink of –1.4 million to –1.9 million tonnes of CO_2 equivalents in the period from 2020 to 2030. In total, the land use, land-use change and forestry sector produces net removals of –0.7 million to –1.2 million tonnes of CO_2 equivalents in the period from 2020 to 2030 (Tab. 25);
- Under the WAM scenario, forest management leads to net emissions in the order of 1.1 to 1.7 million tonnes of CO_2 equivalents in the period from 2020 to 2030. The aggregate effect of afforestation, deforestation and forest management activities leads to total net emissions in the order of 1.2 million to 1.8 million tonnes of CO_2 equivalents in the period from 2020 to 2030. In total, the land use, land-use change and forestry sector produces net emissions of 1.9 million to 2.6 million tonnes of CO_2 equivalents in the period from 2020 to 2030 (Tab. 25).

Regarding **international transport (bunkers)**, virtually all (more than 99 per cent, see Tab. 3) greenhouse gas emissions stem from air transport, while greenhouse gas emissions from navigation are of negligible importance. Greenhouse gas emissions from international transport are assumed to be the same under the WEM and WOM scenarios, while carbon neutral growth of air transport as of 2020 is assumed under the WAM scenario (although emission compensations taking place outside the aviation sector are most likely, they are not considered as an option here).

In this chapter, solely projections of **domestic emissions** under the different scenarios are provided, in agreement with the target of the second CO_2 Act which is defined as a 20 per cent domestic reduction by 2020 compared to 1990 (Annex B.3). While Switzerland's focus indeed lies on domestic emission reductions, international carbon credits will play a subsidiary role in particular cases (Annex B.3.6), but they are not taken into account for the scenarios presented here.

Fig. 62 > Total greenhouse gas emissions under the WEM, WOM and WAM scenarios as relevant for Switzerland's emission reduction targets (i.e. including emissions of all greenhouse gases from the sectors 1, 2, 3 and 5, including indirect CO_2 emissions from these sectors, excluding direct and indirect emissions from sector 6, excluding emissions and removals from land use, land-use change and forestry, and excluding emissions from international transport). Also shown are actual inventory data for the years 1990 to 2015. The vertical axis to the right indicates emissions relative to 1990. Values are provided in Tab. 25 and Tab. 26. Year-to-year variations visible in all scenarios for the years 1990 to 2015 reflect the impact of meteorological conditions on heating demand (see also section 3.2.3). For projections up to 2030, a smooth trend of meteorological conditions is assumed (in line with the heating degree days shown in Tab. 24).



Tab. 25 > Greenhouse gas emissions under the WEM, WOM and WAM scenarios by sector. The total is shown as relevant for Switzerland's emission reduction targets (i.e. including emissions of all greenhouse gases from the sectors 1, 2, 3 and 5, including indirect CO_2 emissions from these sectors, excluding direct and indirect emissions from sector 6, excluding emissions and removals from land use, land-use change and forestry, and excluding emissions from international transport). See footnote 33 for a discussion of the emission trends in source category 1A1. From 1990 to 2015, the WEM and WAM scenarios correspond to actual inventory data.

		1990	1995	2000	2005	2010	2015	2020	2025	2030
		Mt CO_2eq								
Total as relevant for Switzerland's emission reduction targets	**WEM**	**53.8**	**52.5**	**52.5**	**55.0**	**54.5**	**48.1**	**46.0**	**43.6**	**41.8**
	WOM	**53.9**	**53.2**	**53.9**	**57.4**	**58.9**	**55.3**	**56.1**	**54.2**	**53.8**
	WAM	**53.8**	**52.5**	**52.5**	**55.0**	**54.5**	**48.1**	**45.8**	**40.1**	**35.1**
1 Energy	WEM	41.8	41.9	42.2	44.0	43.2	37.1	35.4	33.5	32.1
	WOM	42.0	42.3	43.2	45.9	46.7	43.1	43.9	42.0	41.6
	WAM	41.8	41.9	42.2	44.0	43.2	37.1	35.3	30.2	26.0
1A1 Energy industries	WEM	2.5	2.6	3.2	3.8	3.8	3.3	3.8	3.7	4.1
	WOM	2.5	2.7	3.2	3.8	4.0	4.1	5.1	5.2	6.5
	WAM	2.5	2.6	3.2	3.8	3.8	3.3	3.8	3.4	3.3
1A2 Manufacturing industries and construction	WEM	6.5	6.2	5.9	6.0	5.8	5.0	4.4	4.3	3.9
	WOM	6.5	6.2	6.0	6.1	6.0	5.6	5.6	5.3	5.1
	WAM	6.5	6.2	5.9	6.0	5.8	5.0	4.4	3.9	3.2
1A3 Transport	WEM	14.7	14.3	15.9	15.9	16.3	15.3	14.8	13.7	12.9
	WOM	14.7	14.3	16.0	16.2	17.0	16.1	15.8	15.1	14.7
	WAM	14.7	14.3	15.9	15.9	16.3	15.3	14.7	13.3	11.9
1A4 Other sectors	WEM	17.6	18.2	16.6	17.9	16.8	13.2	12.0	11.5	10.8
	WOM	17.8	18.6	17.5	19.4	19.3	16.9	16.9	16.0	14.9
	WAM	17.6	18.2	16.6	17.9	16.8	13.2	12.0	9.3	7.2
1A5 Military	WEM	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1
	WOM	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1
	WAM	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1
1B Fugitive emissions from oil and natural gas	WEM	0.4	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2
	WOM	0.4	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2
	WAM	0.4	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2
2 Industrial processes and product use	WEM	3.6	2.9	3.1	3.8	4.0	4.0	3.7	3.4	2.9
	WOM	3.6	2.9	3.2	4.0	4.5	4.6	4.6	4.7	4.7
	WAM	3.6	2.9	3.1	3.8	4.0	4.0	3.6	3.2	2.7
3 Agriculture	WEM	6.8	6.5	6.1	6.1	6.2	6.1	6.0	5.9	5.9
	WOM	6.8	6.5	6.1	6.1	6.2	6.1	6.1	6.1	6.1
	WAM	6.8	6.5	6.1	6.1	6.2	6.1	6.0	5.8	5.5
5 Waste	WEM	1.1	0.9	0.9	1.0	0.9	0.8	0.8	0.8	0.8
	WOM	1.1	1.0	1.0	1.1	1.1	1.0	1.0	0.9	0.9
	WAM	1.1	0.9	0.9	1.0	0.9	0.8	0.8	0.8	0.8
Indirect CO_2 (excluding sector 6)	WEM	0.4	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.1
	WOM	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5
	WAM	0.4	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.1
4 LULUCF (not included in the total)	*WEM*	*–0.3*	*–3.7*	*5.0*	*–2.2*	*–1.3*	*–0.9*	*1.0*	*1.0*	*0.9*
	WOM	*–0.3*	*–3.7*	*5.0*	*–2.2*	*–1.3*	*–0.9*	*–0.7*	*–1.1*	*–1.2*
	WAM	*–0.3*	*–3.7*	*5.0*	*–2.2*	*–1.3*	*–0.9*	*1.9*	*2.6*	*2.5*
International transport (not included in the total)	*WEM*	*3.2*	*3.7*	*4.7*	*3.5*	*4.3*	*5.0*	*4.8*	*5.1*	*5.4*
	WOM	*3.2*	*3.7*	*4.7*	*3.5*	*4.3*	*5.0*	*4.8*	*5.1*	*5.4*
	WAM	*3.2*	*3.7*	*4.7*	*3.5*	*4.3*	*5.0*	*4.8*	*4.8*	*4.8*

Tab. 26 > Greenhouse gas emissions under the WEM, WOM and WAM scenarios by gas. Values are shown as relevant for Switzerland's emission reduction targets (i.e. including emissions of all greenhouse gases from the sectors 1, 2, 3 and 5, including indirect CO_2 emissions from these sectors, excluding direct and indirect emissions from sector 6, excluding emissions and removals from land use, land-use change and forestry, and excluding emissions from international transport). From 1990 to 2015, the WEM and WAM scenarios correspond to actual inventory data. The maximum value for NF_3 is 8.5 kilotonnes of CO_2 equivalents (reached in the year 2010).

		1990	1995	2000	2005	2010	2015	2020	2025	2030
		Mt CO_2eq								
Total as relevant for Switzerland's emission reduction targets	**WEM**	**53.8**	**52.5**	**52.5**	**55.0**	**54.5**	**48.1**	**46.0**	**43.6**	**41.8**
	WOM	**53.9**	**53.2**	**53.9**	**57.4**	**58.9**	**55.3**	**56.1**	**54.2**	**53.8**
	WAM	**53.8**	**52.5**	**52.5**	**55.0**	**54.5**	**48.1**	**45.8**	**40.1**	**35.1**
CO_2 (excluding LULUCF, excluding sector 6, excluding international transport)	WEM	44.2	43.4	43.6	45.8	45.0	38.7	37.0	35.0	33.5
	WOM	44.3	43.9	44.6	47.6	48.5	44.7	45.4	43.4	42.9
	WAM	44.2	43.4	43.6	45.8	45.0	38.7	36.9	31.8	27.4
CH_4 (excluding LULUCF, excluding sector 6, excluding international transport)	WEM	6.1	5.8	5.4	5.3	5.3	5.1	4.9	4.9	4.8
	WOM	6.1	5.9	5.5	5.4	5.4	5.3	5.2	5.1	5.1
	WAM	6.1	5.8	5.4	5.3	5.3	5.1	4.9	4.8	4.5
N_2O (excluding LULUCF, excluding sector 6, excluding international transport)	WEM	2.8	2.7	2.5	2.4	2.5	2.4	2.3	2.3	2.3
	WOM	2.8	2.7	2.6	2.4	2.5	2.4	2.5	2.5	2.5
	WAM	2.8	2.7	2.5	2.4	2.5	2.4	2.3	2.2	2.2
HFCs	WEM	0.0	0.2	0.6	1.1	1.3	1.5	1.5	1.2	0.8
	WOM	0.0	0.2	0.7	1.3	1.7	2.1	2.3	2.5	2.6
	WAM	0.0	0.2	0.6	1.1	1.3	1.5	1.4	1.1	0.7
PFCs	WEM	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
	WOM	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
	WAM	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
SF_6	WEM	0.1	0.1	0.1	0.2	0.1	0.3	0.1	0.1	0.1
	WOM	0.1	0.1	0.1	0.2	0.2	0.3	0.2	0.2	0.2
	WAM	0.1	0.1	0.1	0.2	0.1	0.3	0.1	0.1	0.1
NF_3	WEM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	WOM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	WAM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect CO_2 (excluding sector 6)	WEM	0.4	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.1
	WOM	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5
	WAM	0.4	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.1

Fig. 63 > Greenhouse gas emissions under the WEM, WOM and WAM scenarios by sector as shown in Tab. 25. Also shown are actual inventory data for the years 1990 to 2015. See Fig. 65 for a more detailed disaggregation within the energy sector, in particular allowing for a distinction of the transport sector. For international transport, the WOM scenario (orange line hidden) is identical to the WEM scenario.

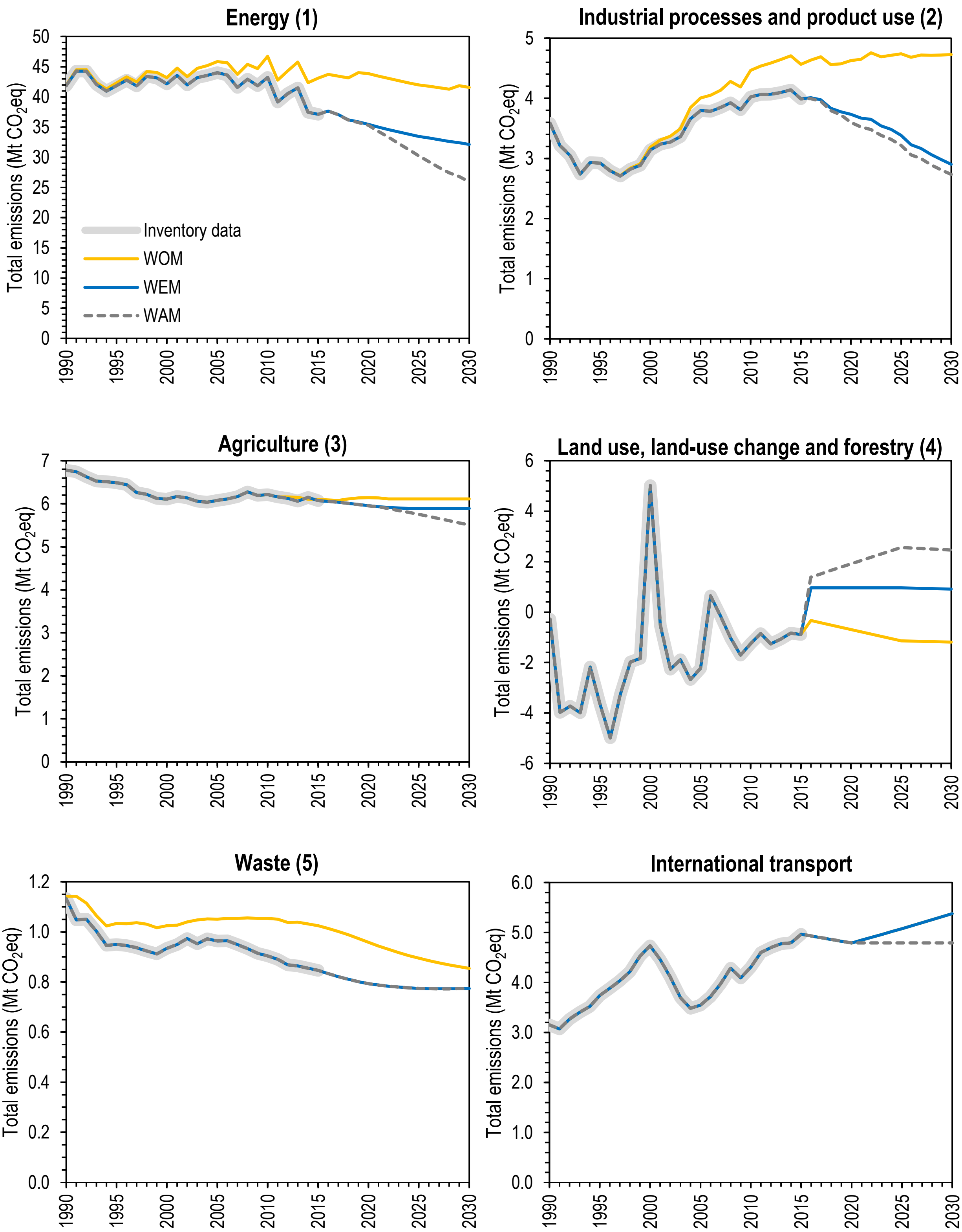


Fig. 64 > Greenhouse gas emissions under the WEM, WOM and WAM scenarios by gas as shown in Tab. 26. Also shown are actual inventory data for the years 1990 to 2015. The panel for SF_6 and NF_3 shows the sum of the two gases (SF_6 strongly dominates, see Tab. 26 for the individual contributions).

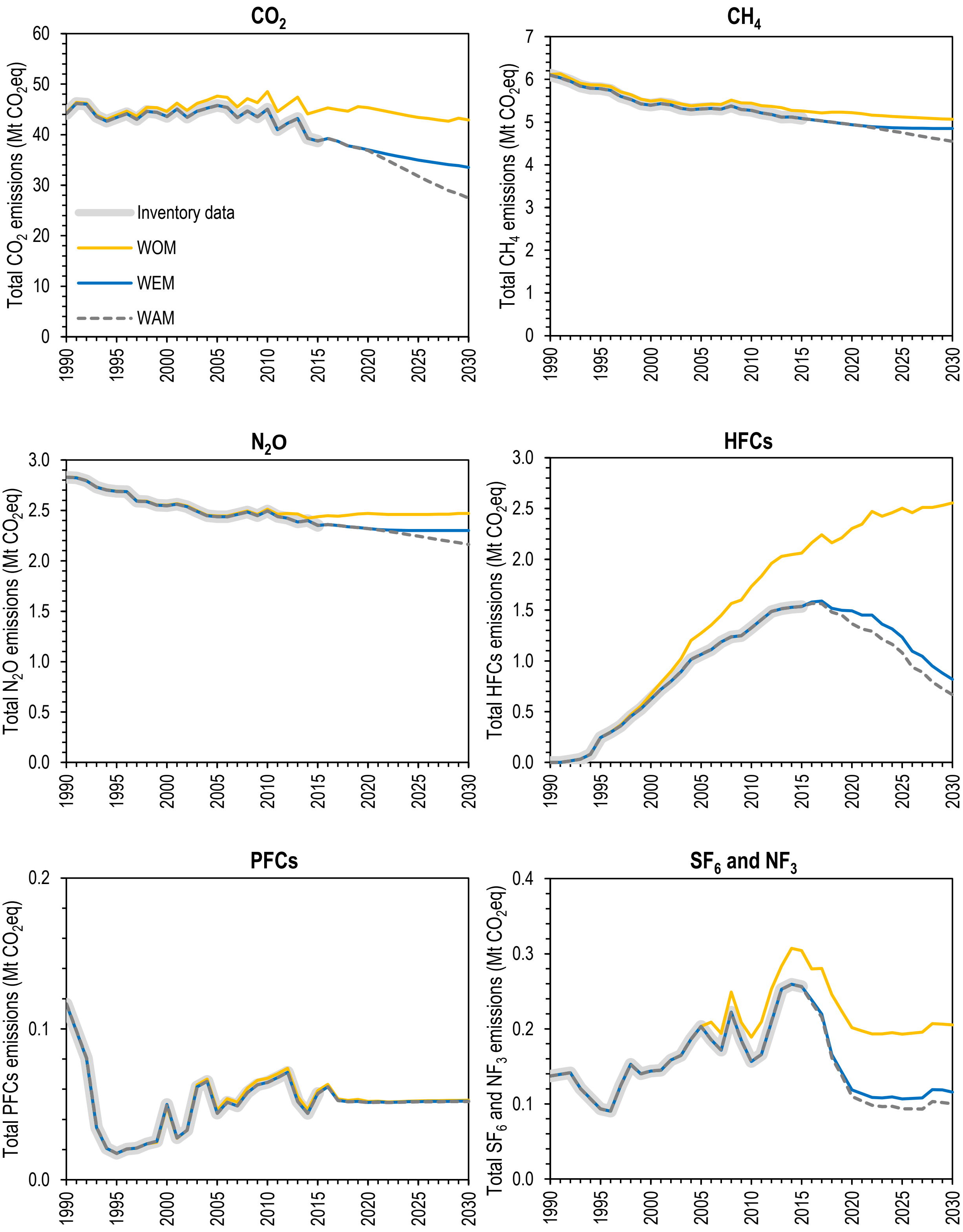


Fig. 65 > Greenhouse gas emissions in the different source categories of the energy sector under the WEM, WOM and WAM scenarios as shown in Tab. 25. Also shown are actual inventory data for the years 1990 to 2015. 'Transport' corresponds to source category 1A3. Source category 1A4 is dominated by greenhouse gas emissions from residential and commercial use of fossil fuels, while source category 1A5 covers greenhouse gas emissions from non-road military vehicles including military aviation (see section 3.2.3 for more details). For the source categories 1A5 'Other' and 1B 'Fugitive emissions from oil and natural gas' the WOM scenarios (hidden orange lines) are identical to the WEM scenarios.

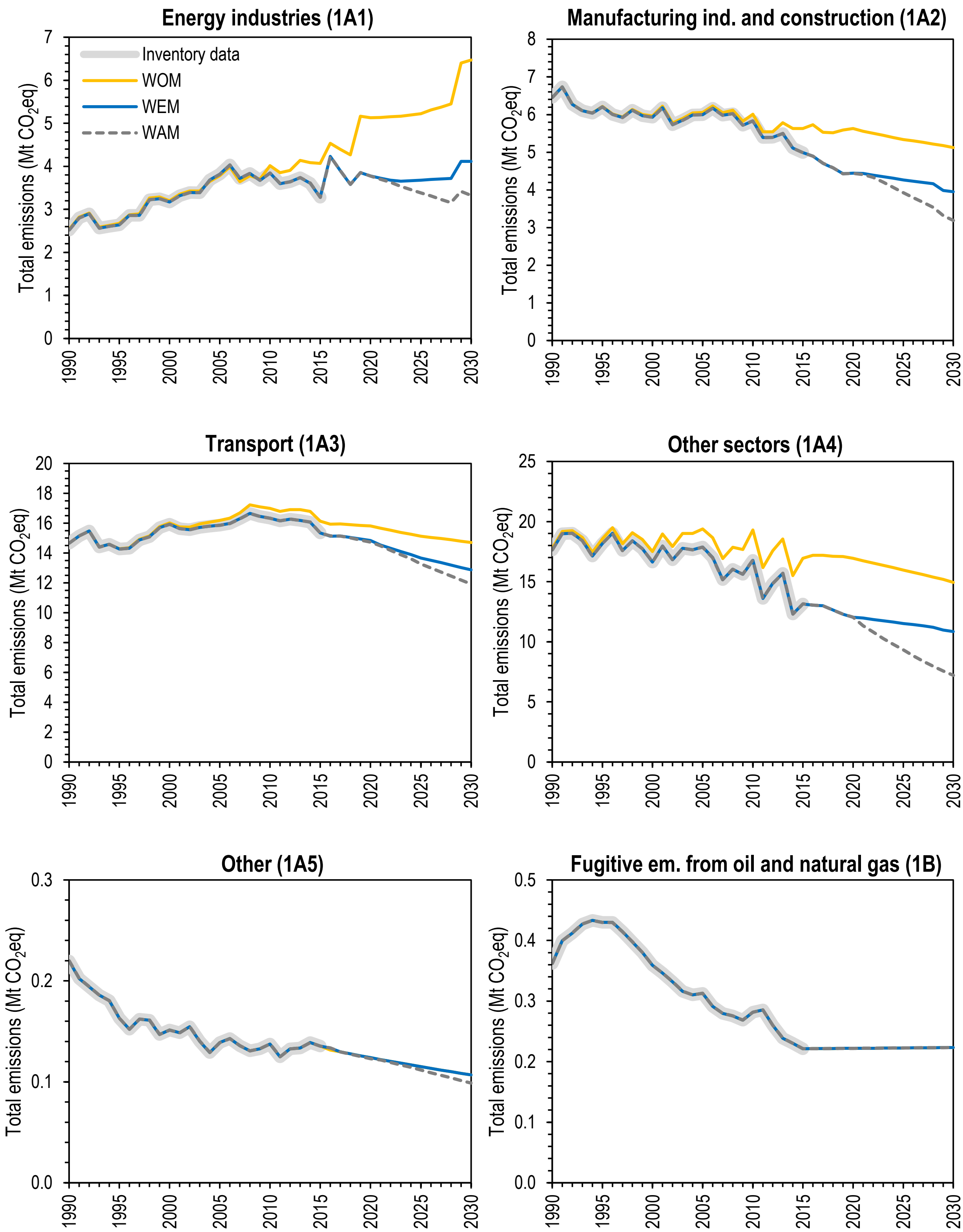


Fig. 66 > Contribution of the different sectors to the evolution of total greenhouse gas emissions under the WEM, WOM and WAM scenarios. Emissions are considered as relevant for Switzerland's emission reduction targets (i.e. including emissions of all greenhouse gases from the sectors 1, 2, 3 and 5, including indirect CO_2 emissions from these sectors, excluding direct and indirect emissions from sector 6, excluding emissions and removals from land use, land-use change and forestry, and excluding emissions from international transport). Contributions from the energy sector are further disaggregated to illustrate the most important source categories (1A1, 1A2, 1A3, 1A4, 1A5, and 1B).

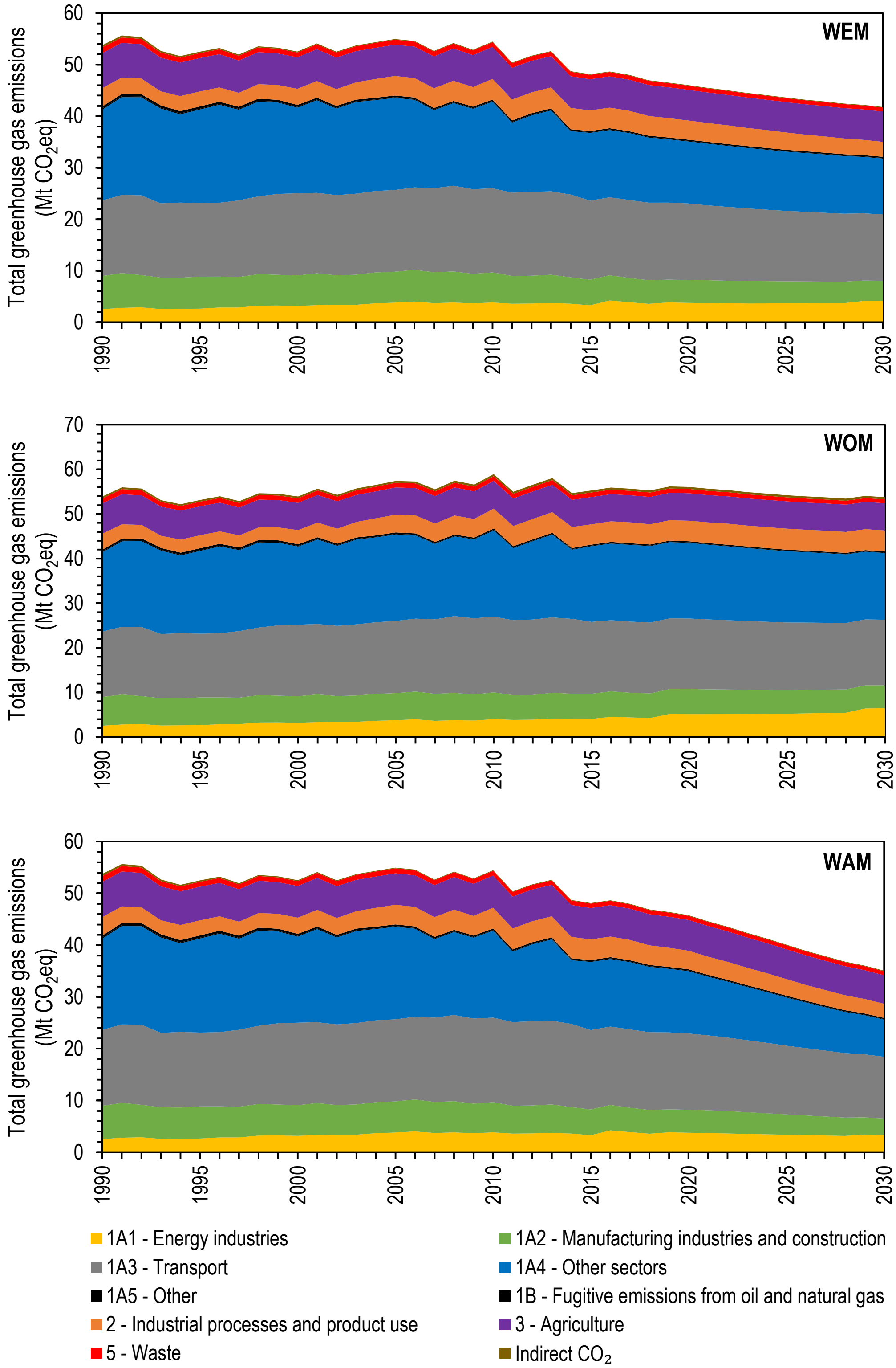
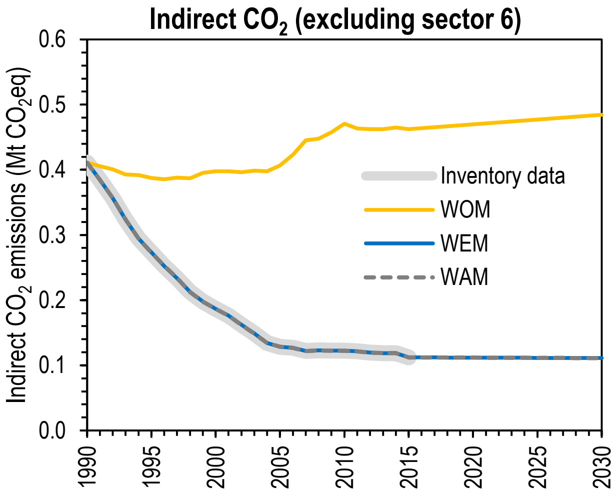


Fig. 67 > Indirect CO_2 emissions under the WEM, WOM and WAM scenarios (excluding sector 6) as shown in Tab. 25. Also shown are actual inventory data for the years 1990 to 2015.



5.2 Assessment of aggregate effect of policies and measures

5.2.1 Total effect of currently implemented and adopted policies and measures

The total effect of currently implemented and adopted policies and measures – calculated based on the difference between the emissions under the WOM and WEM scenarios – is presented in Tab. 27 by gas and in Tab. 28 by sector. For 2020, the total effect of currently implemented and adopted policies and measures is estimated at a reduction of 10.0 million tonnes of CO_2 equivalents (annual reduction, not cumulative). This estimate depends on the assumptions regarding the evolution of the underlying drivers and contains considerable uncertainties (see sensitivity analysis in section 5.3.9). Further, the total effect of currently implemented and adopted policies and measures also depends on the bifurcation points of the WEM and WOM scenarios, which are shown in Tab. 29. The contributions of each sector are discussed in the following. Importantly, the total effect of policies and measures as presented in this chapter does not necessarily correspond to the sum of the mitigation impacts of individual policies and measures as reported in chapter 4. Among the reasons are (i) differences in the policies and measures considered as well as in the bifurcation points, (ii) differences in the methodologies applied, (iii) interactions of policies and measures only considered when estimating the total effect but not the individual mitigation impact, etc.

Tab. 27 > Total effect of currently implemented and adopted policies and measures by gas. Emissions are considered as relevant for Switzerland's emission reduction targets (i.e. including emissions of all greenhouse gases from the sectors 1, 2, 3 and 5, including indirect CO_2 emissions from these sectors, excluding direct and indirect emissions from sector 6, excluding emissions and removals from land use, land-use change and forestry, and excluding emissions from international transport). Shown are the differences between the WOM and WEM scenarios as presented in Tab. 26.

	1990	1995	2000	2005	2010	2013	2015	2020	2025	2030
	Mt CO_2eq (annual reduction, not cumulative)									
CO_2	0.2	0.4	1.0	1.8	3.5	4.2	6.0	8.3	8.4	9.4
CH_4	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.2
N_2O	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2
HFCs/PFCs/SF_6/NF_3	0.0	0.0	0.0	0.2	0.4	0.6	0.6	0.9	1.4	1.8
Indirect CO_2	0.0	0.1	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.4
Total as relevant for Switzerland's emission reduction targets	**0.2**	**0.6**	**1.4**	**2.4**	**4.5**	**5.4**	**7.1**	**10.0**	**10.6**	**12.0**

Tab. 28 > Total effect of currently implemented and adopted policies and measures by sector. Emissions are considered as relevant for Switzerland's emission reduction targets (i.e. including emissions of all greenhouse gases from the sectors 1, 2, 3 and 5, including indirect CO_2 emissions from these sectors, excluding direct and indirect emissions from sector 6, excluding emissions and removals from land use, land-use change and forestry, and excluding emissions from international transport). Shown are the differences between the WOM and WEM scenarios as presented in Tab. 25.

	1990	1995	2000	2005	2010	2013	2015	2020	2025	2030
	Mt CO_2eq (annual reduction, not cumulative)									
1 Energy	0.2	0.4	1.0	1.9	3.5	4.3	6.0	8.4	8.5	9.5
2 Industrial processes and product use	0.0	0.0	0.0	0.2	0.4	0.6	0.6	0.9	1.4	1.8
3 Agriculture	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.2	0.2	0.2
5 Waste	0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.1
Indirect CO_2	0.0	0.1	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.4
Total as relevant for Switzerland's emission reduction targets	**0.2**	**0.6**	**1.4**	**2.4**	**4.5**	**5.4**	**7.1**	**10.0**	**10.6**	**12.0**

Tab. 29 > Bifurcation points of the WEM and WOM scenarios for the individual sectors.

Sector	Bifurcation point
Energy sector (including transport)	The bifurcation point is 1990. Some policies and measure in the energy sector already have a minor mitigation impact in 1990 (see *EPFL and Infras* (2016) and *EPFL* (2017) for details).
Industrial processes and product use sector	No measures specifically targeting process emissions of CO_2, CH_4 and N_2O are considered under any of the scenarios. Regarding F-gases, the bifurcation point is 1990.
Agriculture sector	The bifurcation point is 2011 (first calculation with different assumptions for the WEM and WOM scenarios for the following year, see section 5.3.3 for more explanations).
Land use, land-use change and forestry sector	The bifurcation point is 2015 (first calculation with different assumptions for the WEM and WOM scenarios for the following year, see section 5.3.4 for more explanations).
Waste sector	The bifurcation point is 1990.
Indirect CO_2	The bifurcation point is 1990.

Energy (including transport)

For 2020, the aggregate effect of currently implemented and adopted policies and measures in the energy sector (including transport) is estimated at 8.4 million tonnes of CO_2 equivalents (Tab. 28), i.e. the energy sector is expected to contribute about 84 per cent to the aggregate effect of currently implemented and adopted policies and measures. For 2030, the aggregate effect of currently implemented and adopted policies and measures in the energy sector (including transport) is estimated at 9.5 million tonnes of CO_2 equivalents. As required by the reporting guidelines, the estimated and expected effects of individual policies and measures are addressed in chapter 4. Importantly, the model for the calculation of the scenarios in the energy sector as applied by *EPFL and Infras* (2016) and *EPFL* (2017) (see section 5.3.1 for details) does not simply sum up the effects of individual policies and measures, but also considers the interactions and, thus, the combined effects of policies and measures. *EPFL and Infras* (2016) and *EPFL* (2017) estimate that in the energy sector the combined effects of policies and measures are responsible for about 12 per cent of the aggregate effect of currently implemented and adopted policies and measures. The aggregate effect of currently implemented and adopted policies and measures in the energy sector is strongly modulated by the introduction of renewable energy sources and the potential need for gas-fired combined-cycle power plants as a replacement for nuclear power plants (Fig. 68).

Industrial processes and product use

As no policies and measures affecting process emissions of CO_2, CH_4 and N_2O from industry are considered, all scenarios are identical and, thus, no aggregate effects of policies and measures are expected for these gases. However, policies and measures with regard to F-gases substantially influence emissions of HFCs, PFCs, SF_6, and NF_3 from the industrial processes and product use sector. In particular, the phase-out of fluorinated refrigerants assumed under the WEM scenario leads to a substantial reduction of total greenhouse gas emissions of 0.9 million tonnes of CO_2 equivalents in 2020 and 1.8 million tonnes of CO_2 equivalents in 2030 compared to the WOM scenario (Tab. 27 and Tab. 28; annual reduction, not cumulative).

Agriculture

For 2020, the aggregate effect of currently implemented and adopted policies and measures in the agriculture sector is estimated at 0.2 million tonnes of CO_2 equivalent, remaining about constant for each year up to 2030 (Tab. 28). Both CH_4 and N_2O emission reductions contribute about equally to the aggregate effect of currently implemented and adopted policies and measures in the agriculture sector. The bifurcation point of the WEM and WOM scenarios is 2011 and not 1990 as for other sectors (Tab. 29), because retrospectively it is impossible to elaborate meaningful WOM scenarios for this sector (see also section 5.3.3).

Waste

For the waste sector, the aggregate effect of currently implemented and adopted policies and measures can almost completely be attributed to the ban on landfilling of combustible waste (section 4.8.2), which is considered for the WEM and the WAM scenarios, but not for the WOM scenario (section 5.3.5). The effect of the ban on landfilling of combustible waste is slightly reduced due to incentives for increasing biogas production, which lead to somewhat increased fugitive CH_4 emission under the WEM and WAM scenarios, compared to the WOM scenario. Overall, emissions under the WOM scenario exceed emissions under the WEM scenario by 0.2 million tonnes of CO_2 equivalents in 2020 and by 0.1 million tonnes of CO_2 equivalents in 2030 (Fig. 63).

5.2.2 Total additional effect of planned policies and measures

The total additional effect of planned policies and measures – calculated based on the difference between the emissions under the WEM and WAM scenarios – is presented by gas in Tab. 30 and by sector in Tab. 31. The starting points of the various planned policies and measures are detailed under the respective sections in chapter 4. For 2030, the total additional effect of planned policies and measures is estimated at a reduction of 6.7 million tonnes of CO_2 equivalents (annual reduction, not cumulative), where the main contribution comes from the energy sector.

Tab. 30 > Total additional effect of planned policies and measures by gas. Emissions are considered as relevant for Switzerland's emission reduction targets (i.e. including emissions of all greenhouse gases from the sectors 1, 2, 3 and 5, including indirect CO_2 emissions from these sectors, excluding direct and indirect emissions from sector 6, excluding emissions and removals from land use, land-use change and forestry, and excluding emissions from international transport). Shown are the differences between the WEM and WAM scenarios as presented in Tab. 26.

	1990	1995	2000	2005	2010	2013	2015	2020	2025	2030
	Mt CO_2eq (annual reduction, not cumulative)									
CO_2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	3.2	6.1
CH_4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3
N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
HFCs/PFCs/SF_6/NF_3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2
Indirect CO_2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total (excluding LULUCF, including indirect CO_2)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.3**	**3.5**	**6.7**

Tab. 31 > Total additional effect of planned policies and measures by sector. Emissions are considered as relevant for Switzerland's emission reduction targets (i.e. including emissions of all greenhouse gases from the sectors 1, 2, 3 and 5, including indirect CO_2 emissions from these sectors, excluding direct and indirect emissions from sector 6, excluding emissions and removals from land use, land-use change and forestry, and excluding emissions from international transport). Shown are the differences between the WEM and WAM scenarios as presented in Tab. 25.

	1990	1995	2000	2005	2010	2013	2015	2020	2025	2030
	Mt CO_2eq (annual reduction, not cumulative)									
1 Energy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	3.2	6.2
2 Industrial processes and product use	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2
3 Agriculture	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4
5 Waste	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect CO_2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total as relevant for Switzerland's emission reduction targets	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.3**	**3.5**	**6.7**

5.3 Methodology

The methodologies applied to calculate Switzerland's greenhouse gas emission scenarios are tailored to the particular characteristics of each sector, always ensuring consistency with actual data of the greenhouse gas inventory. To provide a basic understanding of the models and approaches used, details relevant for each sector are summarised in Tab. 32 and discussed in the following sections.

Tab. 32 > Overview of models and approaches used to project Switzerland's greenhouse gas emissions from different sectors.

	Gases	Type and characteristics of approach or model	Original purpose of approach or model	Strengths and weaknesses	Accounting of overlaps and synergies
1 Energy	CO_2, CH_4, N_2O	Computable general equilibrium model for CO_2, for CH_4 and N_2O constant ratio to CO_2.	Assessment of planned climate and energy strategies at global and regional levels (no fundamental adjustments needed).	Comprehensive simulation of Switzerland's economy, considering interactions of policies and measures. Need for reliable assumptions regarding the future evolution of exogenous variables. The recursive dynamic nature of the model somewhat impacts the results.	Accounts for interactions between the effects of different policies and measures, direct and indirect rebound effects, as well as spill-over effects in all economic sectors.
2 Industrial processes and product use	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3	Bottom-up estimates according to the 2006 IPCC guidelines for national greenhouse gas inventories.	Greenhouse gas inventory (no fundamental adjustments needed).	Calculations at the level of single processes, requiring a full set of projections of activity data and emission factors.	Policies and measures are assumed to target distinct sources of greenhouse gases, i.e. overlaps and synergies are considered negligible.
3 Agriculture	CO_2, CH_4, N_2O				
4 Land use, land-use change and forestry		Stochastic empirical single tree forest management scenario model (MASSIMO3) for CO_2, simple assumptions for CH_4 and N_2O.	Projections of the development of forest resources.	Specifically designed to reflect the characteristics of Swiss forests, based on data from the national forest inventories.	
5 Waste		Bottom-up estimates according to the 2006 IPCC guidelines for national greenhouse gas inventories.	Greenhouse gas inventory (no fundamental adjustments needed).	Calculations at the level of single processes, requiring a full set of projections of activity data and emission factors.	
Indirect CO_2	Indirect CO_2				
International transport	CO_2, CH_4, N_2O	Energy perspectives of *Prognos* (2012), i.e. detailed bottom-up model.	Projection of the development of the energy sector.		

5.3.1 Energy

In preparation of Switzerland's seventh national communication and third biennial report, the greenhouse gas emission scenarios for the energy sector were revised fundamentally, taking into account the latest available data and providing a WOM scenario with a bifurcation point as early as 1990. The new approach, for the first time based on a computable general equilibrium model, has various strengths. It not only takes into account the full spectrum of policies and measures tackling energy use and related greenhouse gas emissions related to the energy sector, but also accounts for interactions between the effects of different policies and measures, direct and indirect rebound effects, as well as spill-over effects in all economic sectors. Such a comprehensive investigation would not be possible based on bottom-up impact assessments of policies and measures alone. The approach, however, also suffers from the usual weaknesses of economic models, in particular provoked by the need for reliable assumptions regarding the future evolution of exogenous variables (such as energy prices, gross domestic product, population, etc.). An overview of the key steps performed to establish the WEM, WOM and WAM scenarios for the energy sector, including information on underlying assumptions, is provided in the following[34].

[34] The computable general equilibrium model does not cover emissions from the source category 1B, which are of minor importance regarding total emissions from sector 1 'Energy'. The projections for source category 1B are thus calculated based on the results of *Prognos* (2012) for 2030, with interpolated values between the last inventory year and 2030. Identical emissions are assumed from the source category 1B for all scenarios over the full time period from 1990 to 2030.

Calculation of CO_2 emissions for the WEM scenario

In a first step, the computable general equilibrium model, GEMINI-E3 from the Swiss Federal Institute of Technology in Lausanne, is used to calculate CO_2 emissions from the energy sector for the WEM scenario (*EPFL and Infras*, 2016; *EPFL*, 2017). For many aspects, the assumptions used in the model are based on the energy perspectives of *Prognos* (2012), but underlying scenarios have been updated to follow the observed and anticipated trends where needed. Key underlying assumptions – in particular population, gross domestic product and energy prices – have been updated as well (see Tab. 24). The WEM scenario takes into account currently implemented and adopted measures (Tab. 23), generally assuming that the measures will be continued in a similar manner, i.e. without any strengthening or weakening, up to 2030. Only in cases where implemented or adopted regulations already stipulate a (possible) strengthening, e.g. in the case of the CO_2 levy on heating and process fuels (section 4.2.5) or the partial compensation of CO_2 emissions from motor fuel use (section 4.4.5), a future strengthening relative to the state of the year 2015 is considered under the WEM scenario. For the most important policies and measures the assumptions going beyond the descriptions in chapter 4 are as follows (for details regarding all policies and measures see *EPFL and Infras*, 2016 and *EPFL*, 2017):

- **CO_2 levy on heating and process fuels** (section 4.2.5): As of 2018, the computable general equilibrium model dynamically adjusts the CO_2 levy according to the modelled emissions for the year 2016 and the prescribed intermediate targets (see Tab. 16). Based on the model results for 2016, it is thus assumed that the rate of the CO_2 levy increases to 96 Swiss francs per tonne of CO_2 as of 2018[35];
- **Emissions trading scheme** (section 4.2.6): The cap is reduced by a rate of 1.74 per cent per year until 2020 and held constant thereafter;
- **Negotiated reduction commitments (for exemption from the CO_2 levy)** (section 4.2.7): The emissions reduction targets of companies exempt from the CO_2 levy are not further enhanced after 2020;
- **National buildings refurbishment programme** (section 4.3.3): 300 million Swiss francs or at maximum one third of the revenues from the CO_2 levy on heating and process fuels are earmarked for the national buildings refurbishment programme up to 2017, while 450 million Swiss francs or at maximum one third of the revenues from the CO_2 levy on heating and process fuels are available as of 2018. Under the WEM scenario, it is assumed that the national buildings refurbishment programme is stopped as of 2020;
- **Building codes of the cantons** (section 4.3.4): Until 2020 it is assumed that the annual incremental CO_2 savings remain constant thanks to the new revision of the regulations in 2014 (*EnDK*, 2014), which will gradually come into effect between 2016 and 2020. Beyond 2020, it is assumed that the annual incremental CO_2 savings decrease by two per cent per year due to erosion of the attributable impact by technological progress;
- **CO_2 emission regulations for newly registered vehicles** (section 4.4.2): It is assumed that the set targets, 95 grams of CO_2 per kilometre by 2020 for new passenger cars and 147 grams of CO_2 per kilometre by 2020 for new light commercial vehicles, are reached by 2023 (the delay is caused by temporary arrangements such as e.g. double counting of highly-efficient electric vehicles or similar). No further strengthening of the CO_2 emission regulations for newly registered vehicles is assumed until 2030;
- **Partial compensation of CO_2 emissions from motor fuel use** (section 4.4.5): The share of CO_2 emissions from motor fuel use to be offset by fuel importers increases as prescribed in the CO_2 Ordinance (two per cent in 2014–2015, five per cent in 2016–2017, eight per cent in 2018–2019, and 10 per cent in 2020), and is held constant at 10 per cent after 2020.

While a brief overview is given in the following, details about the methodologies used to calculate CO_2 emissions from the energy sector for the WEM scenario are provided in the respective project reports (*EPFL and Infras*, 2016; *EPFL*, 2017). GEMINI-E3 is a multi-country, multi-sector, recursive dynamic computable general equilibrium model, which has been extensively used to assess planned climate and energy strategies at global and regional levels during the last 20 years. It is based on the assumption of total flexibility in all markets, both macroeconomic markets such as the capital and the exchange markets (with the associated prices being the real rate of interest and the real exchange rate, which are

[35] The CO_2 statistics reporting the relevant CO_2 emissions from heating and process fuels for the year 2016 was published by the Swiss Federal Office for the Environment on 11 July 2017 (https://www.bafu.admin.ch/bafu/de/home/dokumentation/medienmitteilungen/anzeige-nsb-unter-medienmitteilungen.msg-id-67501.html). Indeed, actual data request an increase of the rate of the CO_2 levy to 96 Swiss francs per tonne of CO_2 as of 2018.

then endogenous), and microeconomic or sector markets (goods, factors of production). Simulations start from a statistically observed bundle of consumer goods, i.e. the Swiss input-output table 2008 (*Nathani et al.*, 2011), and then changes in relative prices provoke deviations from this bundle through substitutions between alternative goods. Thereby, a representative household uses its disposable income to purchase the bundle of goods that gives greatest satisfaction, and the choice is affected (and affects) relative prices. For instance, when fossil fuels become more expensive, e.g. due to the CO_2 levy on heating and process fuels, the representative household replaces some fossil fuel by electricity (mostly heat pumps) and invests more for heat insulation of buildings. A calibration ensures that the model is able to reproduce the economic development with the associated energy consumptions and CO_2 emissions for the historical years (1990–2015), i.e. the model is calibrated to the observed historical growth rates and emission pathways. Key parameters for calibration are the elasticities of substitution which reflect the degree to which inputs to production (labour, capital, energy) or goods in consumption may be substituted, and the rates of autonomous technological progress, which define the rates of improvement in efficiency that occurs independently of political intervention.

Where possible, measures are directly implemented in the model. This is the case for measures with regard to price such as the CO_2 levy on heating and process fuels and the price of emission allowances in the emissions trading scheme. Further, for companies which are exempt from the CO_2 levy on heating and process fuels (section 4.2.7) a shadow price on emissions is introduced. However, an estimate of the CO_2 savings and related economic data are required for each measure that cannot be directly implemented in the model, such as equivalent subsidies, taxes and abatement costs. Additionally, the model requires information on the share of different energy sources that are affected by a specific measure. The data needed to calibrate the model is derived from existing or new (bottom-up) impact assessments. Thereby, double counting of effects is carefully avoided, i.e. for overlapping measures only the additional impact is considered (*EPFL and Infras*, 2016).

As mentioned above, the model includes technological progress, which may evolve autonomously or driven by polices and measures. In particular, where policies and measures cannot be directly implemented in the model by means of a price, the effect of policies and measures are translated into a policy-induced technological progress. For instance, this is the case for the building codes of the cantons (section 4.3.4) or the CO_2 emission regulations for newly registered vehicles (section 4.4.2).

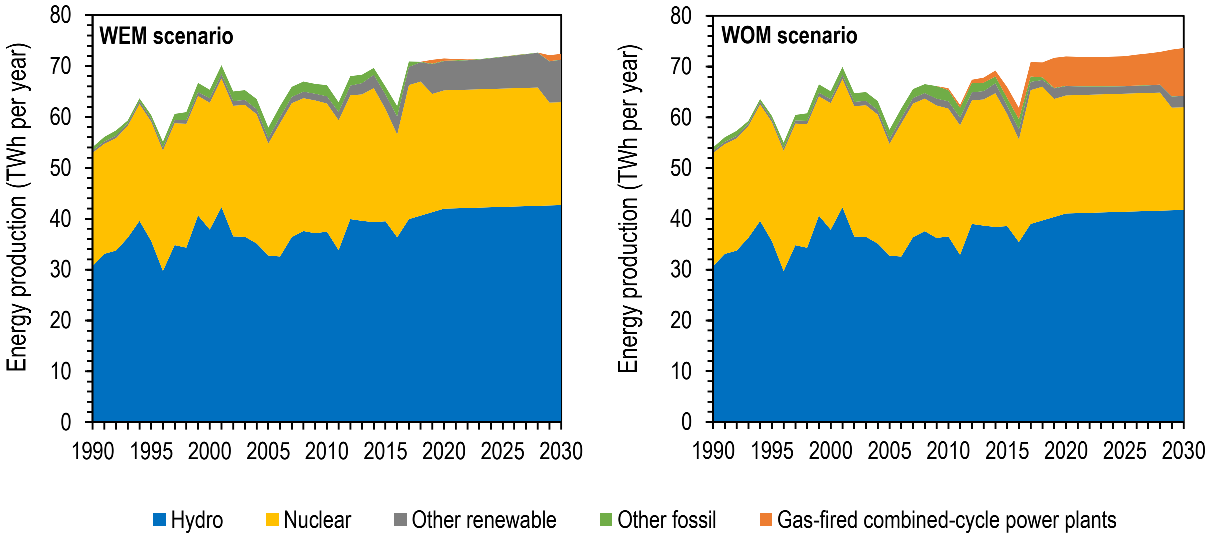
The model takes into account domestic compensation required by policies and measures such as the partial compensation of CO_2 emissions from motor fuels use (section 4.4.5) or the obligation to offset emissions from gas-fired combined-cycle power plants (section 4.3.6). Methodological details regarding the implementation of domestic compensation are provided in *EPFL and Infras* (2016). In brief, domestic compensation is either represented by an increase in energy efficiency at a cost based on the experience from existing compensation projects (data provided by KliK, see also section 4.4.5) or by subsidies for additional emission reductions by firms (as KliK buys domestic carbon credits at a price exceeding the rate of the CO_2 levy on heating and process fuels). Accordingly, domestic compensation is now fully contained in the model results, and, thus, cannot be reported separately.

Crucial for the CO_2 emissions under the different scenarios is the electricity production projected by the model. In the wake of the nuclear incident in Fukushima in 2011, the Swiss Federal Council and the Swiss Parliament decided to decommission the existing nuclear power plants at the end of their service life (section 4.3.1). This decision has a major impact on future electricity generation as decommissioning of nuclear power plants is compulsory under all scenarios, and, thus, prescribed in the model (a first reactor is decommissioned in 2019, a second in 2029, all others operate beyond 2030). However, apart from this constraint regarding nuclear power plants, the computable general equilibrium model chooses the most economical way to generate the required electricity, taking into account all direct and indirect effects of policies and measures in place under the respective scenario. This results in the operation of gas-fired combined-cycle power plants, with an energy output of 1.1 terawatt-hours per year under the WEM scenario by 2030 (for an overview of the resulting energy mixes for electricity generation under the WEM scenario see Fig. 68, left). Under the WEM scenario the model completely takes into account the required compensation of emissions from gas-fired combined-cycle power plants (section 4.3.6), with a share of 50 per cent domestic compensation and the price for international carbon credits fixed at 10 Swiss francs per tonne of CO_2 (however, the compensation using international carbon credits is of course not considered in Switzerland’s national totals).

Regarding the evolution of the transport sector, the computable general equilibrium model relies on inputs from the road traffic model primarily used for the greenhouse gas inventory (see section 3.2.9 in *FOEN*, 2017a). With regard to

Switzerland's seventh national communication, the projections established with the road traffic model have been updated (*Infras*, 2017). The road traffic model is based on a bottom-up approach, taking into account the composition of the Swiss vehicle fleet and differentiating various vehicle classes, fuel types and emission standards. For past and future years, energy consumption is then calculated based on parameters such as the composition of the fleet, the distances travelled, the fuel types used, and the specific fuel consumption. As the differences in fuel prices between Switzerland and neighbouring countries levelled as a consequence of a substantial change in the exchange rate for the Swiss franc to the Euro in January 2015, the so-called 'tank tourism' was declining and, for gasoline, ceased completely (for details see *Keller*, 2015). In the absence of justifiable estimates for the future exchange rate for the Swiss franc to the Euro, it is assumed that 'tank tourism' remains at the level of 2015 for future years (*EPFL*, 2017). The road traffic model directly targets vehicle kilometres, i.e. passengers per vehicle are not quantified for this exercise. Regarding the use of biofuel in the transport sector, the road traffic model has been revised and now projects a much more moderate contribution of biofuel to total fuel consumption in the transport sector. By 2030, it use assumed that the share of biofuels is two per cent with regard to the total consumption of gasoline and diesel (*Infras*, 2017).

Fig. 68 > Energy mixes for electricity generation under the WEM (right) and WOM (left) scenarios as deduced with the computable general equilibrium model (GEMINI-E3). The decommissioning of nuclear power plants at the end of their service life is compulsory in each scenario (a first reactor is decommissioned in 2019, a second in 2029, all others operate beyond 2030).



EPFL (2017)

As briefly addressed in *EPFL* (2017), the computable general equilibrium model does not account for the possibility that firms in the emissions trading scheme may save excess emission allowances for later use. This implies that some of the emission reductions (in particular those resulting from the closure of one of the two Swiss refineries in 2015) are achieved 'on credit' only, as firms will make use of the available excess emission allowances at some point in the future. To reflect these circumstances in the mid-term and long-term evolution of projected greenhouse gas emissions, the emissions avoided by the closure of the refinery are again added to the total emissions within the emissions trading scheme, as they are still 'available' in the cap. Adding the 0.5 million tonnes of CO_2 in 2016 and in the following years leads to a somewhat artificial increase of emissions in source category 1A1 'Energy industries' from 2015 to 2016 (see Fig. 65).

Further, the recursive dynamic nature of the computable general equilibrium model has, to some extent, an impact on the model results. In particular, the energy prices (crude oil and gas) are assumed to be lower in *EPFL* (2017) compared to *EPFL and Infras* (2016) for the current year due to recent developments in the energy market, but (according to the forecasts used) reach about the same values in 2030. This implies that in *EPFL* (2017) prices have to rise at a higher rate, which sets a stronger price signal. Due to the recursive dynamic set-up of the computable general equilibrium model – where foresight of the agents (households, firms) is limited to the next period – this leads to additional reductions of emissions compared to *EPFL and Infras* (2016). In 2030, this effect amounts to approximately 0.4 million tonnes of CO_2. In a model with perfect foresight where agents would optimise over the entire period and take the projected development of energy prices into account, this effect would be much smaller. The 0.4 million tonnes of CO_2 are therefore a reduction triggered mostly by the inherent dynamics of the model and only to a smaller extent by the fact that energy prices were lower than projected in 2015. While the complete effect of the model dynamics on the mid-term to long-term CO_2 emissions can only be estimated partially based on the sensitivity analysis (section 5.3.9), the scenarios provided by *EPFL* (2017) are adjusted by +0.4 million tonnes of CO_2 in 2030 to at least account for the minimal effect. The adjustment is applied to one third to source category 1A4a and to two thirds to source category 1A4b, linearly increasing from zero in 2016 to +0.4 million tonnes of CO_2 in 2030.

Overall, the simulations with the computable general equilibrium model provide the optimised use of goods including energy, thereby reflecting the effect of policies and measures in place at any time (see Tab. 23). As a final step, the CO_2 emissions resulting under the modelled energy demand and energy efficiency are calculated for the energy sector.

Calculation of CO_2 emissions for the WOM scenario

In the computable general equilibrium model, the implemented policies and measures can be 'switched off' in a rather simple way, allowing for a model run corresponding to the WOM scenario. For this purpose, the effects of policies and measures on prices as well as all policy-induced technological progress are omitted. The resulting WOM scenario has a bifurcation point as early as 1990 and is driven by key underlying assumptions (such as energy prices and population), as well as autonomous technological progress spreading regardless of the absence of policies and measures (*EPFL and Infras*, 2016; *EPFL*, 2017). Under the WOM scenario, an energy output of 9.4 terawatt-hours per year by gas-fired combined-cycle power plants is needed by 2030 (for an overview of the resulting energy mixes for electricity generation under the WOM scenario see Fig. 68, right). As the WEM scenario, the WOM scenario provided by *EPFL* (2017) is adjusted for the effect caused by the inherent dynamics of the model.

Calculation of CO_2 emissions for the WAM scenario

The WAM scenario uses the same underlying assumptions regarding growth of population, gross domestic product, energy prices, and autonomous technological progress as the WEM scenario. In addition to the WEM scenario, the WAM scenario takes into account the impact of the strengthening of the existing measures and of new instruments as proposed in the third CO_2 Act (section 4.2.4). The following adjustments of the most important measures are considered under the WAM scenario:

- **CO_2 levy on heating and process fuels** (section 4.2.5): Linear increase of the rate of the CO_2 levy on heating and process fuels from 96 Swiss francs per tonne of CO_2 in 2020 to the proposed maximum rate of 210 Swiss francs per tonne of CO_2 in 2030;
- **Emissions trading scheme** (section 4.2.6): Linking with the emissions trading scheme of the European Union, reduction of the cap at a rate of 2.2 per cent per year from 2021 to 2030 (see section 4.2.6 for details);
- **Negotiated reduction commitments (for exemption from the CO_2 levy)** (section 4.2.7): The emission reduction targets of companies exempt from the CO_2 levy on heating and process fuels are enhanced and strengthened, leading to a total reduction of the emissions of exempt companies of 10 per cent in 2030 compared to 2020;
- **National buildings refurbishment programme** (section 4.3.3): Increase of the maximum amount of the revenues from the CO_2 levy on heating and process fuels earmarked for the national buildings refurbishment programme from 300 million to 450 million Swiss francs per year in 2018. Financing of the programme is terminated in 2025, leading to a gradual phase out of the additional impact after 2025;
- **Building codes of the cantons** (section 4.3.4): Widespread application of the 2014 standard of the model ordinances in all cantons, also beyond 2020 (no decrease of the impact as assumed for the WEM scenario);
- **CO_2 emission regulations for newly registered vehicles** (section 4.4.2): Further (linear) decrease of the emissions limit for new passenger cars from 95 to 68 grams of CO_2 per kilometre and for new light commercial vehicles from 147 to 105 grams of CO_2 per kilometre from 2025 until 2029. Note that these targets are based on an earlier proposition in the European Union that has been replaced in the meantime. Because the new propositions cannot be translated into quantifiable targets yet, targets of 68 and 105 grams of CO_2 per kilometre have been used to quantify the possible mitigation impacts of a further strengthening from 2025 onwards;
- **Partial compensation of CO_2 emissions from motor fuel use** (section 4.4.5): Increase of the domestic compensation rate from 10 per cent in 2020 to 15 per cent in 2030;

- **Biofuels:** Increase of the shares of biofuels to five per cent (bio-ethanol) and seven per cent (bio-diesel) respectively (*Infras*, 2017) until 2030. *Infras* (2017) assumes that the shares of biofuels used for the WEM and WAM scenarios start to diverge in 2015. This leads to a difference in emissions in the transport sector between the two scenarios of 100 thousand tonnes of CO_2 in 2020.

These adjustments are provisional in the sense that they reflect the propositions of the Swiss Federal Council that will be discussed in the Swiss Parliament from 2018 on. The mitigation impacts of the measures are generally calculated individually using bottom-up approaches. Where available (e.g. for the CO_2 levy on heating and process fuels or for the CO_2 emission regulations for newly registered vehicles), model simulations have been used to estimate the mitigation impacts. For other measures (e.g. the national buildings refurbishment programme), projections are calculated based on existing ex-post analyses. The estimation of the additional reduction of the emissions trading scheme is based on the reduction of the cap. The planned adjustments of the negotiated reduction commitments (for exemption from the CO_2 levy) and of the partial compensation of CO_2 emissions from motor fuel use are interpreted as reduction objectives; the mitigation impact of these measures then corresponds to these objectives. Finally, the WAM scenario is constructed using the estimated additional mitigation impacts with respect to the WEM scenario of the relevant measures.

CH_4 and N_2O emissions for all scenarios

The methodologies for the WEM, WOM and WAM scenarios described above were exclusively established for CO_2 emissions from the energy sector, as CH_4 and N_2O emissions – with a share of just above one per cent in total greenhouse gas emissions from the energy sector (Tab. 3) – are of minor importance. Hence, CH_4 and N_2O emissions in the energy sector are derived based on the following assumptions:

- For years covered by the greenhouse gas inventory (1990–2015), CH_4 and N_2O emissions of the WEM scenario are available from inventory data. While for the years 1990 to 2015 the WAM scenario corresponds to the WEM scenario, CH_4 and N_2O emissions of the WOM scenario are calculated out of the CO_2 emissions of the WOM scenario by application of the same ratios of CH_4 to CO_2 and N_2O to CO_2 as in the WEM scenario (i.e. of inventory data) in each individual year;
- For projected years (2016–2030), CH_4 and N_2O emissions of the WEM, WOM and WAM scenarios are calculated out of the CO_2 emissions of the corresponding scenario by application of the same ratios of CH_4 to CO_2 and N_2O to CO_2 as in the WEM scenario in the year 2015 (i.e. the latest year with inventory data).

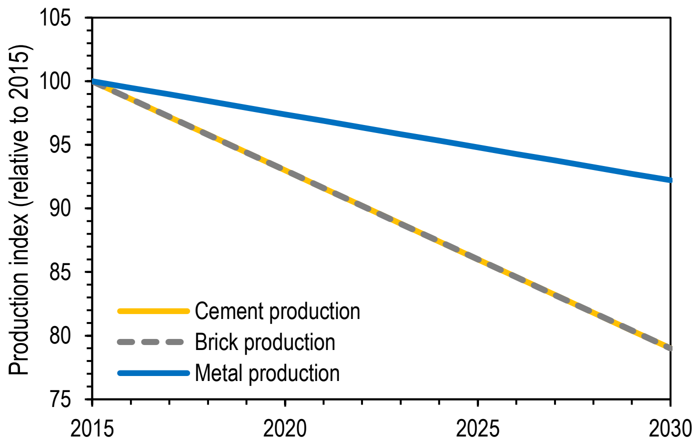
5.3.2 Industrial processes and product use

Greenhouse gas emission scenarios for the industrial processes and product use sector were calculated following exactly the same methodology as used for the greenhouse gas inventory, i.e. bottom-up estimates according to the 2006 IPCC guidelines for national greenhouse gas inventories (*IPCC*, 2006). Details about the methodologies, including relevant emission factors, are documented in *FOEN* (2017a). The strength of this approach is that greenhouse gas emission scenarios are calculated at the level of single processes. This, however, requires a full set of projections of activity data and emission factors (which may potentially be considered a weakness of the approach).

In Switzerland, there are few industrial branches that release relevant amounts of process-related greenhouse gases. The dominant part of process-related greenhouses gases emitted from the industrial processes and product use sector stems from the cement industry, followed by emissions of F-gases from the use as refrigerants and by emissions of CO_2 from the thermal cracking process (production of ammonia and ethylene). With the exception of F-gases, measures in the industry sector are primarily targeting energy-related emissions (section 4.3), which are included under the energy sector (for the respective projections see section 5.3.1). However, the emissions trading scheme (section 4.2.6) also covers process-related emissions, permitting companies to reach their reduction obligations not only by more efficient use of energy, but also by optimisation of their production processes leading to reduced process-related emissions of greenhouse gases (for instance, in a plant producing nitric acid, a new catalyst led to a substantial reduction of N_2O emissions). Nevertheless, for most emitters of process-related greenhouse gases covered by the emissions trading scheme (in particular for the cement industry, the major emitter) this possibility hardly exists due to physical/chemical limits regarding further reductions of the emission factors. As described in section 5.3.1, it is thus assumed that all companies within the emissions trading scheme reach their full reduction obligations by reductions of energy-related emissions (or acquisition of emission allowances). As the Ordinance on Air Pollution Control (section 4.5.4) and the NMVOC incentive fee (section 4.5.5) are exclusively considered regarding the scenarios for indirect CO_2 emissions, provisions relating to substances stable in the atmosphere (section 4.5.2) represent the only policy and measure leading to differences between the WEM, WOM and WAM scenarios for the industrial processes and product use sector.

The relevant activity data for industrial production are inferred from the energy perspectives of *Prognos* (2012). Production of mineral products (cement, bricks and tiles) and metal production are assumed to decline over the coming decades (Fig. 69), leading to a reduction of total greenhouse gas emission from these branches of about 45 per cent by 2030 compared to 1990. For other industrial processes whose emissions are of minor importance and for which detailed production projections are unavailable, it is assumed that activity remains constant at the level of past years (depending on the process, mean values over the last ten years or over the full time period since 1990 are used). Where projections are deduced from *Prognos* (2012), values are calculated based on the results for 2030, with linear interpolation between the last inventory year and 2030.

Fig. 69 > Production indices for cement, bricks and metal until 2030 (relative to 2015). Identical production indices are used for the WEM, WOM and WAM scenarios.



Prognos (2012)

Regarding emissions of F-gases, which strongly depend on the scenario, projections are based on a well-established bottom-up model (*Carbotech*, 2015). This model, described in detail in *FOEN* (2017a), is not only used to derive the emission estimates for the annual greenhouse gas inventory, but also serves to project future emissions. From 1990 up to the most recent inventory year, i.e. currently 2015, the model is based on the most recent import statistics, supplemented by available information from the branch associations and companies concerned. The model makes assumptions about product life time as well as emission factors relevant for assembly, operation and disposal of appliances. For the projections, the two most important applications of fluorinated gases – refrigeration and electrical equipment – are considered in detail, while emissions from other applications are hold constant over time. The main factors defining the scenarios are the phase-out of HFCs, decreasing emission factors in refrigeration, and the limit set on SF_6 emissions following the provisions relating to substances stable in the atmosphere (HFCs, PFCs, SF_6, NF_3) (section 4.5.2). All scenarios have been updated to be consistent with the most recent inventory data.

Tab. 33 provides an overview of assumptions in the industrial processes and product use sector with regard to the WEM, WOM and WAM scenarios. Regarding F-gases, *Carbotech* (2015) provides further details about underlying assumptions and methodologies.

Tab. 33 > Assumptions used for the projections of emissions from the industrial processes and product use sector under the WEM, WOM and WAM scenarios.

	WEM	WOM	WAM
Industrial production	In close correspondence with the assumptions on industrial production used in the energy perspectives of *Prognos* (2012), the cement, brick, tile and steel production are assumed to decline over the coming decades. For other processes, which are of minor importance, it is assumed that activities remain at the level of past years.	As there are no policies and measures affecting the production rates, the evolution is identical for all three scenarios.	As there are no policies and measures affecting the production rates, the evolution is identical for all three scenarios.
HFCs as refrigerants	Growing restrictions on the use of F-gases (in concert with technological progress) are	The WOM scenario assumes no forced phase-out and replacement of fluorinated	Similar but faster replacement of HFCs as refrigerants compared to the WEM

	assumed. This leads to a gradual replacement of HFCs used as refrigerants (*Carbotech*, 2015). Further, measures to reduce leakage (secure handling of refrigerants, monitoring etc.) are continuously introduced.	gases and therefore emissions of HFCs keep increasing (*Carbotech*, 2015).	scenario is assumed. It is further assumed that optimisation of disposal leads to additional prevention of emissions (*Carbotech*, 2015).
SF_6	Agreements with relevant sectors, leading to reduction of emissions.	Constant use of SF_6 and higher emission factors compared to the WEM and WAM scenarios.	Stepwise prohibition of SF_6, leading to a replacement for use in electrical equipment.
Gases from other industrial processes and solvent use	Other process-related emissions (e.g. from ammonia/ethylene production, nitric acid production) and emissions from solvent use are assumed to maintain the level of past years.	Identical evolution for all three scenarios.	Identical evolution for all three scenarios.

5.3.3 Agriculture

Greenhouse gas emission scenarios for the agriculture sector are based on projected activity data, e.g. livestock numbers, crop production data (amount of crops harvested, areas of crop cultures, meadows and pastures) and use of synthetic fertilisers and recycling fertilisers (such as sewage sludge, compost, as well as liquid and solid digestate) from different agricultural policy evaluation models. Most other model parameters for emission calculation (e.g. nitrogen excretion rates, emission factors) were kept constant throughout the projection time frames. An important exception is the productivity of dairy cows (i.e. milk yield), which was projected to develop according to the respective scenarios.

Generally, time series beyond 2015 (WEM, WAM) and 2011 (WOM) respectively were extended by continuing the time series according to the development of the respective parameters in the scenario models used. Some data such as e.g. crop yields may exhibit considerable year-to-year variability and this may lead to somewhat arbitrary projections due to an arbitrary starting point. However, observing the overall behaviour of the projections, no indication that this would lead to a systematic misalignment is found. Hence, it is concluded that the eventual offsets of individual time series projections cancel out each other.

In the following, considerations regarding different aspects relevant under the WEM, WOM and WAM scenarios are presented.

Animal livestock population

The development of livestock population is dependent on price scenarios and consequently on policies concerning market price support and free trade agreements with the European Union as well as consumer demand (*Peter et al.*, 2009; *Peter et al.*, 2010; *Zimmermann et al.*, 2011; *Möhring et al.*, 2015; *Möhring et al.*, 2016). Furthermore, the modalities for agricultural subsidies and direct payments are an important driver for the development of livestock population.

Feeding regimes

Feeding regimes are generally assumed to remain unchanged with the single exception of dairy cows whose energy intake depends on milk production. An important political measure in this regard could be the governmental promotion of grassland-based milk and meat production (*Swiss Federal Council*, 2012). Some respective incentives were already implemented in the agricultural policy 2014–2017 and will continue in the agricultural policy 2018–2021.

Manure management

Different modes of (financial) incentives might influence the livestock management and subsequently the type of manure management. Manure management is governed by the stable system which is again mainly influenced by requirements for animal-friendly livestock husbandry and the respective incentives and label programmes. Furthermore, the need for low-emission stables and manure management systems might have a certain influence in the future. A separate report by the Swiss Federal Office for the Environment and the Swiss Federal Office of Agriculture regulates the respective requirements (*FOEN and FOAG*, 2012).

Nitrogen excretion by animals

Nitrogen excretion rates determine the amount of manure nitrogen managed and applied to soils and hence govern N_2O emissions. Nitrogen excretion rates varied in the past due to changing production modes and particularly due to the feeding of protein-reduced animal feeds. It is most likely that nitrogen excretion rates will continue to change in the future although there are no clear indications of directions of future trends. For cattle, the federal programme for grassland-based milk and meat production (*Swiss Federal Council*, 2012) might be decisive, while for monogastrics environmental regulations as well as financial constraints and subsidy systems may be most influential. *Sollberger et al.* (2013) found that there is still an unexplored potential to increase nitrogen efficiency in pig fattening.

Crop cultures

An important driver for the future development of the cropping areas and the respective agricultural portfolio is the mode of future direct payments. Accordingly, trends in the development of different crop cultures may differ due to differential governmental incentives. The current system of direct payments contains several mechanisms to incentivise more sustainable production such as support for environmental-friendly production systems (e.g. organic agriculture), promotion of ecological compensation areas (biodiversity) or advancement of extensive crop management (*Möhring et al.*, 2016). In addition to the governmental subsidy system, macroeconomic price levels particularly related to possible free-trade agreements as well as the need for animal fodder will determine the portfolio of crop cultures in the future.

Fertilisers and fertiliser management

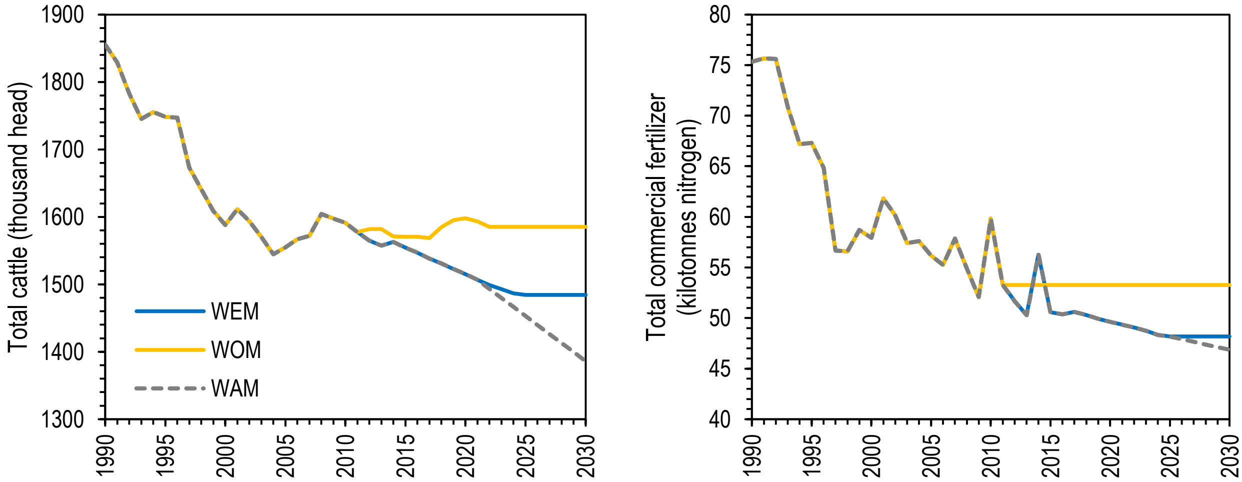
Fertiliser management depends on the standards of the Suisse-Bilanz (fertiliser management plan) that have to be observed in order to fulfil the proof of ecological performance and to get access to direct payments (*Swiss Federal Council*, 2009; *Herzog and Richner*, 2005). The Suisse-Bilanz was revised recently with only small changes. Consequently, no major changes are immediately foreseeable in this area. However, the Suisse-Bilanz might be a convenient tool to promote nitrogen use efficiency in the future by altering the level of maximum fertiliser allowances. Furthermore, the rigour of the enforcement of the standards defined in the Suisse-Bilanz can have substantial effects on fertiliser management.

Nitrogen use efficiency

Nitrogen use efficiency is strongly related to agricultural greenhouse gas emissions and nitrogen surplus can be used as proxy for N_2O emissions (e.g. *Schils et al.*, 2007). Parameters determining the nitrogen surplus and hence the nitrogen use efficiency are primarily the ammonia emission factors and the share of nitrogen lost as nitrate (leaching and runoff). Nitrogen use efficiency will be mainly affected by the programmes for resource efficiency (e.g. *Swiss Federal Council*, 2009), the Ordinance on the Promotion of Quality and Sustainability in the Agrifood Sector (*Swiss Confederation*, 2013) as well as by the general requirements under the proof of ecological performance (e.g. Suisse-Bilanz). The breeding of new crop varieties with higher nitrogen use efficiencies might be another aspect to consider.

In the following, the circumstances and sources of information relevant for the WEM, WOM and WAM scenarios are discussed. Fig. 70 shows the evolution of the most relevant key parameters under the different scenarios.

Fig. 70 > Evolution of the most relevant key parameters under the WEM, WOM and WAM scenarios for agriculture: Total cattle (left) and total commercial fertiliser (right).



Based on *FOEN* (2017a), *Möhring et al.* (2016) and *Peter et al.* (2010)

WEM scenario

The basis of the WEM scenario is the agricultural policy 2018–2021 (section 4.6). In general, no major changes were implemented compared to the previous agricultural policy (2014–2017). Specifically the decoupling of the direct payments from the amount of animals living on the farms was maintained, reducing incentives for intensification in the livestock sector that would lead to negative environmental impacts (*Swiss Federal Council*, 2009). *Möhring et al.* (2015) investigated the repercussions of the agricultural policy 2014–2017 with the multi-agent model SWISSland and later explored the impact of the new agricultural budget and adjusted policies for 2018–2021 (*Möhring et al.*, 2016). Substantial cuts in the overall agricultural subsidy budget for the time period from 2018 to 2021 are expected due to governmental austerity measures. Projections are thus based on data and information available by 2016 on the economic development in the European Union and the world markets, the macroeconomic forecast for Switzerland as well as on the future agricultural policy 2018–2021. The effects of an eventual market liberalisation in the 2018–2021 time period was not considered.

Development of animal populations, productivity of dairy cows (milk yield), development of cropping areas and fertiliser use were projected until the year 2025. For the subsequent years, all values were kept constant at the levels projected for 2025.

WOM scenario

The WOM scenario for agriculture is based on the continuation of the agricultural policy 2011. The great number of drivers that influenced the development of agricultural structures since 1990 (e.g. technological progress, breeding programmes, macroeconomical framework, agricultural policy, etc.) does not allow to distinguish the specific mitigation impacts of individual political measures retrospectively. Accordingly, 2011 was chosen as bifurcation point since concrete projections were made for the agricultural policy 2011 at this time. The fundamental assumption is that the scheme of the direct payments and the requirements under the proof of ecological performance would not have been adjusted and will not be adjusted in the future. Greenhouse gas emissions are projected according to *Peter et al.* (2010), as expected after the implementation of the agricultural policy 2011. *Peter et al.* (2010) projected the future development of the agricultural portfolio according to calculations made with the S-Integral model. The S-Integral model is a comprehensive agricultural supply model which simultaneously takes into account economic, agronomic and ecological aspects and interrelationships (*Peter et al.*, 2008). Projections were made for three agricultural price scenarios of which the high price level scenario was chosen here. The portfolio of agricultural operations (i.e. the production levels of the individual livestock animals and crop cultures) develops according to the macroeconomic development that was given exogenously as model input. Technical, organisational and structural framework conditions were assumed to remain largely unchanged. The time horizons of the projections reach in most cases until 2022, and all values are kept constant for subsequent years until 2030.

WAM scenario

Up to 2021, emissions follow the same course as under the WEM scenario, i.e. the development according to the agricultural policy 2018–2021 (*Möhring et al.*, 2016). After 2021, emissions are projected to decline according to the target scenario in the climate strategy for agriculture (*FOAG*, 2011). A substantial reduction of agricultural greenhouse gas emissions until 2050 is aspired. Technical and organisational measures shall reduce greenhouse gas emissions by at least one third. By influencing consumption patterns as well as the respective production structures further reductions of similar scale are aspired (*FOAG*, 2011). The envisaged decrease of emissions is in line with the roadmap of the European Commission for moving to a competitive low carbon economy in 2050 (*EC*, 2011).

The climate strategy for agriculture is rather a declaration of intent and encompasses only some general hints on the future roadmap of a climate-friendly agriculture. Up to date, very few concrete measures are available that could be readily implemented. However, tools and measures are being established and consolidated at the moment such as the AgroCleanTech platform that will support farmers and other related stakeholders in the fields of renewable energy, energy efficiency and climate change mitigation. *Peter et al.* (2009) and *Peter et al.* (2010) as well as publications from the Animal Nutrition Group of the Swiss Federal Institute of Technology in Zurich (e.g. *Kreuzer*, 2012) or the IP-Suisse programme (*Mieleitner et al.*, 2011; *Alig et al.*, 2015) list various potential mitigation measures that will be pursued in such a context. Two measures intended to financially support relevant projects by agricultural stakeholders, namely the resource programme (section 4.6.3) and the Ordinance on the Promotion of Quality and Sustainability in the Agrifood Sector (*Swiss Confederation*, 2013), were implemented by the Swiss Federal Office for Agriculture.

Tab. 34 provides an overview of specific assumptions in the agriculture sector with regard to the WEM, WOM and WAM scenarios.

Tab. 34 > Assumptions used for the projections of emissions from the agriculture sector under the WEM, WOM and WAM scenarios.

	WEM	WOM	WAM
Animal livestock population	The agricultural policy 2018–2021 influences animal population as predicted by *Möhring et al.* (2016). Direct payments were decoupled to a certain degree from cropping area and particularly from the amount of animals living on the farms, reducing incentives for intensification that would lead to negative environmental impacts (*Swiss Federal Council*, 2009). Consequently, animal populations more directly depend on price levels and are projected to decline. This is particularly true for dairy cows, which are projected to exhibit a further increase in milk yield. Beyond 2025 (the time horizon of *Möhring et al.*, 2016) animal populations are assumed to be constant for all animal categories.	Overall, *Peter et al.* (2010) expected rather constant livestock populations until 2022. Beyond 2022, constant populations are assumed for most animal categories.	Until 2021 the same projections as for the WEM scenario are used. After 2021 livestock populations are projected to decrease until overall agricultural greenhouse gas emissions reach the minimum reduction target set in the climate strategy for agriculture in 2050 (*FOAG*, 2011), i.e. one third of the level of 1990. This means that livestock populations have to fall by more than 25 per cent between 2021 and 2050. A reduction of the consumption of animal products should accompany the reduction of the livestock populations in order to prevent the imports of greenhouse gas-intensive animal products.
Feeding regime	With the exception of mature dairy cows, energy intake and CH_4 rates remain constant at the value of 2015, i.e. no technical measures concerning animal diets are implemented. Milk yield and hence gross energy intake of mature dairy cattle are assumed to further increase until 2025 (*Möhring et al.*, 2016). Accordingly, the CH_4 emission factor for both enteric fermentation and manure management increases proportionally. An important political measure could be the promotion of extensive milk and meat production based on grassland diets (*Swiss Federal Council*, 2012). Some respective incentives were already implemented in the agricultural policy 2014–2017. The associated effects in the WEM and WAM scenarios are roughly reflected in the projected developments of milk yields, grassland areas and other feed crops (*Möhring et al.*, 2016).	With the exception of mature dairy cows, energy intake and CH_4 rates remain constant at the value of 2011, i.e. no technical measures concerning animal diets are implemented. Milk production and hence gross energy intake of mature dairy cattle level off approximately around 2011 (*Peter et al.*, 2010). Accordingly, the CH_4 emission factors for both enteric fermentation and manure management of mature dairy cows also remain more or less at the level of 2011.	Energy intake as well as all other related feeding parameters are assumed to be equal to those under the WEM scenario. The findings of the Animal Nutrition Group of the Swiss Federal Institute of Technology in Zurich (e.g. *Kreuzer*, 2012) might help to define alternative feeding strategies with low emission intensities in the future. However, scientific results are not yet in the state to allow widespread implementation. Accordingly, the respective emission reductions are not yet included in the inventory model scenario.
Manure management	The current tendency towards more animal-friendly livestock husbandry might continue with a steady trend towards loose housing systems and more manure excreted on pasture. This would also be in line with the programme for grassland-based milk and meat production (*Swiss Federal Council*, 2012). However, due to the lack of tangible projections, the shares of manure excreted on pasture, range and paddock as well as the shares of the individual manure management systems cannot be predicted satisfactorily and are thus left constant at the level of 2015.	Manure management system distribution is assumed to remain constant (distribution as in 2011).	The same assumptions are implemented as under the WEM scenario.
Nitrogen excretion by animals	All nitrogen excretion rates are assumed to remain constant at the level of 2015 with the exception of mature dairy cows. Nitrogen excretion of mature dairy cows is projected to increase until 2025 due to the higher milk production projected by *Möhring et al.* (2016), which is related with higher feed intake rates.	Nitrogen excretion rates of all animal except mature dairy cattle are assumed to remain constant at the level of 2011. Nitrogen excretion rates of mature dairy cattle depend on milk production and are assumed to level off around 2011 as no further increase of milk yield is projected (*Peter et al.*, 2010).	The same assumptions are implemented as under the WEM scenario. Eventual programmes that might lead to higher excretion rates for cattle (e.g. grassland-based milk and meat production) or lower excretion rates (e.g. further promotion of nitrogen-reduced feeds for swine) are not modelled due to the lack of tangible projections.
Crop cultures	Targeting of direct payments is improved, particularly for the promotion of common goods and the securing of a socially acceptable development (*Swiss Federal Council*, 2009; *FOAG*, 2010). Direct payments are divided into contributions for an open cultivated landscape, contributions for security of supply, contributions for biodiversity and contributions for landscape quality. Furthermore, macroeconomic price levels as well as the need for animal fodder determine the portfolio of crop cultures in the future. Taking into account these aspects, *Möhring et al.* (2015) and *Möhring et al.* (2016) projected the future development of the individual crop cultures. Overall, crop production is projected to remain more or less stable. Beyond 2025, constant yields and areas are assumed.	Development of crop cultures between 2011 and 2022 is calculated according to *Peter et al.* (2010). Areas of arable crops are slightly declining while land use for meadows and pasture is slightly increasing. Between 2022 and 2050, areas and yields are assumed to remain constant.	For crop yields the same projections are used as under the WEM scenario. In Switzerland, an increase of the agricultural area is not possible and a decrease is very unlikely because inland food supply security is an important target of agricultural policy.
Fertilisers and fertiliser management	Use of commercial fertilisers is projected to slightly decrease by 4.8 per cent between 2015 and 2025 (*Möhring et al.*, 2016). Beyond 2025, constant fertiliser use is assumed.	After 2011, the total amount of applied commercial fertiliser is assumed to remain constant as total agricultural area and total dry matter production is not changing significantly.	The same projections are used as under the WEM scenario until 2025. Afterwards, consumption of commercial fertilisers is projected to further decline by 15 per cent until 2050 due to further promotion of nitrogen use efficiency.
Nitrogen use	Further development of the scheme of direct payments with	Since total amount of applied	Falling commercial fertiliser levels combined

efficiency	adjustments in the proof of ecological performance (*Swiss Federal Council*, 2009). Further, programmes for resource efficiency in agriculture are designed to increase nutrient use efficiency in order to fulfil the environmental goals for agriculture (*FOEN and FOAG*, 2008). Consequently, the agricultural policy 2018–2021 plans to address the above mentioned issues. However, due to the lack of specific indications, ammonia emission factors and nitrogen loss rates are projected to remain constant at the level of 2015 in the inventory model.	commercial fertiliser as well as total nitrogen available from animal manure are assumed to remain constant, no increase in nitrogen use efficiency is achieved.	with more or less stable crop yields immediately implies that nitrogen use efficiency must substantially increase. This could be reached through crop breeding, more efficient use of synthetic fertilisers or increasing the nitrogen use efficiency of manure fertilisers by reducing losses of ammonia and nitrate. However, due to the lack of specific information, the fractions of nitrogen lost as ammonia and nitrate are kept constant in the calculation model, which might lead to a somewhat unrealistic situation. *Kupper and Menzi* (2011) studied the possibility of reductions of ammonia. The respective findings might be used to refine the projections under the WAM scenario in the future.

5.3.4 Land use, land-use change and forestry

To project greenhouse gas emissions from the land use, land-use change and forestry sector, the stochastic empirical single tree forest management scenario model (MASSIMO3), which is based on data from the three successive national forest inventories, was used. The model was specifically designed to reflect the characteristics of Swiss forests. MASSIMO3 is also used for the calculation of the Swiss forest management reference level for accounting for forest management under the Kyoto Protocol for the second commitment period (2013–2020). The model mainly consists of a single tree growth component, a wood harvesting component, and a component on natural regeneration. These model components as well as in-growth and mortality rates are empirically derived from data of the national forest inventory (*Kaufmann*, 2011), as detailed in the following:

- **Single tree growth** is estimated using a single tree model. It depends on the diameter at breast height, on the basal area of the stand under consideration, on a competition index, on site fertility, on the elevation, and on the stand age. The estimation of stand age is based on a model that has been derived from tree ring analysis on the sample plots of the national forest inventory. In-growth rates are considered as well;
- **Wood harvesting component**: To calculate annual clear-cut areas in even-aged forest (80 per cent of the forest area), the following rotation periods are assumed: 90–110 years on very good sites, 110–130 years on good sites, 130–150 years on medium sites, and 180 years on poor sites in alpine regions. Mature stands are harvested within a time span of 20–30 years in order to promote natural regeneration. This is common practice in the Swiss forestry sector and is also reflected in the data of the national forest inventory. Stands are thinned as soon as their basal area has increased by 10 per cent since the last thinning event. This criterion guarantees that a stand reaches the development stage of mature timber during a rotation period. The thinning techniques implemented in the model runs are derived from the national forest inventories;
- Information for plots with **natural regeneration** is extracted from a database containing regeneration plots according to the national forest inventories;
- **Mortality rates and management strategies** are considered as observed in the last few years, since MASSIMO3 is based on data of the three national forest inventories covering the time period 1985–2005, comprising all management activities with significant impact during that period.

MASSIMO3 produces a time series of carbon stocks, harvest rates, and gross growth for Swiss forests per decade starting in 2006. The model thus gives information on changes in carbon stored in forests. Changes in emissions or removals from non-CO_2 gases are not calculated by the model. Accordingly, it is assumed that, until 2030, the non-CO_2 gases stay at the mean value of the emissions between 1990 and 2007 since no changes are expected in the occurrence of wildfires nor in afforestation and deforestation. As greenhouse gas emissions in the land use, land-use change and forestry sector are dominated by activities in source category 4A1 ‘Forest land remaining forest land’, projections are focussing on this source category, assuming that all other source categories remain at their current level. Source category 4A1 is closely related to the forest management activity under the Kyoto Protocol. Using MASSIMO3 and defining future harvesting rates to derive forest management scenarios, greenhouse gas balances under the WEM, WOM and WAM scenarios were calculated. The scenarios presented here show net emissions and removals as reported under the UNFCCC. For accounting purposes under the Kyoto Protocol, the net emissions from selected activities are considered in relation to the forest management reference level. The characteristics of the WEM, WOM and WAM scenarios, which correspond to the scenarios presented in Switzerland’s last submission, are detailed in Tab. 35.

Tab. 35 > Assumptions used for the projections of emissions from the land use, land-use change and forestry sector under the WEM, WOM and WAM scenarios.

	WEM	WOM	WAM
Forest area, afforestation, deforestation	The forest area as well as the changes in forest area (afforestation, deforestation) are calculated using an extrapolation of the trend 1990–2009 (values derived from the Swiss land use statistics AREA, *SFSO*, 2012).	Afforestation and deforestation activities are identical for all scenarios.	Afforestation and deforestation activities are identical for all scenarios.
Forest management, political measures	In order to reach the optimal combination of the objectives identified in Switzerland's Forest Policy 2020 (section 4.6.5), it is important that Swiss forests are stable and managed in a sustainable way. The WEM scenario, in accordance with the Forest Policy 2020, is defined as a scenario where the living biomass pool remains constant at the level of 2006 (growing stock from NFI3/2004–2006), meaning that gross growth equals cut and mortality.	No political measures considered.	Compared to the WEM scenario, a different approach for forest management is taken into account. Switzerland's wood resource policy (*FOEN/SFOE/SECO*, 2017; section 4.7.3) promotes higher harvesting rates in Swiss forests. With the excellent image of sustainably produced Swiss wood, the future demand for wood products is expected to increase.
Harvesting rates	To reach constant biomass, harvesting rates have to increase by 16 per cent until 2025 compared to 1995–2006 (harvesting rate for the periods of NFI2/1993–1995 and NFI3/2004–2006; *Kaufmann*, 2011). Without increase of harvesting rates, standing volume in Swiss forests would further increase and lead to unstable forests not fulfilling the objectives of sustainable forest management. After 2025, harvesting rates are assumed to stay at this level.	Without political measures, Swiss forests would act as a considerable CO_2 sink because growing stock in Swiss forests would further increase, thereby leading to an unsustainable forest structure. Under the WOM scenario, harvesting rates stay at the level of 1995–2006 (periods of NFI2/1993–1995 and NFI3/2004–2006; *Kaufmann*, 2011) until 2030.	As the aim of Switzerland's wood policy under the WAM scenario is to increase wood production by 2025 in the interest of harvesting the potential sustainable wood supply, harvesting rates have to increase by up to 30 per cent compared to 1995–2006 (harvesting rate for the periods of NFI2/1993–1995 and NFI3/2004–2006; *Kaufmann*, 2011). After 2025, harvesting rates are assumed to stay at this level. The feasibility of such an increase in harvesting was determined in a scientific study, 'Switzerland's potential sustainable wood supply' (*FOEN*, 2011).
Other source categories and greenhouse gases	As greenhouse gas emissions in the land use, land-use change and forestry sector are dominated by activities in source category 4A1 'Forest land remaining forest land', projections are focussing on this source category, assuming that emissions from all other sources (including emissions of CH_4 and N_2O) remain constant.	Identical assumptions for all scenarios.	Identical assumptions for all scenarios.

Planned improvements

For this submission, there were no recalculations or improvements compared to Switzerland's last submission, because updated results for all three scenarios are not yet available. Until 2020 profound improvements to the modelling work will have been carried out. Results of the projections for all three scenarios will be in line with the methodological improvements related to the forest management reference level, i.e. with the technical corrections already implemented for the calculation of the forest management reference level (see section 11.5.2.3 in *FOEN*, 2016) and with the technical corrections planned for the next years (see section 11.5.2.3 in *FOEN*, 2017a).

5.3.5 Waste

Greenhouse gas emission scenarios for the waste sector were calculated following exactly the same methodology as used for the greenhouse gas inventory, i.e. bottom-up estimates according to the 2006 IPCC guidelines for national greenhouse gas inventories (*IPCC*, 2006). Details about the methodologies are documented in *FOEN* (2017a). The strength of this approach is that greenhouse gas emission scenarios are calculated at the level of single processes. This, however, requires a full set of projections of activity data and emission factors (which may potentially be considered a weakness of the approach). The underlying assumptions used under the different scenarios to project greenhouse gas emissions are described in Tab. 36. As in the waste sector policies and measures are rather limited, the WEM, WOM and WAM scenarios are largely based on the same underlying assumptions, with differences for the WOM scenario regarding landfilling of combustible waste and emissions from biogas production. For all scenarios, it is assumed that waste generation per capita remains the same.

Tab. 36 > Assumptions used for the projections of greenhouse gas emissions from the waste sector under the WEM, WOM and WAM scenarios. In consistency with the greenhouse gas inventory, greenhouse gas emissions from waste incineration facilities are reported under public heat and electricity generation in the energy sector.

	WEM	WOM	WAM
Landfilling of combustible waste	As landfilling of combustible waste was only of secondary importance and is prohibited completely since the year 2000 (section 4.8.2), greenhouse gas emissions from solid waste disposal sites are small, further decreasing, and only result from waste deposited before the implementation of the ban on landfilling of combustible waste. The WEM scenario is thus based on a continuation of the model for landfilling of combustible waste until 2030 (*IPCC*, 2006; *FOEN*, 2017a). The share of CH_4 flared reaches a value of 10 per cent by 2030 (current value eight per cent).	It is assumed that the ban on landfilling of combustible waste was not implemented. Consequently, the amount of waste disposed of at waste disposal sites under the WOM scenario follows the same evolution as under the WEM and WAM scenarios until 1999, but then only decreases to 10 per cent of this value by 2020, remaining constant thereafter[36]. It is further assumed that the share of CH_4 recovered for power production (on total CH_4 produced) is the same under the WOM scenario as under the WEM and WAM scenarios (the share decreases disproportionately as the cost-income ratio is changing for the worse with decreasing CH_4 production of the waste disposal site). Finally, it is assumed that the share of CH_4 flared remains constant at 3.5 per cent from 1990 to 2030.	Same as for the WEM scenario.
Wastewater handling	Emissions from wastewater handling are assumed to scale with the evolution of population.	Same as for the WEM scenario.	Same as for the WEM scenario.
Biogas production	It is assumed that increased demand for biogas leads to the construction of 336 additional biogas facilities by 2030 (*Prognos*, 2012). Accordingly, the total number of biogas facilities reaches 236 by 2020 and 461 by 2030, with a related increase of fugitive emissions over the coming years.	It is assumed that the amount of biogas upgraded under the WOM scenario compared to the amount of biogas upgraded under the WEM and WAM scenarios corresponds to about half of the amount by 2020 and to about one third of the amount by 2030 (*Prognos*, 2012). The total number of biogas facilities under the WOM scenario is then derived assuming the same amount of upgraded biogas per facility as under the WEM and WAM scenarios. Consequently, reduced fugitive emissions from biogas facilities, from upgrading of biogas to natural gas quality and from flaring result under the WOM scenario compared to the WEM and WAM scenarios.	Same as for the WEM scenario.

5.3.6 Indirect CO_2 emissions

For the WEM and WAM scenarios, projections of indirect CO_2 emissions are based on the same assumptions and methodologies as the projections of direct greenhouse gas emissions in the respective sectors (see above). For the WOM scenario, it is assumed that due to the absence of policies and measures the emission factors for NMVOC emissions do not improve over time and, thus, remain constant at the values in 1990 (see section 4.5.5). The same activity data as under the WEM and WAM scenarios are then used to derive NMVOC emissions and subsequently indirect CO_2 emissions under the WOM scenario. For all scenarios, only fossil emissions and only emissions not already included elsewhere are considered (see section 3.2.4 for more details).

5.3.7 International transport

For international transport, the energy perspectives of *Prognos* (2012) provide the energy demand under the WEM scenario (scenario 'WWB', corresponding to a continuation as before). The same emission factors as used in the greenhouse gas inventory are then applied to calculate emissions of CO_2, CH_4, and N_2O. As the CO_2 emissions standard for aircraft (section 4.4.9) is of global significance, it is assumed that it does not lead to differences between the WEM, WOM and WAM scenarios. However, under the WAM scenario the planned inclusion of aviation in the emissions trading scheme (section 4.4.8) as well as the carbon offsetting and reduction scheme for international civil aviation (CORSIA; section 4.4.10) overall enforce a carbon neutral growth on the basis of 2020. Although emission compensa-

[36] The reasoning for this assumption is a decreasing public acceptance of waste disposal sites (odour, need of space, pollution, etc.), leading to the closing of waste disposal sites (where practicable) even without an official ban.

tions may take place outside the aviation sector, it is assumed that emissions from international aviation remain constant after 2020 under the WAM scenario.

5.3.8 Main differences compared to previous submissions

Compared to the greenhouse gas emission scenarios presented in Switzerland's last submission, the following most important changes and improvements regarding methodology and assumptions were implemented in the calculations for the different sectors:

- In the energy sector (including transport, i.e. the source categories 1A1 to 1A5), the greenhouse gas emission scenarios are no longer directly based on *Prognos* (2012), but have been recalculated with a computable general equilibrium model (*EPFL and Infras*, 2016), including an update to the most recent greenhouse gas inventory (*EPFL*, 2017);
- With the computable general equilibrium model (*EPFL and Infras*, 2016; *EPFL*, 2017), the partial compensation of CO_2 emissions from motor fuel use (see section 4.4.5) is directly calculated for the different scenarios. Accordingly, the resulting greenhouse gas emission reductions are now included in the evolution of greenhouse gas emissions from the different source categories, while they have not been allocated to any of the sectors in previous reports;
- As an essential input to the computable general equilibrium model, the perspective of the future development of transport demand was reconsidered, in particular substantially reducing the projected use of biofuels and considering a more realistic share of electric vehicles. Accordingly, the updated projections for greenhouse gas emissions from the transport sector show a less pronounced decrease compared to the previous submission;
- In the industrial processes and product use sector, the modelling of emissions of F-gases has been updated to be consistent with the most recent greenhouse gas inventory (*FOEN*, 2017a);
- The greenhouse gas emissions scenarios for international transport (aviation and marine) under the WOM scenario were reconsidered.

5.3.9 Sensitivity analysis

In the context of the development of the new greenhouse gas emission scenarios for the energy sector (including transport), the computable general equilibrium model was also used to perform a sensitivity analysis (*EPFL and Infras*, 2016). In brief, for the CO_2 emissions from the energy sector (including transport), which contribute the dominant part to Switzerland's total greenhouse gas emissions, so-called 'sensitivity scenarios' were analysed for the WEM scenario. Thereby, the following key underlying assumptions, which may introduce the largest amount of uncertainty into the model calculations, were altered within reasonable limits (i.e. increased and decreased with regard to their reference value):

- Gross domestic product;
- International price of oil;
- International price of gas;
- Technological progress;
- Bottom-up estimates of the mitigation impacts of non-price policies and measures used for the simulations with the computable general equilibrium model.

A low and a high scenario were then produced by combining the altered key underlying assumptions in such a way that the new sets of key underlying assumptions either favoured high emissions or low emissions. The main results of the sensitivity analysis are as follows:

- For the WEM scenario, CO_2 emissions from the energy sector (including transport) cover a range (relative to the scenario calculated with the reference values for the key underlying assumptions) from –3 to +12 per cent by 2020. By 2030, the range increases to –9 to +23 per cent;

- An increase of the gross domestic product by one per cent leads to an increase of CO_2 emissions from the energy sector (including transport) by 1.14 per cent;
- An additional improvement of energy efficiency by one per cent leads to a decrease of CO_2 emissions from the energy sector (including transport) by 0.16 per cent;
- An increase of the international price of oil by one per cent leads to a decrease of CO_2 emissions from the energy sector (including transport) by 0.28 per cent.

Further methodological details as well as figures and tables are available in chapter 5 of *EPFL and Infras* (2016).

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6 Vulnerability assessment, climate change impacts and adaptation measures

This chapter has been brought in line with the structure as suggested by the revised UNFCCC reporting guidelines used for preparation of this national communication. Its contents were rearranged to best reflect circumstances and activities linked to the topics of vulnerability assessment, climate change impacts and adaptation measures.

6.1 Climate modelling, projections and scenarios

6.1.1 Update on the state of models and scenarios

The official scenarios on climate change currently used in Switzerland (CH2011 scenarios) were launched in 2011 under the aegis of the Swiss Federal Institute of Technology in Zurich and MeteoSwiss (*CH2011*, 2011). The CH2011 scenarios present a consolidated view on future climate change in Switzerland. The scenarios are based on a large number of European-scale regional climate model experiments available at that time from international projects. Statistical methods were used to produce multi-model estimates of changes and associated uncertainties in seasonal mean temperature and precipitation changes for three representative Swiss regions and three scenario periods. The CH2011 scenarios are based on two non-intervention emission scenarios (A2 and A1B) that anticipate increases in emissions, and one climate stabilisation scenario (RCP3PD) that assumes emissions to be cut by about 50 per cent by 2050 and that stabilizes global warming at about tow degrees Celsius with respect to pre-industrial conditions. Besides regional and seasonal mean changes, the new scenarios also provide changes in daily mean values at individual meteorological station sites in Switzerland. Scenario data were made available in digital form at *http://www.ch2011.ch*.

The CH2011 scenarios served as a basis for a variety of climate change impact studies in Switzerland. The largest such study – 'CH2014-Impacts' led by the Oeschger Centre for Climate Change Research – investigated quantitative impacts of climate change focusing on ecologic, economic and social impacts (CH2014-Impacts, 2014). The CH2011 scenarios further served as an important basis for framing the national climate adaptation strategy (see section 6.4).

Through the practical application of the scenarios, a number of shortcomings and limitations have been unveiled. To find a broader applicability among users, the existing CH2011 scenario products were extended as a response to specific user requests. These amendments were coordinated by members of the respective community and were published as several extension articles (*Bosshard et al.*, 2015; *Fischer et al.*, 2015b; *Fischer et al.*, 2016) along with respective data portals. The CH2011 scenarios together with their extensions constituted the basis of the recently published overview report on climate change in Switzerland coordinated by the Swiss Academies of Arts and Sciences (*Swiss Academies of Arts and Sciences*, 2016).

With the advancement of new higher-resolved regional climate model projections over Europe from the EURO-CORDEX initiative (*http://www.euro-cordex.net/*) and with an improved scientific understanding, it is desirable to update the national scenarios of 2011. The new generation of climate change scenarios for Switzerland (CH2018 scenarios), to be launched in 2018, is developed as a focus area of the National Centre for Climate Services established in 2015 (*http://www.nccs.ch*, see also section 6.4.2). As in *CH2011* (2011), this project involves several partners from academia and federal offices.

While the CH2018 scenarios are still being produced, the results presented in the following are based on the former CH2011 scenarios and its later extensions. The CH2018 scenarios will be made available through the website *http://www.ch2018.ch*.

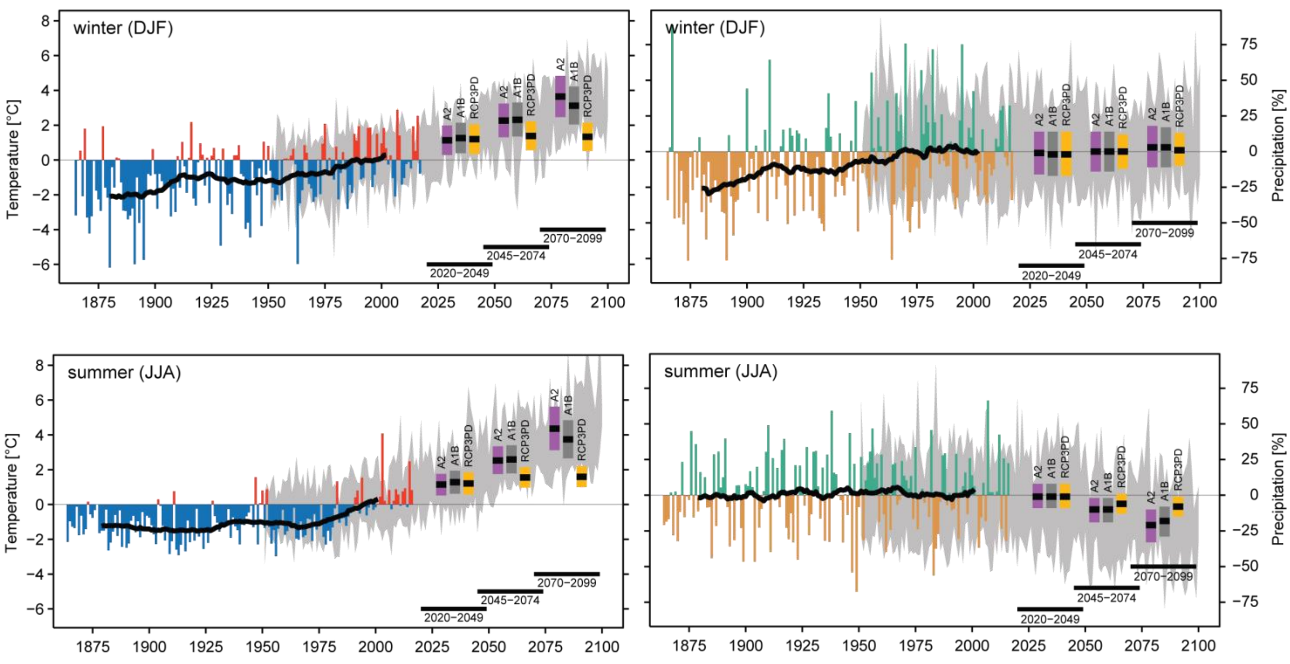
6.1.2 Main results for temperature, precipitation and climate extremes

Temperature and precipitation

In the course of the 21st century, Swiss climate is projected to depart significantly from present and past conditions. Mean temperature will very likely increase in all regions and seasons. Summer mean precipitation will likely decrease by the end of the century all over Switzerland, while winter precipitation will likely increase in Southern Switzerland for the investigated emission scenarios A2, A1B and RCP3PD. In other regions and seasons, models indicate that mean precipitation could either increase or decrease. The projections of future temperature and precipitation are consistent with past observations.

Towards the end of the 21st century, Swiss climate will be strongly affected by the future course of global greenhouse gas emissions. As an example, Fig. 71 shows the observed seasonal temperature evolution (winter and summer) in north-eastern Switzerland, as well as projected changes for the three different emission scenarios and scenario periods. Compared to the reference period 1980–2009, and for all Swiss regions considered, the best estimates for the non-intervention scenarios project increases of seasonal mean temperature of 3.2–4.8 degrees Celsius by the end of the century for the A2 scenario and 2.7–4.1 degrees Celsius for the A1B scenario. To derive changes with respect to the pre-industrial period, the observed warming over Switzerland of about 1.5 degrees Celsius since the mid-19th century must be added (*CH2011*, 2011). Summer mean precipitation is projected to decrease by 21–28 per cent for the A2 scenario and 18–24 per cent for the A1B scenario. For the climate stabilisation scenario (keeping global temperature change below two degrees Celsius relative to preindustrial levels), Swiss climate would still change over the next decades, but is projected to stabilise at an annual mean warming of 1.2–1.8 degrees Celsius and a summer drying of 8–10 per cent by the end of the century. Uncertainties due to climate model imperfections and natural variability typically amount to about one degree Celsius in temperature and 15 per cent in precipitation.

Fig. 71 > Past and future changes in seasonal temperature (degree Celsius) and precipitation (per cent) over north-eastern Switzerland. The changes in temperature and precipitation are relative to the reference period 1980–2009. The thin coloured bars display the year-to-year differences with respect to the average of observations over the reference period; the heavy black lines are the corresponding smoothed 30-year averages. The grey shading indicates the range of year-to-year differences as projected by climate models for the A1B scenario (specifically, the 5–95 percentile range for each year across the available model set). The thick coloured bars show best estimates of the future projections, and the associated uncertainty ranges, for selected 30-year time-periods and for three greenhouse gas emission scenarios.



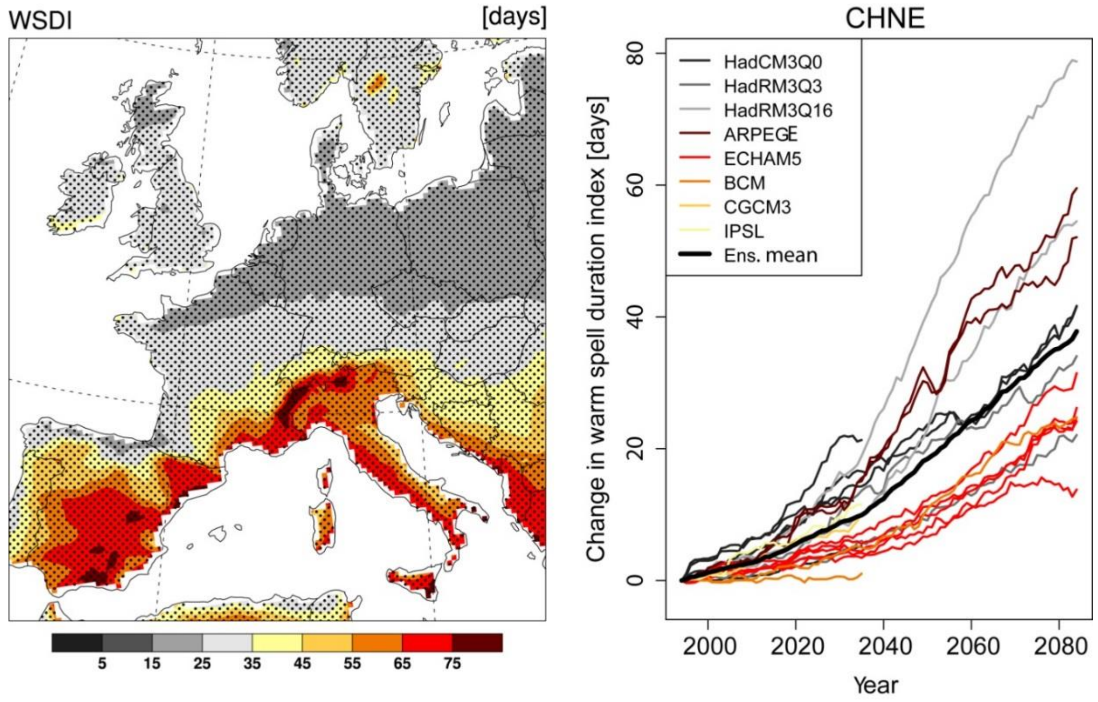
CH2011 (2011), updated with available observed data beyond 2011

The projected increase in temperature for Switzerland is consistent with large-scale warming over Europe for all seasons. In winter, the warming is amplified in Northern Europe, partly due to decreased snow cover. In summer, stronger warming is projected in Southern Europe, partly driven by drier surface conditions. Northern Europe will likely get wetter and Southern Europe will get drier, which is consistent with the global picture of drier subtropics and wetter high latitudes. In between those opposing trends, precipitation in the Alpine region could either increase or decrease in all seasons – except summer, when Mediterranean drying likely encompasses the Alps and Central Europe. The expected decrease in mean summer precipitation is pre-dominantly an effect of a reduced number of wet days, while the average intensity of precipitation remains at a level similar to today's climate. As a consequence, the probability of consecutive dry days increases.

Temperature extremes

By the end of the 21st century, and for the range of scenarios considered, it is very likely that the frequency, duration and intensity of summer warm spells and heat waves in Switzerland will increase significantly. As an illustrative example, changes in the warm spell duration index (WSDI)[37] were calculated for each of the climate models considered in *CH2011* (2011). Fig. 72 shows that the multi-model ensemble mean projects an increase in WSDI of almost 40 days per summer by the end of the century in north-eastern Switzerland (ranging from 10 to 80 days in individual climate model runs). Southern Europe is expected to experience stronger increases in warm spells and heat waves than Switzerland, and northern Europe somewhat weaker increases.

Fig. 72 > Projected changes in warm spell duration. Spatial changes in the warm spell duration index (WSDI; May–September) in 2070–2099 (with respect to 1980–2009) for the multi-model mean (left) forced with the A1B emission scenario. Stippled areas indicate significant changes (95 per cent confidence level) in more than 66 per cent of the climate models. 30-year running means of WSDI are shown on the right for the individual models and the multi-model mean (black line) for north-eastern Switzerland. The legend lists the eight involved global models. Simulations driven with the same global model are shown in the same colour.



CH2011 (2011)

During winter, the number of cold winter nights and days is likely to decrease. Over north-eastern Switzerland, the climate models considered in *CH2011* (2011) project a strong reduction in the number of cold winter nights by 50–90 per cent by the end of the century.

Heavy precipitation and droughts

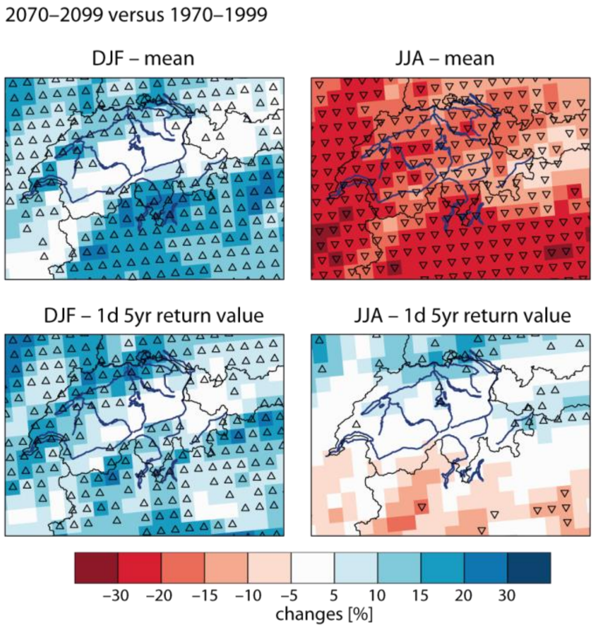
On a global scale climate models simulate a significant future increase in heavy precipitation in the tropics and mid-to-high latitudes by the end of the century. Consistent with the global scale, for Switzerland, regional climate models simulate more frequent and more intense heavy precipitation events (see Fig. 73). In winter, heavy precipitation increases at a similar rate as mean precipitation. In summer, heavy precipitation events show a tendency to increase despite the general decrease in mean precipitation (*Rajczak et al.*, 2013).

In parallel with these changes, a shift from solid (snow) to liquid (rain) precipitation is expected with increasing temperatures over Switzerland, with potential implications for the frequency of floods.

37 A warm spell is defined as a period of at least six consecutive days with maximum temperatures exceeding the local 90th percentile for days in the reference period. The warm spell duration index is the total number of days per year (May to September) that are part of a warm spell.

Together with the decrease in summer mean precipitation, the length of summer dry spells is likely to increase (*CH2011*, 2011), indicating an increased risk of drought for Switzerland. However, model uncertainties in projecting changes of droughts are generally higher than for changes in temperature extremes and heavy precipitation.

Fig. 73 > Projected changes of mean precipitation (upper panel) and heavy precipitation (lower panel) for winter (DJF) and summer (JJA) in Switzerland by the end of the century. Shown is the multi-model mean of ten regional climate models according to the A1B emission scenario. Change in heavy precipitation is described by the change of the daily precipitation sum with a return value of five years. Regions in which eight out of ten models agree on the mean sign of change are marked with a triangle symbol.



Adapted from *Rajczak et al.* (2013)

Winter storms

Confidence in projections of windiness in Central Europe remains relatively low and hence no robust projection for extreme wind storms in Switzerland can be made. For instance, it remains unclear whether devastating winter storms such as 'Lothar' and 'Vivian' will become more or less frequent in the future. It is expected that low pressure systems and the accompanying storm winds over Northern Europe will intensify, while weakening over Southern Europe. Switzerland is located in-between these large-scale centres of change, which is why robust projections are hardly possible (*Swiss Academies of Arts and Sciences*, 2016).

6.2 Climate change impacts on nature, society and economy

Impact studies since the last national communication are still based on the climate scenarios calculated in 2011 (CH2011 scenarios). New climate scenarios are under way, but will only be available in the course of 2018. In the meantime, data with higher temporal resolution and additional (statistical) parameters like the number of days exceeding certain thresholds have been calculated, but the basic scenario is still the same. Therefore, a number of studies and the corresponding results from the last national communication still represent the current state of knowledge and therefore remains cited in this report.

6.2.1 Hydrological cycle and water resources

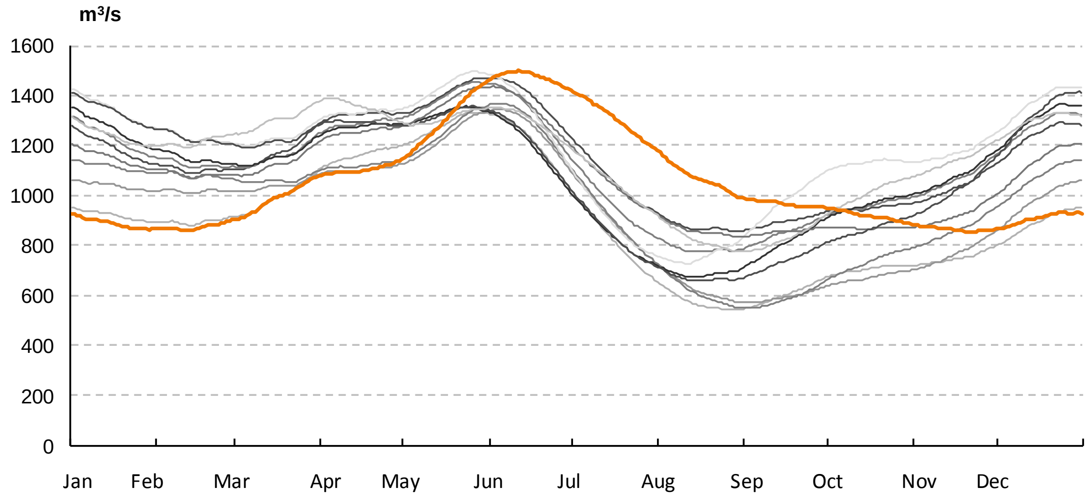
Within the project 'Climate Change and Hydrology in Switzerland' (CCHydro) run by the Swiss Federal Office for the Environment, the effects of climate change on the water balance in Switzerland during the 21th century were studied (*FOEN*, 2012a). The aim of this project was to present scenarios with enhanced spatial and temporal resolution for the hydrological cycle and runoff in the different climate regions and altitudes in Switzerland for the periods around 2035 and 2085, based on the latest climate projections. This would provide a basis for analysing changes in extreme discharge values (high and low water), water temperatures, and water resources and their annual distribution regimes.

From the European ENSEMBLE project, ten climate model chains were selected. They correspond to an increase in greenhouse gas emissions based on the A1B emissions scenario. The delta change method was used for regional downscaling of the climate scenarios. The ten climate scenarios used in this study are described in *CH2011* (2011). The PREVAH model (*Viviroli et al.*, 2009) was used to model the water regime and runoff.

Stream flow scenarios

In the near future (until 2035), annual runoff in Switzerland will change very little, apart from temporary increases in runoff in highly glaciated regions. In the long term (by 2085) the annual runoff will fall slightly, particularly in the Lake Maggiore basin (*FOEN*, 2012a). However, the seasonal distribution of runoff (runoff regime) will shift almost everywhere in Switzerland. By the end of the century, catchments with a glacial and snowmelt driven runoff regime will only be found in isolated areas and the seasonal distribution of runoff will follow the rainfall distribution. In the non-glaciated regions, runoff is expected to be higher in winter but lower in summer (*Steger et al.*, 2013). On the Rhine, e.g., a second seasonal runoff maximum will develop over time in winter in addition to the existing one in early summer (Fig. 74). On the Swiss Plateau a distinct minimum runoff in August and two seasonal peaks in January and March are expected. Runoff during low flow events will decrease considerably and these periods will be longer. For instance, runoff in the Aare in late summer will gradually fall below levels currently experienced in winter. In the catchments of the Alps and, in particular, their northern slope, low flow events will shift from winter to late summer and will be less pronounced.

Fig. 74 > Discharge projections in River Rhine at Basel. The orange line indicates the control period, grey lines the ten climate scenarios over the period 2070–2099.

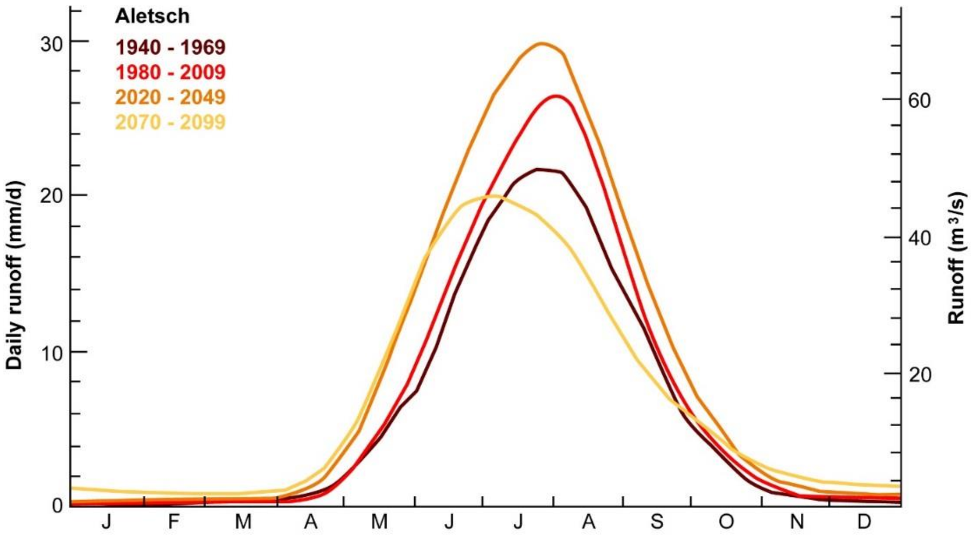


FOEN (2012a)

Effects of climate change on water reservoirs

The runoff regime changes which have already been observed over the past decades, can be explained by the changes in climatic conditions (*Collins*, 2006; *Ban et al.*, 2015; *Fischer et al.*, 2015a; *Rajczak et al.*, 2013). Since average annual air temperature in Switzerland increased by almost two degrees Celsius over the past decades (section 2.5) and is expected to increase further (section 6.1.1), it is likely that this will have an impact on seasonal hydrological reserves in Switzerland. The increase in temperature will lead to an increase in evapotranspiration. Therefore, less water will be available for runoff. The temperature increase will also be accompanied by a rise in the snow line. The average area covered by snow will be continually reduced, as is the depth and duration of the snow cover (section 6.2.2) resulting in decreasing amounts of snow available for melting. During the period 1980–2009, some 40 per cent of the water flowing from Switzerland to the neighbouring countries consisted of snow melt. This proportion will fall to about 25 per cent by 2085. This will lead to an increasing proportion of rainfall being free to drain away immediately, particularly in winter. Less than two per cent of annual runoff is currently derived from the summer glacier ice melt, but in summer the proportion is much greater in streams in the vicinity of glaciers. Because glaciers – which react only slowly to environmental changes – are not in balance, they will continue to melt rapidly. This will lead at first to more runoff in the Alpine catchments due to increased melt and in a later period to less runoff. Whilst smaller glaciers are already demonstrating decreasing runoff levels, the peak of melt runoff will be reached around 2040 for glaciers with greater volume. By 2100, the remaining volume of ice will be very small (section 6.2.2). Fig. 75 shows changes in the seasonal runoff of the Aletsch glacier catchment (large, middle and upper Aletsch) in Valais. Since the 1940s, summer runoff in the Aletsch region has increased and will increase further. Maximum runoff in summer will occur already in July instead of early August. In the long term dramatic changes are expected: the maximum seasonal runoff will drop below 1940–1969 levels because the glacier surface area will decrease markedly, from 123 square kilometres in 2009 to a mere 39 square kilometres at the end of the 21st century. In addition, the seasonal maximum will shift to June.

Fig. 75 > Development of seasonal runoff in the Aletsch glacier catchment over a period of thirty years. Glacier surface area is 123 square kilometres, average altitude of catchment is 2925 metres above sea level.



FOEN (2012a)

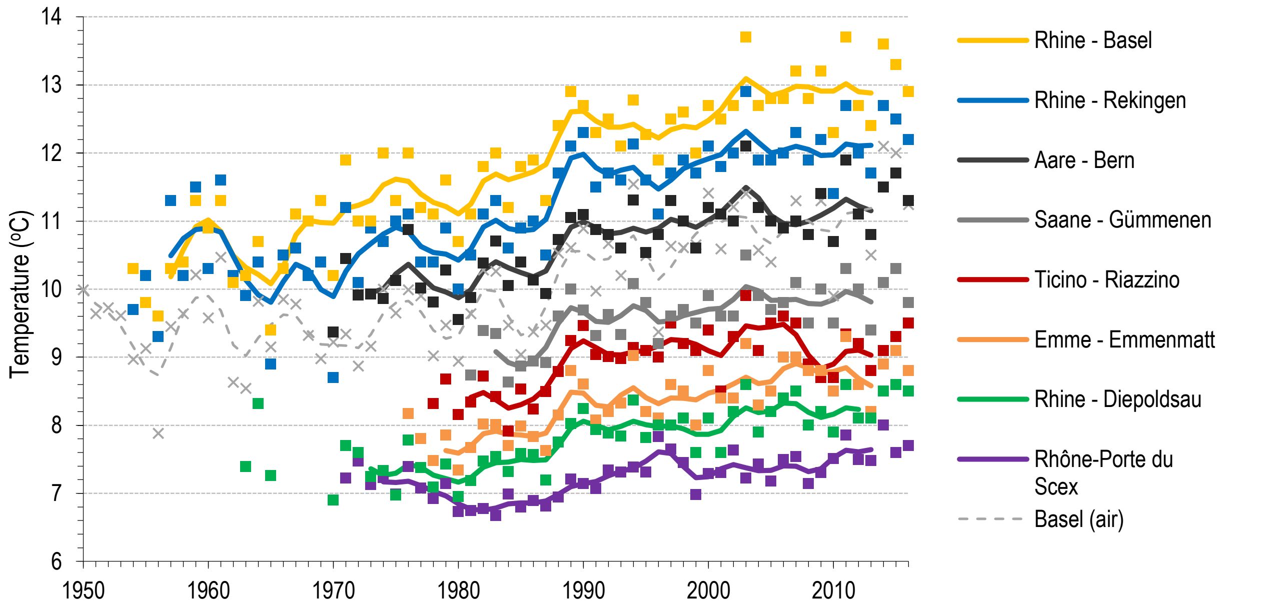
Change in the pattern of precipitation regimes could have serious consequences for the natural replenishment of groundwater and water supply. The hot summer of 2003 and the prolonged precipitation deficit from 2003 to 2005 resulted in unusually low values for the groundwater levels and discharge rates at most of the monitoring stations of the National Groundwater Monitoring (NAQUA) (*FOEN*, 2009). Similar effects were observed in 2015 (*FOEN*, 2016a). Conversely, the floods of 1999 and the prolonged precipitation surplus from 2000 to 2002 resulted in very high groundwater levels and discharge rates. Based on the CH2011 scenarios, it can be assumed that precipitation intensity and strength will tend to increase in the long term and high groundwater levels and spring discharge rates may thus occur more frequently. However, summer droughts may happen more often and last longer in the future. So far, no clear trends have been identified for both the groundwater levels and the discharge rates.

Impacts on water temperature and water quality

Regarding water chemistry, Swiss waters are in a good condition (*FOEN*, 2015b). Up to now there is no evidence that the water quality has altered due to climate change. This is not the case with regard to water temperature. Indeed, the significant rise in air temperature (section 2.5) has simultaneously been followed by that of surface and groundwater temperature. Water temperatures of various rivers and streams have been continuously recorded since 1963 within the framework of the national temperature measurement network (Fig. 76). This allows highlighting the effects of various natural and anthropogenic influences on the annual development of water temperatures. The analyses of those measurements show clear tendencies towards increased annual mean temperatures of up to 1.2 degrees Celsius, and 1.5 to 3 degrees Celsius in summer, particularly at lower altitudes as well as downstream of lakes (*Jakob et al.*, 2010). In alpine regions the increase in the annual mean temperature is less pronounced, due to the compensating influences of melt-water from glaciers. A rapid increase in temperature is noticeable in spring, irrespective of the altitude. The causes of this temperature change cannot always be clearly identified. Anthropogenic and natural climate change induced effects have a combined influence on the water temperature regime (*Swiss Academies of Arts and Sciences*, 2016).

The temperature changes impact decisively on the development and on the composition of aquatic life. A further rise of the water temperature in the future, especially at times of low flows, could probably also lead to a deterioration of the chemical water quality. The quality of drinking water resources could also change if groundwater temperatures increased. Indeed, the water temperature is one of the most important regulators of biologic processes in aquatic groundwater ecosystems. Temperature regulates the metabolic and redox processes and defines the evolution, the growth rate and the composition of biocenoses.

Fig. 76 > Change of yearly water temperature at different measuring stations 1954–2016. For comparison the air temperature at Basel is included in the graph (symbol 'x' and grey dashed trend line). Yearly moving average lines over seven years are represented.



Swiss Federal Office for the Environment

6.2.2 Cryosphere

Freezing level

In wintertime, the seasonal freezing level (altitude, where surface air temperature is zero degree Celsius) has risen by about 300 metres per degree Celsius of warming from approximately 600 metres in the 1960s to approximately 900 metres in the 1990s (*Scherrer and Appenzeller*, 2006). If warming in winter continues as expected, the freezing level will further rise by about 280 metres until 2060 in case of a mitigation scenario (about +1.4 degrees Celsius, best estimate), by about 460 metres in case of a non-intervention scenario (about +2.3 degrees Celsius, best estimate) (*CH2011*, 2011).

Snow

The occurrence of a snow cover on the Swiss plateau, where the majority of the population lives, shows a high inter-annual variability. Due to the already observed warming, precipitation falling as snow has been decreasing (*Serquet et al.*, 2011). Together with effects of snow melting, a reduction of snow depth and snow duration has been observed in the past decades. For example, on the plateau the number of days with a snow depth of at least five centimetres has been 50 per cent lower in the last 20 years than in the decades before (*Marty*, 2008). On the other hand, despite the warming trend, winter temperatures above about 2000 metres above sea level are still predominantly below freezing and changes in snow cover have thus not yet been observed (*Marty and Meister*, 2012).

From recent analyses (*Schmucki et al.*, 2015; *Serquet et al.*, 2011) it can be concluded that under future climate scenarios the snow season will get shortened in Switzerland by 4–8 weeks per year. As the lower limit of the snow cover corresponds roughly to the freezing level, an upward shift of the snow line until the mid of this century is expected, with noticeable implications for seasonal runoff. These will be even more pronounced towards the end of the 21st century, when numerical models project a reduction of the snow water equivalent by 50 per cent (best estimate).

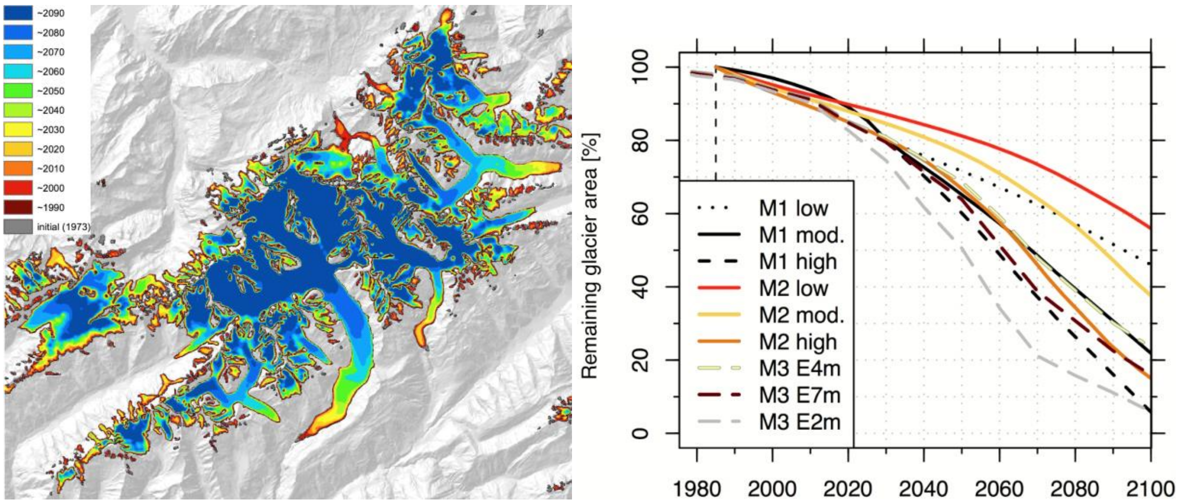
Glaciers

The retreat and massive loss of volume of glaciers in the Alps is the best visible indicator of the recent increase in atmospheric temperature. The changes of the glaciers in the Swiss Alps are measured every year and compiled by the network GLAMOS (*http://glaciology.ethz.ch/messnetz/index.html*, see section 8.3.4). In recent years evidence of vigorous impacts on glaciers has been accumulated, including collapse structures on the glacier surface, disintegration into pieces, separation of glacier tongues from the main ice body at steep slopes, leaving dead ice in formerly covered areas. At various locations all over the Swiss Alps glacier lakes have formed or grown as a result of continuing glacier retreat. From the ca. 2'900 square kilometres of glacier area in the mid-1970s, only about 2'100 square kilometres remained in

2003 (*Paul et al.*, 2011) and an estimated 1’900 square kilometres in 2013. The first glacier-wide mass-balance records worldwide with a coverage of 100 years (*Huss et al.*, 2015) showed that mass balances were predominantly negative between 1920 and 1965, with accelerated mass loss in the 1940s. After a phase with moderate mass gains lasting until the late 1980s, persistently negative balances have been observed until the present.

Several studies indicate that Alpine glaciers are far out of balance with the current climate. Due to delayed response effects, glaciers would continue to shrink even without any further increase in temperature. If temperatures are going to increase further as projected by climate models (e.g. *CH2011*, 2011), the loss of glaciers will be much more dramatic. Modelling studies (Fig. 77) indicate a strong future area loss of 50–90 per cent (for a temperature increase between two and six degrees Celsius) by 2100 for Switzerland (*Linsbauer et al.*, 2013) and the entire Alps (*Huss*, 2011). A recent study (*Huss and Fischer*, 2016) further indicates that 52 per cent of all very small glaciers in Switzerland, which account for more than 80 per cent of the total number of glaciers in mid- to low-latitude mountain ranges, will completely disappear within the next 25 years. Evidence of impacts of vanishing glaciers on the high-mountain landscape and processes has increased and will further increase in the future, including effects on the water cycle, sediment processes, slope stability, thus affecting tourism, energy, and natural hazards sectors (*Haeberli et al.*, 2013).

Fig. 77 > Left: Future changes in glacier extent – modelled glacier area for the Aletsch region based on a temperature increase of four degrees Celsius by 2100 and no change in precipitation. Right: Area loss of Swiss glaciers – modelled development of the glacier area in Switzerland using three different approaches (M1, M2, M3) and climate change scenarios (low/E4m, moderate/E7m, high/E2m) (for explanation see *Linsbauer et al.*, 2013).



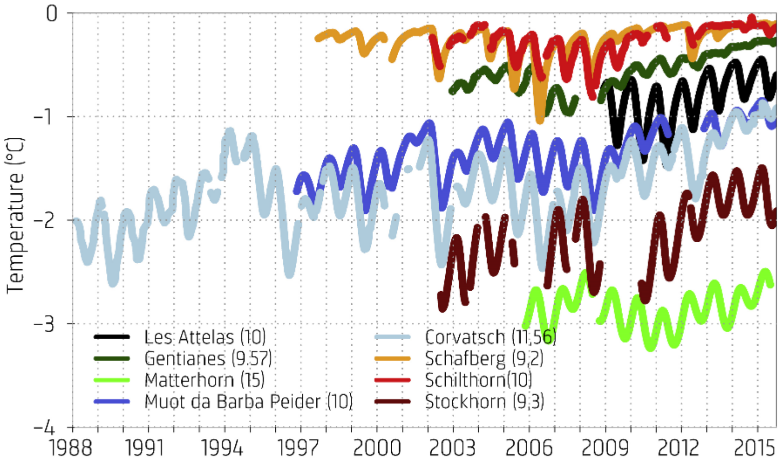
Adapted from *Linsbauer et al.* (2013)

Permafrost

The warming of permafrost in high mountain regions such as the Swiss Alps is a slow process with long-term implications. While first measurements of permafrost in rock glaciers have started in Switzerland in the late 1980s, systematic monitoring is performed since 2000 by the Swiss Permafrost Monitoring Network (PERMOS) and now also includes other landforms like debris or steep rock slopes (see also section 8.3.4). The evaluation of significant trends is difficult because time series mainly cover the past 10 very warm years and temperature anomalies associated with extreme warm years (such as 2003, 2009, and 2011) are superimposed over the longer-term trend. Further, several factors (surface and sub-surface properties, snow cover) may alter the magnitude and delay of the changes in ground temperatures compared to atmospheric changes resulting in high regional and local variability. However, in relation to operational observation (Fig. 78), current conditions are above average warm with active layers at record depths for most of the sites in recent years (*PERMOS*, 2016). In addition, temperature trends at greater depth show clear warming trends for a number of sites (*PERMOS*, 2016). Furthermore, the increasing rock glacier creep velocities as well as decreasing ice contents that are measured along with increasing ground temperatures are noteworthy at many sites. Analyses of documented rock fall events (*PERMOS*, 2016) with starting zones in high elevations indicate that the frequency of events with volumes of one million cubic kilometres or more has increased in the past about 20 years, as compared to the 20th century (*Huggel et al.*, 2012; section 6.2.3).

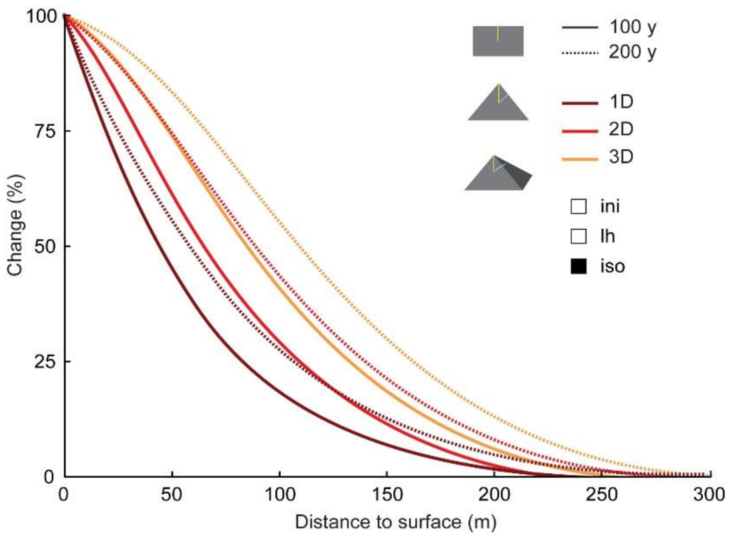
A further temperature increase according to the CH2011 scenarios (*CH2011*, 2011) will cause warming or complete thawing of cleft ice in rock faces as well as further warming and increasing active layer depths of ice rich debris slopes and rock glaciers (*Haeberli et al.*, 2010). The warming of the outer about 50 metres of frozen rock faces is already an effect of the temperature rise in the 20th century. It will penetrate into greater depths and increase the thermal imbalance. For summits and ridges such effects will be particularly pronounced as the warming may penetrate from different sides (Fig. 79, *Noetzli and Gruber*, 2009).

Fig. 78 > Borehole temperature. Synthesis results of more than 20 years of borehole temperature monitoring at the reference sites of the PERMOS network. Here, the temperatures at about 10 metres depth are shown (the exact depth is given in parenthesis). The results are very heterogeneous, essentially because effects due to latent heat or surface cover (snow, coarse blocks) strongly influence the penetration of changes in climate conditions into the ground.



PERMOS (2016) updated with data for 2015

Fig. 79 > Percentage of a temperature signal at the surface that has penetrated to depth: This effect is shown for a one- (flat terrain), two- (ridge), and three-dimensional (pyramid) situation after 100 (solid lines) and 200 years (dotted lines). In the two- and three-dimensional situations, values are plotted versus the shortest distance to the surface. Checkboxes indicate that calculations are not initialised (ini), latent heat is not considered (lh), but isotropic subsurface conditions prevail (iso).



Noetzli and Gruber (2009)

6.2.3 Natural hazards

Floods

Floods in Switzerland are dominantly caused by extreme precipitation, sometimes in connection with snowmelt and/or high lake water levels. During the last 500 years, periods with many and few floods alternated in Switzerland. Since the 1970s, Switzerland is in a period of high flood frequency. However, no direct relationship was found between flood frequency and mean air temperature (*Schmocker-Fackel and Naef*, 2010). The comparison of flooding patterns in different European countries suggests that changes in large scale atmospheric circulation are responsible for the flood frequency fluctuations. Unfortunately it is not yet possible to make any clear statements about future changes in atmospheric circulation and therefore of changes in extreme and very rare precipitation events in the Alpine area (*CH2011*, 2011).

For major floods in the alpine catchments and the large Swiss rivers to occur, a high zero degree level during the event is necessary. Otherwise the precipitation falls as snow over large parts of the catchment and does not contribute to runoff. Therefore, floods occur mainly in summer and fall in the majority of Swiss catchments. The projected temperature increase will lead to a rise of the zero degree level, which in turn extends the flood seasonality and tends to increase the volume and extension of floods in the Alpine area (*Köplin et al.*, 2013).

Not all catchments are equally sensitive to changes in extreme precipitation, depending on the storage capacity of the soils and the geology. *Naef* (2011) distinguishes three types of catchments:

- Catchments with a small storage capacity which is often exceeded during flood events. An increase of extreme precipitation will lead to a linear increase in flood discharge;
- Catchments with medium storage capacity in which no filling of the storages could be observed until now but where even a slight increase in rainfall amount or intensity during a flood event might lead to the filling of the storages and a non-linear and unproportional heavy flood runoff reaction;
- Catchments with a very large storage capacity. In these catchments a more extreme precipitation event can still be stored partly and will only lead to a slightly increase in flood runoff.

Rock falls, debris flow and landslides

Changes in temperature and precipitation are likely to have a range of secondary effects on the occurrence of natural hazards, in particular in mountain environments. However, while theoretical understanding exists for increased mass-movement activity as a consequence of projected climate change, impacts can only hardly be detected in observational records for the time being (*Stoffel and Huggel*, 2012).

Processes related to warming of permafrost (*Hasler*, 2011) may increase the frequency and magnitude of rock fall. Combined with the increasing availability of sediment due to rock fall, deepening of active layers, glacier retreat and the possibility of mass movements into high mountain lakes, new and complex hazard situations may emerge in regions where they have not been reported from before. A prominent example is Guttannen (Grimsel region), where cascading effects and mass movement processes (e.g. debris flows) were observed since 2009 and have implied prevention costs in the order of tens of millions of Swiss Francs (*Swiss Academies of Arts and Sciences*, 2016).

One of the most obvious consequences of climate change at higher elevations is the glacier downwasting and related formation of ice-marginal lakes, ice avalanches and gravitational processes originating from the debuttressing of previously glaciated walls and hillslopes (*Linsbauer et al.*, 2015; *NELAK*, 2013; *Schaub*, 2015). Glacier downwasting is likely to promote many rock slope failures in the near future, probably within the next several decades. Important effects of climate change on slope stability are also related to the warming and thawing of permafrost (section 6.2.2). Slopes currently underlain by degrading permafrost will probably become less stable at progressively higher altitudes with ongoing climate change. The probability of rock instability and the incidence of large (more than 1 million cubic metres) rock falls will likely increase in a warming climate (*Huggel*, 2009). Quite a large number of slope failures have been documented in permafrost areas and have been related to increasing temperatures, the most recent example at Piz Cengalo (Val Bregaglia) in late August 2017, leading to debris flows of several million cubic meters which severely affected the village of Bondo.

Changes in sediment supply and land-use are further key determinants for mass-movement frequency and magnitude. Recent observations in the Swiss Alps indicate that sediment supply can in fact change significantly as a result of permafrost degradation of rock and scree slopes or mass movements related to other processes (*Huggel et al.*, 2012). As such, warming has been reported to exert indirect control on debris-flow magnitude and frequency through the delivery of larger quantities of sediment into the debris-flow channels under current conditions than in the past (*Lugon and Stoffel*, 2010). The volume of debris flows in many parts of the Swiss Alps has risen by one order of magnitude since the early 20th century (*Stoffel*, 2010) and is likely to further increase with ongoing permafrost degradation. The actual triggering conditions of debris flows have been shown to occur less frequently today as compared to most of the 20th century (*Schneuwly-Bollschweiler and Stoffel*, 2012) and are not expected to increase in the future (*Stoffel et al.*, 2014).

Despite uncertainties, recent developments at high-elevation sites clearly show that the sensitivity of mountain and hillslope systems to climate change is acute and that events beyond historical experience are likely to occur as climate change continues.

At lower elevations, the temporal frequency of landslides might be affected by climate change, and the events could occur more frequently in winter and spring as a result of warmer temperatures and larger precipitation sums (*Lopez Saez et al.*, 2013). The occurrence of debris flows and shallow landslides at lower elevations (Prealps, Plateau, and Jura) depends on the incidence of intense thunderstorms or long-lasting, persistent rainfalls. Such conditions are likely to become more frequent, in particular in winter and spring. As a consequence, a shift might be expected in the seasonality of debris flows and shallow slides, and the occurrence of such events might increase in the decades to come.

6.2.4 Water management

Knowledge regarding the future impacts of climate change on the water balance and on water management in Switzerland is generally limited to a qualitative understanding. The reason for this is that only relatively uncertain scenarios for climate change (precipitation, extreme events) are available and that the spatio-temporal resolutions of these scenarios cannot adequately cope with the heterogeneous nature of the Alps. With the study 'Climate Change and Hydrology in Switzerland' (*FOEN*, 2012a) quantitative hydrological projections up to 2100 have been developed which highlight, inter alia, seasonal flow redistribution as well changes in frequency of low flow events. A detailed impact analysis of the changing flow regimes on sectors other than hydropower production was subject to a national research programme (NRP 61 'Sustainable Water Management', *http://www.nfp61.ch*).

Changing runoff and groundwater tables will have consequences on water management. The existing flood protection measures need to be reviewed. Water temperature has already significantly increased, in parallel to air temperature. This restricts the cooling capacity of rivers in dry and hot periods with regard to the discharge of heated water. The Swiss Water Protection Act limits such discharges at a water temperature of 25 degrees Celsius. Thus, the legal provisions in various areas (handling of cooling water or wastewater, lake control regulations, residual flows) must be reviewed. The potential need for additional (multipurpose) reservoirs must be clarified. More frequent and serious low water events and higher winter flows could increasingly affect navigation on the river Rhine.

6.2.5 Biodiversity

The observed impacts of climate change on biodiversity and some perspectives for the future at the national level were reviewed in 2013 (*Vittoz et al.*, 2013). For all taxonomic groups considered, the following impacts are already evident: Species distribution shifts towards higher elevations, spread of thermophile species, colonisation by new species from warmer areas, and phenological shifts.

In the driest areas, increasing droughts are affecting tree survival and fish species are suffering from warm temperatures in lowland regions. River ecosystems will be doubly affected by climate change, i.e. by both the higher air temperature and the seasonal redistribution of river flows. Higher air temperatures together with the associated higher water temperatures and lower water levels in summer are likely to put pressure on river ecology and thereby also on fishing.

Plants

Climate warming is already affecting the phenology of plants. In the region of Basel, the wild cherry (*Prunus avium* L.) now blooms 15–20 days earlier than in 1950 (*FOEN and MeteoSwiss*, 2013), and the growing season has lengthened an average of 2.7 days per decade between 1951 and 2002 (*Defila and Clot*, 2005). Longer growing seasons enable plants to grow at higher elevations. Many botanists have been resurveying plant species on mountain summits above 2'800 metres (e.g. *Frei et al.*, 2010; *Stöckli et al.*, 2011; *Vittoz et al.*, 2009) and observed increases in plant species richness on most of the summits, with only a few summits showing a stable or decreasing species richness. As the direct anthropogenic influence on ecosystems increases towards lower elevations, it is increasingly difficult to disentangle the impacts due to direct human activities from those induced by climate change. However, *Moradi et al.* (2012) observed an increase of thermophile, rich-soil-indicator and shade-indicator species in Swiss montane fens. These changes were interpreted as a higher productivity in warmer conditions, on drier soils and/or under airborne nitrogen deposition. Similarly, the 12 per cent increase of xerophile species in the last 10 years observed by a national monitoring programme in lowlands is possibly the consequence of drier conditions because of the warmer temperatures (*Bühler*, 2012).

Birds

The Swiss Bird Index SBI® Climate Change is an indicator developed by the Swiss Ornithological Institute to document the population trends since 1990 of 20 breeding birds for which an extension of range is expected by the end of the 21st century (e.g. thermophile species) and of 20 species for which a shrinking distribution range is expected (e.g. alpine species). The combined index for species with an expected range extension showed a strong increase (*Zbinden et al.*, 2012). For example, the European bee-eater (*Merops apiaster*) has become a regular breeder in Switzerland and its population is increasing. A recent study identified a significant upward shift between 1999–2002 and 2004–2007 in the distribution for 33 out of 95 species, with an average shift of 94 metres for the leading edge (*Maggini et al.*, 2011). Conversely, the species for which a decrease of the range is expected under future climatic conditions did so far not show a declining trend on average (*Zbinden et al.*, 2012). For some species of this group, however, significant population trends since 1990 have already become apparent (*Revermann et al.*, 2012).

Insects

As poikilothermic[38] animals, insects depend strongly on warmth for their development and reproduction. Hence, warmer temperatures accelerate their growth. In the Swiss lowlands, *Altermatt* (2012) observed that 24 out of 28 butterfly species advanced their seasonal appearance over a 13-years monitoring period. This earlier onset allowed a longer reproduction period and 72 per cent of the multivoltine[39] butterfly species increased the frequency of supplementary generations (*Altermatt*, 2010). Changes in the elevational distribution were also observed in the comparison of old (1920–1941) and recent inventories in the Swiss National Park (*Pasche et al.*, 2007). These distribution shifts are in agreement with projections of species distribution models. In Switzerland, an increase in mean temperature of two degrees Celsius by 2050 might lead, e.g., to a decrease of 3 to 15 butterfly species per square kilometre in lowlands because of the upward shift and to a slight increase above 1200 metres above sea level (*BDM*, 2009). But, on subalpine/alpine ridges, this increase will correspond to an almost complete species turnover (*Pearman et al.*, 2011). Many thermophile aquatic species took advantage of the warmer temperatures to expand their distribution. Some species that were only sporadically observed at the beginning of the 20th century are now colonising Switzerland (e.g. the dragonflies *Aeshna affinis* and *Sympetrum meridionale*). According to models, this could lead to increased species richness in ponds but also to the rarefaction or even extinction of species limited to cold, alpine lakes (*Rosset and Oertli*, 2011).

Projections for biodiversity

On the basis of existing observations and model results, it is possible to make some projections concerning the future climate change impacts on biodiversity in Switzerland. Species will certainly move towards higher elevations, and new species will colonise Switzerland. Some species will probably disappear at the regional scale, partly in high mountains because of the decreasing area of the alpine and nival belts, partly in the lowlands because of the increasing summer droughts and existing obstacles to dispersal (landscape fragmentation). Moreover, disruptions in species interactions caused by individual migration rates or phenological shifts are likely to have consequences for biodiversity (*Walther*, 2010). Conversely, the inertia of the ecosystems (species longevity, restricted dispersal) and the local persistence of populations will probably result in lower extinction rates than expected with some models. The adaptation capacity of many species with respect to climate change will depend on their ability to colonise new favourable sites. However, dispersal will be limited by the strong fragmentation of the Swiss landscape (*Meier et al.*, 2012) and this fragmentation forces many species to persist only in small, isolated populations, with low genetic diversity, which will limit their ability to adapt to new climatic conditions (*Lavergne et al.*, 2010).

6.2.6 Agriculture

In general, climate change in Switzerland is expected to entail a shift of suitable areas for agricultural production, and to involve both positive (e.g. a longer vegetation period) and negative (e.g. increasing incidence of pest infestations owing to milder winters) aspects. Changes in the nature of extreme weather events, in particular more frequent, intense and longer-lasting summer heat waves, could also challenge agriculture, e.g. by reducing the reliability of harvests. The extent to which climate change will affect agriculture will depend, however, on the regional settings, the overall politi-

[38] Organism having a body temperature that varies with the temperature of its surroundings.

[39] A species that has two or more broods of offspring per year.

cal framework and the specific economic situation of the farms. Economic considerations are expected to play a crucial role for the adoption of adaptation measures.

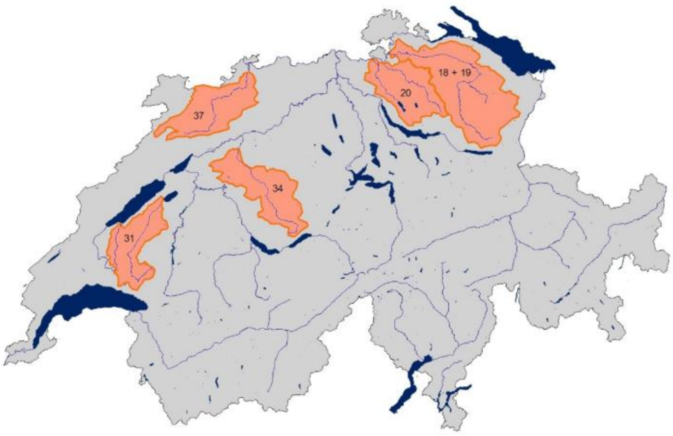
Water demand and supply for agriculture in a changing climate

Drought is a major threat to agricultural production. Even in Switzerland, where drought is not a recurrent phenomenon under current climatic conditions, water scarcity can induce considerable damages. This was the case in 2003, when the unprecedented heat wave led to losses of about 500 million Swiss francs in the agriculture sector.

Annual water requirements for agriculture irrigation in Switzerland are of about 130 million cubic metres on average, but an ex-post estimate of potential water need for 2003 resulted in 572 million cubic metres (*Fuhrer*, 2012). Because water abstraction has to comply with legislation regarding minimum discharge levels in rivers, irrigation is not always possible.

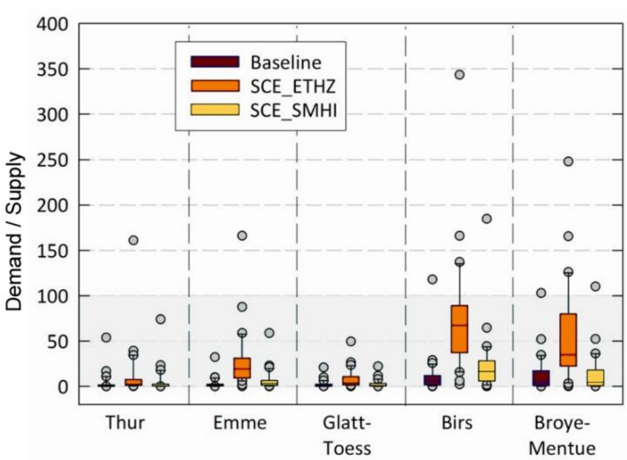
Climate scenarios for Switzerland propose decreasing precipitation amounts during the summer season (*CH2011*, 2011). Accordingly, results of hydrological simulations carried out for selected river catchments (Fig. 80) using two climate change scenarios representing the range of projections given in *CH2011* (2011) indicate that already by 2060 average water requirement for agriculture in parts of Switzerland could amount to as much as 50 per cent of the river water supply (Fig. 81). In extreme years water demand could easily exceed supply, suggesting that conflicts concerning the utilisation of water resources are likely to arise more frequently in the future if no preventive measures are taken.

Fig. 80 > Geographic location of the six river catchments considered for the analysis of future water requirements. From south-west to north-east: Broye-Mentue (31), Birs (37), Emme (34), Glatt-Töss (20), and Thur (18+19).



Fuhrer (2012)

Fig. 81 > Average ratio (per cent) between water demand for irrigation and supply under current (brown boxes) and future (orange and yellow boxes) climatic conditions, for the six catchments highlighted in Fig. 80. For both scenarios, median, 25/75 per cent quantiles (box), 10/90 per cent quantiles (whiskers) und extreme values are given. Two climate change scenarios (SCE_SMHI and SCE_ ETHZ) for 2060 representing the lower and upper end of the range of projections given in *CH2011* (2011) were considered for the analysis.



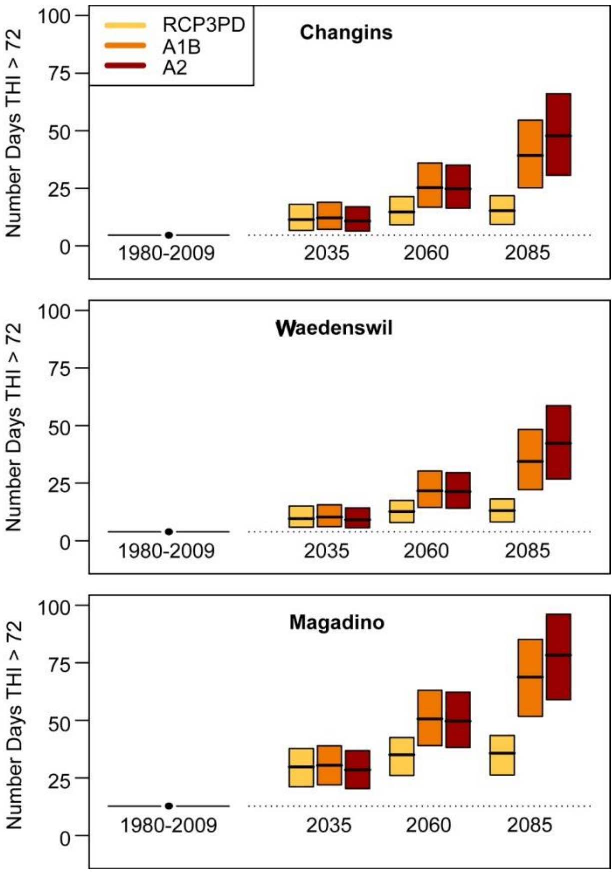
Fuhrer (2012)

Implications of increasing summer temperatures for animal performance

Heat stress caused by elevated daytime temperatures and high humidity levels has the potential to considerably affect animal performance and health (*Johnson*, 1994). For Swiss agriculture the risk of reduced animal performance is of concern especially in relation to milk production. A retrospective analysis of the so-called temperature-humidity index (*Thom*, 1958) has revealed that under current climatic conditions an important risk of heat stress for dairy cows (temperature-humidity index larger than 72) exists in the long term only for Southern Switzerland (Fig. 82, see also *Fuhrer and Calanca*, 2012).

This situation could change in the future, though, because according to the newest climate change scenarios for Switzerland (*CH2011*, 2011) summer temperatures could increase in average by up to four degrees Celsius until 2060 and up to six degrees Celsius until 2085, depending on the emission scenario used. As seen in Fig. 82, the consequences are a marked increase in the average number of days with a temperature-humidity index larger than 72. The increase is more distinct for the second half of the century under the A1B and A2 emission scenarios. As a result, critical conditions under the A1B and A2 emission scenarios are expected to persist on average for two (Northern Switzerland: Changins, Wädenswil) to three months (Southern Switzerland: Magadino) by the end of the century. This calls for the adoption of protective measures, both in relation to indoor and outdoor environments.

Fig. 82 > Change in the temperature-humidity index (THI). Projected changes between reference period 1980–2009 (horizontal bar on the left) and future time slices (box plots on the right) in the long-term average number of days per year with a temperature-humidity index larger than 72 at Changins (top), Wädenswil (middle) and Magadino (bottom) for the three emission scenarios RCP3PD (yellow), A1B (orange) and A2 (brown).



Calanca (2014)

6.2.7 Forest and Forestry

The forest ecosystems and the goods and services they provide may be affected considerably by climate change by means of drought, forest fires, storms or biotic calamities like bark beetle infestations. Compared to the slow processes that take place in forests (forest growth, seed distribution, genetic adaptation etc.), climate change occurs at a rate that overwhelms potential natural adaptation processes of forests like tree migration or genetic adaptation. Important forest products and services such as timber production and the protective function from natural hazards could be reduced. This also has an impact on the Swiss forestry and the timber industry, both sectors together currently employing nearly 80 thousand people.

Tree growth and vegetation shifts

Climate change acts in different ways on the tree species and the composition of forests. It weakens the vigour of drought sensitive tree species and favours the competitiveness of more drought resistant species. Because the tree line is mainly determined by summer temperatures (*Körner and Paulsen*, 2004), warmer conditions induce an upward shift. However, the upward shift of the tree line observed since 1900 is not only driven by climate changes but also by the abandonment of pastures in high altitudes (*Gehrig-Fasel et al.*, 2007; *Vittoz et al.*, 2008). Due to changes in minimum air temperature in spring (less extreme cold events), European ash (*Fraxinus excelsior*), silver fir (*Abies alba* Mill.), wild cherry (*Prunus avium* L.), sycamore (*Acer pseudoplat-anus* L.), sessile oak (*Quercus petraea*), and European beech (*Fagus sylvatica* L.) are successfully regenerating at and beyond the upper elevational limits of adult individuals (*Vitasse et al.*, 2012).

In the inner-Alpine dry valleys climate variability is now the main driving factor for vegetational changes (*Rigling and Dobbertin*, 2011; *Rigling et al.*, 2013). Whereas the scots pine (*Pinus sylvestris* L.) now shows high mortality rates, related to enhanced drought events, the sub-Mediterranean pubescent oak (*Quercus pubescens* Willd.) has locally increased in abundance. Moreover, the natural regeneration of Scots pine is now more restricted to the wetter areas of the Rhone valley, whereas in the driest eastern parts it is more or less absent. On the contrary, saplings of pubescent oak were found in the entire region (*Rigling et al.*, 2013). The growth of pines in drought events is not only reduced, but also the quality of the wood built under water stress is lower, as the hydraulic proper-ties are more vulnerable to drought (*Eilmann et al.*, 2011).

In the Swiss lowlands, the Norway spruce (*Picea abies* L.) covers wide areas outside its natural limits. The natural conditions for Norway spruce are a colder and wetter climate. Today, the Norway spruce stands on climatically unfavourable sites in the lowlands and suffers from drought conditions, leading to lesser foliation. In dry years like 2003 the growth in the lowlands was reduced, whereas it was enhanced at higher and hence colder elevations (*Dobbertin*, 2005).

In some cases climate change enhances the ability of neophytes to invade into forests and to act as ‘invasive aliens’. The tree-of-heaven (*Ailanthus altissima*) becomes more and more invasive in the south-Alpine region of Switzerland (Ticino and Grisons). They are especially successful on shallow and dry sites, where other tree species are less competitive (*Arnaboldi et al.*, 2002). Additionally, the leaves of the tree-of-heaven are toxic and game avoid to feed on them. This is an additional advantage for the tree-of-heaven, leading to an invasive spreading into the forests.

One important factor enhancing the severity of drought periods is the eutrophication by nitrogen deposition. In a long-term field experiment, the water use efficiency, i.e. the relation of assimilated carbon to water, was reduced with increasing nitrogen doses, leading to drought symptoms (*Braun et al.*, 2012). The mean annual nitrogen deposition in forests in Switzerland is about 25 kilograms (*Augustin and Achermann*, 2012), with much higher rates in agricultural regions in the lowlands.

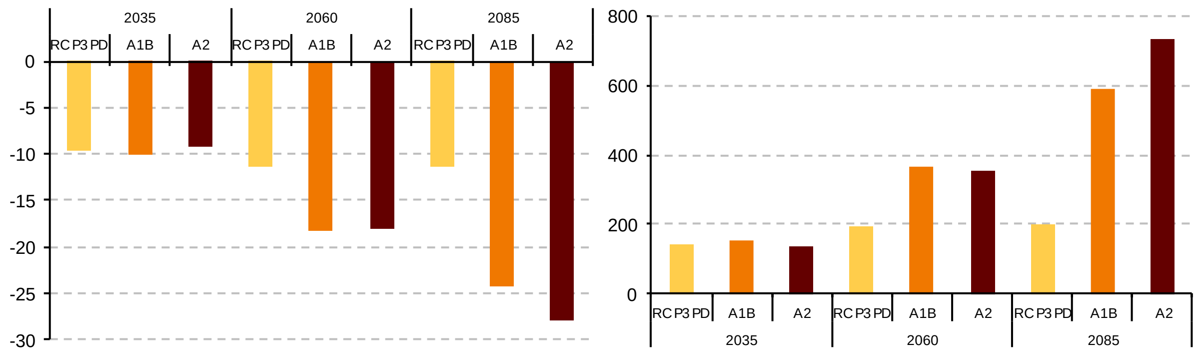
The reported findings are consistent with current knowledge on the ecophysiology of trees and, as far as presently known, with the reactions of forest stands under warmer conditions. However, the future forest composition is difficult to predict, since the influence of climate change on the forests is modified by a lot of other factors, like the site conditions, the regional peculiarities of the development, the influence of pests, diseases, insects, and especially at higher elevations, changes in agricultural practices (*Bugmann and Brang*, 2014). All these factors are affected by climate change, but the influences of each of them and their interactions at a given site is not easy to predict. If the development proceeds as predicted by climate models in many regions, a substantial shift in the tree species composition will occur, favouring more drought tolerant trees like oak species, whereas trees adapted to colder and wetter climate like the Norway spruces will be restricted to sites at higher elevations.

6.2.8 Energy

Impact of climate change on heating and cooling demand

Heating degree days provide an indication of the heating requirement for buildings. For a particular year, heating degree days are defined as the sum of the daily differences between the mean outside temperature from a room temperature of 20 degrees Celsius, but only for days with an outside temperature of 12 degrees Celsius or less. Cooling degree days are calculated analogously to heating degree days and provide an indication of the energy demand for air conditioning. Climate change is likely to modify both heating degree and cooling degree days. Fig. 83 shows the expected evolution of heating degree days and cooling degree days computed from the CH2011 scenarios, i.e. climate change scenarios for Switzerland (*CH2011*, 2011) for the years 2035, 2060 and 2085 using three emissions scenarios (RCP3PD, A1B and A2).

Fig. 83 > Changes in per cent of heating degree days (left) and cooling degree days (right) in respect to the reference period (1980–2009).



Faust et al. (2012)

In 2085, the energy demand for heating is expected to decrease between 8.2 and 20.6 per cent depending on the global emissions scenario. The impact on cooling degree days is much more important than the impact on heating degree days, given the fact that the use of air conditioning in buildings currently is very limited in Switzerland compared to warmer regions. Thus, the final impact on electricity consumption is highly dependent on the propagation of air conditioning in Switzerland in future decades.

Impacts on energy consumption and economic welfare

Using an economic model, a study by *Faust et al.* (2012) simulated the impacts of the future changes of heating degree days and cooling degree days for the year 2050. Tab. 37 presents the Swiss-wide results of these simulations for three global emissions scenarios. Decrease in heating demand will lower the energy consumption of oil and natural gas which are mostly used in Switzerland for heating. In contrast, the increase of cooling demand will boost electricity consumption. The aggregated impacts are a decrease of oil use, and an increase of electricity and natural gas use (natural gas is assumed to serve in part the generation of the additional electricity).

Tab. 37 > Impacts of climate change on the Swiss economy in 2050. Energy consumption is shown as percentage change with respect to the baseline scenario.

	RCP3PD	A1B	A2
Energy consumption			
Oil products	–2.4%	–3.3%	–3.1%
Natural gas	0.2%	0.4%	0.4%
Electricity	1.5%	2.2%	2.1%
CO_2 emissions	–1.9%	–2.6%	–2.5%
Welfare impact in million Swiss francs, 2010	720	999	955
Welfare impact as percentage of total household consumption	0.11%	0.16%	0.15%

Faust et al. (2012)

From an economic point of view, the effect of decreasing heating energy consumption strongly outweighs the effect of increasing cooling energy demand. Thus, the net effect is positive, with a welfare gain ranging from 720 million to 999 million Swiss francs in 2050 depending on the underlying emissions scenario. This welfare gain comes mainly from the money which is not spent anymore on imported oil. In addition to the economic improvement, CO_2 emissions are reduced by a percentage ranging from 1.9 to 2.6 per cent. These results are in line with the findings of other studies that expect climate change to lead to decreasing energy demand in colder regions and increasing energy demand in warmer regions of the world (*Isaac and van Vuuren*, 2009).

Influence of climate change on hydroelectric power production in Switzerland

The implications of changes in runoff and runoff regime on hydraulic power production due to climate change were investigated in a comprehensive study by different Swiss research institutions (*SGHL and CHy*, 2011; *Hänggi et al.*, 2011). Results from the CH2011 emissions scenario A1B have been used for modelling of runoff changes in small and mesoscale catchments in different climatic regions of Switzerland. These results were combined with management models for different types of hydroelectric power plants in order to estimate changes of the production of electricity and of the turnover of the selected typical plants. Due to the fact that annual runoff regimes will be more balanced in the future, in many power plants – namely in run-of-river power plants – winter runoff and hence electricity production will increase. In summer, even with slightly lower runoff, production will not or only slowly decrease since water flow will exceed turbine capacity in most cases. However, in highly glaciated regions, where runoff will decrease considerably in the summer season by the end of the 21st century, electricity production will decrease as well.

In case studies, four different types of power plant schemes have been investigated (Tab. 38). Prättigau is a series of power plants without reservoirs and only little glaciation (3 per cent). The other three schemes have large storage reservoirs. Löntsch has few glaciers (3 per cent) whereas Mattmark (39 per cent) and Oberhasli (29 per cent) are heavily glaciated. Due to the high altitude of Mattmark, runoff from meltwater still contributes much water in 2050 while in Oberhasli meltwater will already be strongly diminishing with declining summer electricity production.

Tab. 38 > Changes in mean production of hydroelectricity. Relative changes of the mean production of hydroelectricity for four different hydropower plant schemes for 2021–2050 compared to the period 1980/1998–2009 following emission scenario A1B.

Power plant	Winter (October to March)	Summer (April to September)	Year (October to September)
Prättigau	+26.5%	+0.4%	+9.3%
Löntsch	+9.3%	–3.3%	+2.2%
Mattmark	+3.2%	–10.1%	–0.6%
Oberhasli	+0.8%	–25.2%	–11.4%

Hänggi et al. (2011)

Based on future production schemes and electricity markets as assumed at the time of the analysis, hydropower production in Switzerland during winter would increase by 10 per cent in 2021–2050 compared to the control period 1980–2009 (Tab. 39). For summer a slight decrease was calculated. The annual production would slightly increase by 0.9 to 1.9 per cent. For individual hydropower sites changes may differ significantly. In southern Valais as well as in Ticino, a general decrease was estimated due to less rainfall and diminished glaciers.

Tab. 39 > Scenarios for the production of hydroelectricity. The optimistic option assumes that in small and mesoscale catchments the decrease in summer runoff does not go below the limit of the existing water intake capacities and therefore summer production remains stable. In the pessimistic option runoff falls below the water intake capacity, leading to decreasing summer production.

Option	Winter (October to March)	Summer (April to September)	Year (October to September)
Optimistic	+10.1%	–4.4%	+1.9% (0.7 terawatt-hours)
Pessimistic	+10.1%	–6.3%	+0.9% (0.3 terawatt-hours)

Hänggi et al. (2011)

A recent study (*FOEN*, 2016a) has examined the impact of the dry summer and autumn of 2015 on hydropower production. After an above-average spring, the run-of-river power plants produced significantly less electricity than usual in the second half of 2015 due to the drought. Thanks to higher natural inflows from glaciated catchment areas and the early use of water stored in reservoirs in the autumn of 2015, overall electricity production from hydropower was still above the average of the previous years. This experience has to be taken into account regarding supply security during winter months, when Switzerland depends on electricity imports.

6.2.9 Health

The projected increase in the frequency and intensity of heat waves (section 6.1.2) in combination with high tropospheric ozone concentrations represents the greatest direct risk of climate change for people's health in Switzerland. The potential impact became manifest for the first time during the heat wave of 2003 when almost thousand cases of death were attributed to the extraordinary heat (*Grize et al.*, 2005). The 2003 heat wave mostly hit the elderly and the very young and was more pronounced in cities where it was exacerbated by the urban heat island effect. Similar effects were registered during the 2015 heat wave (*FOEN*, 2016a).

In Switzerland, the summer of 2015 was the second warmest summer (after 2003) since the beginning of measurements 150 years ago (*MeteoSwiss*, 2016). A study compared observed mortality from June to August 2015 with expected mortality in previous summers and estimated 804 excess deaths (5.4 per cent; 95 per cent confidence interval 3.0 to 7.9 per cent).

Additional direct effects of climate change on health are expected from the increase of other extreme events such as floods, mudslides and, possibly, storms. Given the well-developed immediate disaster control measures in Switzerland, health effects are likely to be manageable. However, extreme events may entail severe psychological consequences for the directly affected population which may last longer and are often underestimated (*Swiss Academies of Arts and Sciences*, 2016).

The increase in temperature and in CO_2 concentration has been paralleled by an increase in total measured pollen in Switzerland and in Europe as a whole, especially of tree pollen (hazel, alder, birch, ash). The starting dates of the pollen season of several allergenic pollen types have shifted to earlier periods of the year. People sensitised to a variety of different pollen may start suffering earlier from hay fever or asthma symptoms and for a prolonged period of the year if pollen production starts earlier in the year and the amount of pollen increases. However, there is no clear evidence that the increase in the occurrence of allergic diseases, which was observed in many westernised countries including Switzerland since the 1960s, is causally linked to pollen concentrations in the air. Research shows that environmental factors such as pollen which trigger symptoms in already diseased people are not necessarily the same as those causing the development of the disease (*Ziello et al.*, 2012; *Clot et. al.*, 2012; *Frei and Gassner*, 2008). Due to climate change, newly imported neophytes (e.g. *Ambrosia artemisiifolia*) may be responsible for new allergenic pollen, intensifying the exposure situation.

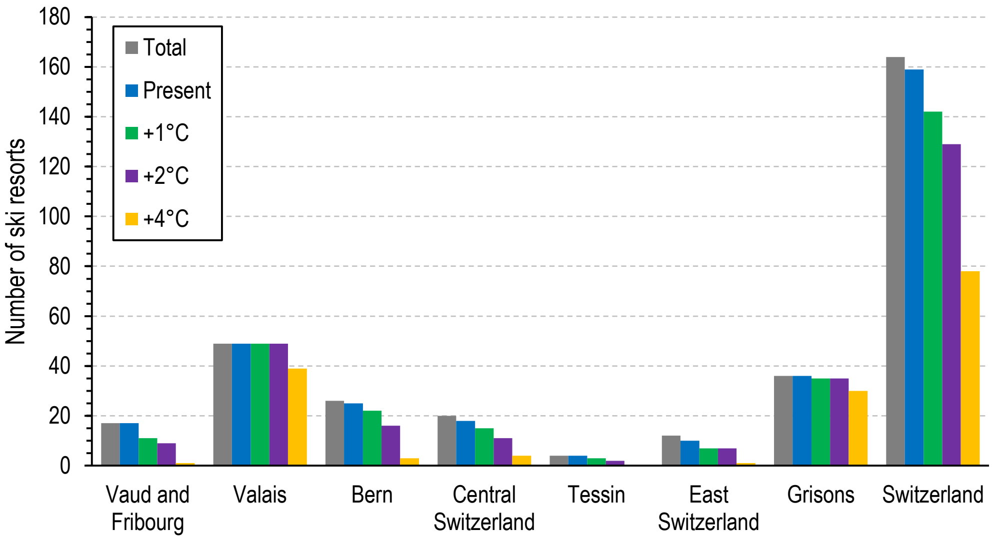
Another important potential health risk of climate change is the occurrence of vector-borne diseases. The diseases result from a transmission of an infectious agent through an animal vector (mosquito, ticks) usually through biting or touching. Increasing temperatures favour growth of vectors and replication rates of infectious agents, e.g. viruses. In Switzerland, the most common vector-borne diseases are tick-borne encephalitis (FSME) and Lyme disease. In recent years, outbreaks of some vector-borne diseases, such as Dengue and Chikungunya fever have been observed in neighbouring countries such as Italy and France, and the respective vector (the mosquito *Aedes aegypti*) is present in Switzerland, too. Yet, it is still highly uncertain what future developments are to be expected as many other factors such as human behaviour, population density, international trade and global tourism affect disease transmission.

6.2.10 Tourism

In Switzerland, tourism is one of the most important sectors directly affected by climate change. This implies that ski resorts in the foothills of the Prealps may not operate profitably in the future (*Lehmann Friedli*, 2011; *Serquet et al.*, 2013; *Klein et al.*, 2016). Due to a lack of wintery atmosphere in the absence of snow, winter sports are expected to lose their appeal to many tourists. With climate change progressing, the altitudinal threshold for snow-reliability will continue to rise.

The Swiss ski resorts currently considered to be snow-reliable have been assessed for an increase of one, two and four degrees Celsius based on the altitude of the station. It appears that the number of ski resorts with economically sufficient snow conditions may drop by at least one fifth for a temperature rise of two degrees Celsius. However, from a national tourism perspective the affected resorts are not so significant (Fig. 84). In case of a four degrees Celsius rise in temperature, low elevation ski resorts will be extremely affected while many high-altitude ski resorts remain snow-reliable. Therefore, the loss expected in Switzerland is below average in comparison with neighbouring Alpine countries (*Serquet et al.*, 2011).

Fig. 84 > Snow-reliability in Swiss ski resorts. Total number of ski resorts (grey) and number of ski resorts that are currently snow reliable (blue) and snow reliable under an increase in temperature of one degree Celsius (green), two degrees Celsius (purple) and four degrees Celsius (orange) compared to today.



Abegg et al. (2007)

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 (*Abegg et al.*, 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 reposition 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 (*NELAK*, 2013; *Lehmann Friedli*, 2013).

Destinations dependent on glaciers as tourist attractions will be affected as glacier retreat continues (see section 6.2.2). Other changes in natural scenery (rivers running dry in late summer, lack of winter atmosphere in the absence of snow) may further reduce the attractiveness of some alpine tourist areas (*Lehmann Friedli*, 2013). However, in some cases, the formation of new mountain lakes by retreat of glaciers may be positive for tourism. This is the case in the Swiss alpine Valley of Gadmen where a lake formed behind a glacial barrier towards the end of the 1990s leading to an increased number of tourists hiking to the nearby hut. Researcher have shown that the suspension bridge, inspired by Nepalese rope bridges and built to avoid the obstacle, became an attraction and largely compensated the irreplaceable loss in term of natural scenery caused by the glacier retreat (*NELAK*, 2013).

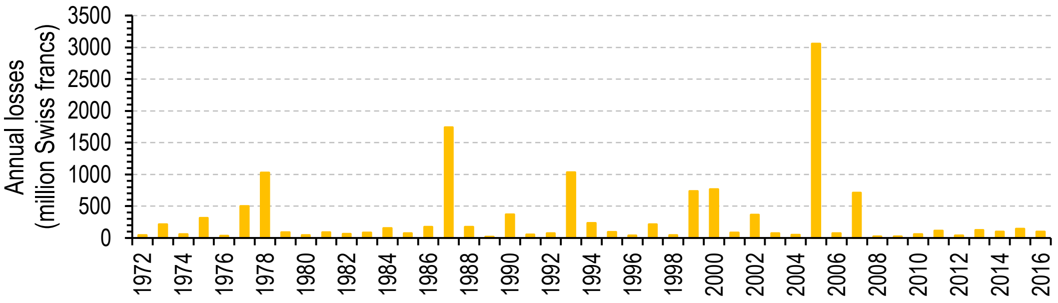
Changes in natural hazards are another element relevant to mountain tourist destinations. Melting permafrost destabilises ground conditions. This may affect infrastructures which are placed at high altitude. Hotel and restaurant buildings, masts of cable cars, avalanche barriers, etc. are vulnerable when anchored in permafrost ground (*Müller*, 2003).

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 (see sections 6.2.2 and 6.2.3). This may present an additional risk to climbers and hikers at high altitudes. Furthermore, the threat to alpine routes from rock fall und rockslides will increase. As potential loss expenses can be much higher than expenses for adaptation measures (e.g. due to glacial lake outburst floods), it is important to invest in strategies that minimise the risk. In addition, possible failures and a negative image due to safety issues could cause additional economic damage (*Lehmann Friedli*, 2013).

6.2.11 Damage due to extreme events

Flooding was the most frequent type of extreme event occurring since 1972 (60 to 95 per cent of all loss events) with the highest estimated damage costs (Fig. 85). Individual extreme events led to high damage in the past, but a trend in damages over time is not detectable from the data. More recent and future extreme events are expected to have a greater damage potential than earlier events due to the overall increase in values and assets located in hazard-prone zones over time.

Fig. 85 > Total annual losses arising from floods, debris flows, landslides and rock falls between 1972 and 2016 (adjusted for inflation, basis 2016).



WSL (2017), updated from *Hilker et al.* (2009)

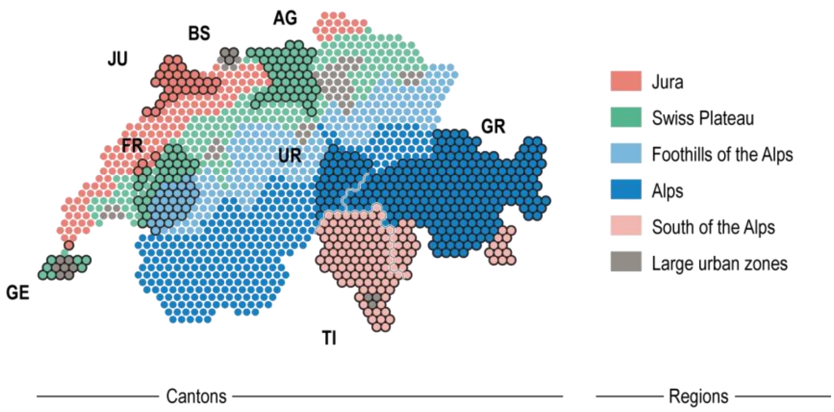
6.3 Assessment of risks and opportunities

As stipulated in the Swiss adaptation strategy (*Swiss Confederation*, 2012a) and its action plan (*Swiss Confederation*, 2014) (see section 6.4), Switzerland shall minimise the risks of climate change and take advantage of opportunities arising as a result of climate change by use of targeted measures. In order to do so, the current climate-related risks and opportunities as well their modification under future conditions, need to be assessed. This has been performed in a comprehensive project lasting from 2010 until 2017. It included:

- Developing a method to systematically assess and compare the risks and opportunities[40];
- Carrying out eight case studies in different regions of Switzerland[41];
- Evaluating and prioritizing the risks and opportunities at the national level in a synthesis report (*FOEN*, 2017a).

Because of its geographical diversity, Switzerland was divided in six main areas: Jura, Swiss Plateau, Foothills of the Alps, Alps, South of the Alps and large urban zones. For each area, one or two representative cantons were selected for a detailed assessment, leading to a total of eight cantonal case studies (Fig. 86).

Fig. 86 > Main geographical regions of Switzerland and areas selected for the assessment of climate-related risks and opportunities.



FOEN (2017a)

[40] See *Holthausen et al.* (2013a).

[41] See *Holthausen et al.* (2013b), *Füssler et al.* (2015a), *Füssler et al.* (2015b), *Füssler et al.* (2015c), *Locher et al.* (2015), *Stöckli et al.* (2015), *Bernasconi et al.* (2016), and *Girard et al.* (2016).

6.3.1 Approach and method

In the Swiss assessment of climate-related risk and opportunities, a risk is defined as the product of the probability of an event and its negative consequence or, when referring to a gradual change, its annual expected negative consequence. An opportunity is defined as the product of the probability of an event and its positive consequence or, when referring to a gradual change, its annual expected positive consequence. These are the risks and opportunities of the climate-related hazards and effects. The risks and the opportunities are determined for two different time horizons (today and 2060). When speaking about the risks and opportunities of climate change, one considers the change between today and 2060 (see also *Holthausen et al*., 2013a).

In the eight case studies, the assessment was based on two climate scenarios and a socio-economic scenario for the 2060 time horizon (2045–2074). To show the possible range of impacts, a ‘weak’ and a ‘strong’ climate scenario were selected. The ‘weak’ scenario corresponds to the expected climate, if worldwide greenhouse gas emissions are reduced by almost 90 per cent by 2100 (mean of RCP3PD). The ‘strong’ scenario corresponds to that of a continuation of current emission trends (extreme values of A1B). The assessment systematically looked at the possible impacts of 17 hazards and effects in nine sectors (health, agriculture, forestry, energy, tourism, infrastructures and buildings, water management, biodiversity as well as open spaces and green areas) and, where found relevant, the potential impacts were analysed in detail. The results are either quantitative or qualitative depending on the availability of data (see also *Holthausen et al*., 2013a).

The synthesis (*FOEN*, 2017a) assembles the results of the case studies to provide a nationwide overview. Unlike the cases studies the results are qualitative and only the ‘strong’ climate scenario was considered. Furthermore, additional criteria were taken into account for evaluation and prioritisation of risks and opportunities. These are: the irreversibility of a consequence, the impairment of critical infrastructure, the impact of expected socio-economic changes, the level of adaptation capacity, and possible synergies or conflicts of interest in relation to the considered risk.

It is important to mention that no new modelling or simulations were carried out for this assessment. The results are based on available research findings, relevant literature as well as expert judgment. In the course of the assessment, more than 360 experts (scientists, representatives of federal and cantonal offices as well as from the private sector) were consulted.

The risk assessment (comparison of today and 2060) was carried out assuming that no adaptation measures are undertaken to minimise the risks. This enables the ex-ante identification of all potential areas where policy options and measures need to be developed and/or embraced. The uncertainties associated with the identified risk and opportunities are significant, as a look 50 years into the future is taken. Plausible expert-reviewed assumptions were used to substitute for missing data or scientific facts.

6.3.2 Assessment results

The main result of this nationwide assessment of climate-related risks and opportunities is a list of all risks and opportunities potentially affecting Switzerland and a shorter list of the key risks and opportunities. Key risks and opportunities are described and analysed in the assessment synthesis report (*FOEN*, 2017a) and presented in Fig. 87. The figure organises the twelve challenges of climate change by risks (left column) and opportunities (right column). Hail and storm activity is placed in the column in the middle, as it is unclear yet whether climate change will soften or intensify future impacts. Key risks (red dots) and key opportunities (green dots) are allocated to the relevant challenges. Certain challenges, such as the rising snow line, changes in habitats, species composition and landscape, as well as climate-related impacts abroad, contain risks and opportunities at the same time. This is illustrated by a connecting line between the left-hand side and the right-hand side columns. The umbrella term ‘Improvement of site conditions’ encompasses various opportunities linked to climate change.

Most of the identified risks are already part of the Swiss adaptation strategy (*Swiss Confederation*, 2012a). However, three additional challenges were identified in the project, which are not dealt with in the strategy. These are risks linked to winter- and hailstorms, the so-called ‘wild card risks’[42] as well as risks and opportunities due to climate-related

[42] ‘Wild card risks’ are risks that could lead to severe consequences but for which the current understanding is too low to allow an assessment of their probability and/or consequences. These could be, e.g., severe impacts in relation with new diseases or cascading effects after extreme climate events.

effects abroad. Furthermore, the project highlighted some opportunities, implying that the strategy must not only consider negative but also positive effects.

The assessment confirmed that Switzerland is already today affected by climate change and will be more so in the future. Although climate change-related opportunities may occur, there are a lot more risks to be expected and to prepare for. Many of the identified key risks could harm human health. The natural environment, especially the aquatic and alpine ecosystems, could be impacted very negatively as well. The economy will be affected both by the effects of climate change in Switzerland and abroad.

Further research is expected to help reducing some of the rather significant uncertainties and to improve understanding of the affected systems, e.g. in the field of biodiversity. Better knowledge of climate and natural system processes – especially process chains, non-linear developments, extreme events and possible thresholds (tipping points) – and developing more detailed climate models are essential. Nonetheless, the assessment shows that the state of knowledge today is sufficient for developing and undertaking adequate adaptation measures.

Since adaptation must take place on a regional and local level, it is the responsibility of the cantons to assess the climate-related risks and opportunities on their territory and to undertake action to minimise these risks. The nationwide synthesis (including a list of all risks and opportunities and a prioritisation thereof) as well as the eight case studies in the different areas of Switzerland provide a sound basis for further action.

6.4 Domestic adaptation polices and strategies

6.4.1 Update on the Swiss adaptation strategy

Climate change impacts provide both, risks and opportunities to Switzerland (see section 6.3). In order to minimise the risks posed and to benefit from the opportunities provided by climate change, adaptation measures need to be planned and implemented in the coming decades.

The Swiss Federal Council developed an adaptation strategy which serves as a framework for the federal offices to adopt a coordinated course of action in responding to the expected changes. It consists of two parts. The first part was adopted on 2 March 2012 (*Swiss Confederation*, 2012a). It describes the goals, challenges and fields of action in adapting to climate change in Switzerland. The second part is an action plan for the period 2014 to 2019 that comprises 63 adaptation measures. It was adopted on 9 April 2014 (*Swiss Confederation*, 2014). The results of the risk assessment (see section 6.3) will be considered in the context of updating the action plan of the Swiss adaptation strategy in 2019.

The legal basis for adaptation action taken by the national government and key elements of the first part of the adaptation strategy are described in section 6.3.1 of Switzerland’s sixth national communication. The second part of the adaptation strategy contains 54 sectoral adaptations measures that address the fields of action identified in the sectoral strategies in the first part of the adaptation strategy. Five measures aim to improve the cross-sectoral knowledge base for adaptation, e.g., by providing updated regional climate scenarios, by improving the hydrological knowledge base and providing updated hydrological scenarios, and by analysing the climate change induced risks and opportunities in Switzerland. Four measures address the coordination of adaptation measures between both, federal offices (horizontal coordination) and the federal and cantonal levels (vertical coordination).

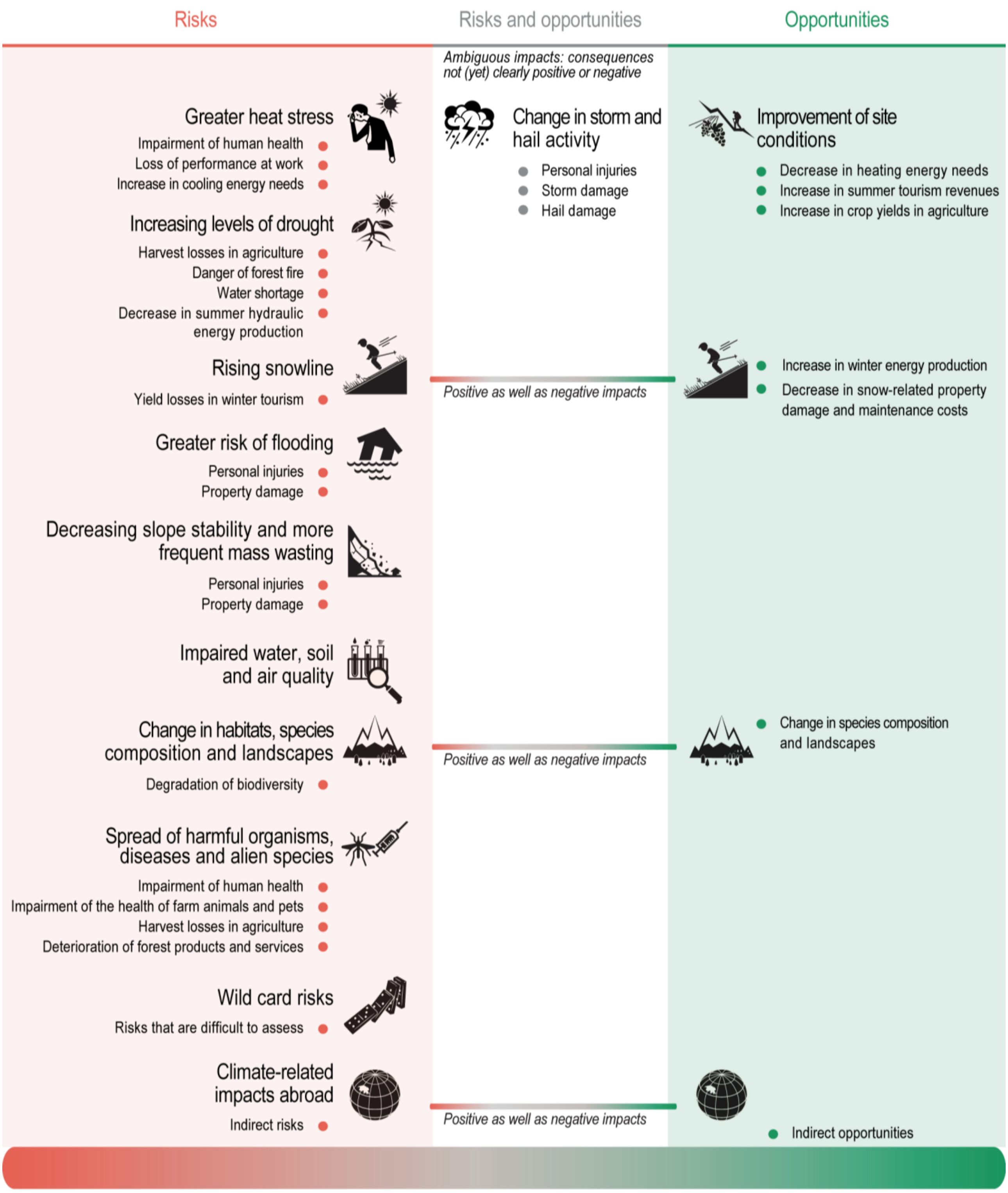
6.4.2 Measures supporting the implementation of the adaptation strategy

The Swiss Federal Office for the Environment promotes and supports the implementation of the Swiss adaptation strategy with – among others – an information platform and a pilot programme to initiate adaptation at the local and regional levels.

Information platform on adaptation to climate change

After the adoption of the Swiss Federal Council’s adaptation strategy in March 2012, an internet-based information platform on adaptation to climate change in Switzerland has been launched. The platform, which is operated by the Swiss Federal Office for the Environment and integrated into its website as a separate subpage (http://www.bafu.admin.ch/klimaanpassung, available in German, French and Italian), shall:

Fig. 87 > Overview of all climate-related challenges and corresponding key risks and opportunities (bullet points) affecting Switzerland.



FOEN (2017a)

- Summarise and provide relevant information on climate change adaptation in Switzerland oriented towards end user needs;
- Sensitise target groups for climate change impacts, vulnerability and adaptation requirements;
- Inform decision making and capacitate stakeholders for sustainable adaptation measures in line with the goals and principles laid down in the Swiss adaptation strategy;

- Enable and foster exchange of information and experiences, networking and cooperation across horizontal and vertical governance levels.

The platform addresses primarily policy makers and administrative bodies from national to local level. Further target groups are associations, networks and experts that are engaged in adaptation activities. With this focus, the platform complements existing Swiss web portals on climate change (see section 9.2) such as *http://www.proclim.ch* (aiming at the scientific community) and *https://naturalsciences.ch/topics/climate* (aiming at the public, teaching staff, students and the media).

Detailed information is provided on the Swiss Federal Council's adaptation strategy, approaches of the cantons, sectoral adaptation activities, and the adaptation pilot programme (see below). The sectors covered are, in line with the national strategy, water management, natural hazards management, agriculture, forestry, energy, tourism, biodiversity management, health and spatial management. Contents are updated and extended periodically.

Pilot programme Adaptation to climate change

As climate change adaptation is still a relatively new issue, activities and experiences on regional and local level are widely lacking. Therefore, the pilot programme 'Adaptation to climate change' was set up under the leadership of the Swiss Federal Office for the Environment together with the civil protection, public health, agriculture, spatial development and the food safety and veterinary offices as a national funding initiative to support cantons, regions and municipalities in tackling climate change-related challenges (*www.bafu.admin.ch/klimaanpassung-pilotprogramm*). The programme's goals are:

- To contribute to putting the Swiss adaptation strategy into practice;
- To raise awareness for climate change adaptation in cantons, regions and municipalities;
- To trigger and implement innovative, cross-sector pilot projects;
- To capitalise climate change-related opportunities, minimise risks, and increase adaptive capacity in the pilot areas;
- To enhance vertical and horizontal cooperation, as well as to initiate and foster exchange between cantons, regions and municipalities.

Following a call for projects in 2013, more than 100 proposals were submitted. 31 projects were selected for funding (50 per cent funding rate, as a general rule). They were assigned to five thematic clusters:

- Management of local water scarcity (eight projects);
- Management of natural hazards (six projects);
- Management of ecosystem and land-use changes (ten projects);
- Resilient urban development (three projects);
- Knowledge transfer and governance (four projects).

The projects, implemented from 2014 to 2016, spread over the whole country and covered both a broad range of activities (analyses and planning, development of strategies, concepts and tools, applied research, information and communication) and a variety of executing organisations (cantons, regions, municipalities, enterprises, associations, insurance, research, etc.). Scientific support was provided by ProClim, the Forum for Climate and Global Change of the Swiss Academies of Sciences. The final phase in 2017 comprised a programme evaluation (*Landis et al.*, 2017b), the synthesis of results (*FOEN*, 2017) as well as dissemination activities. A follow-up programme is in preparation.

National Centre for Climate Services

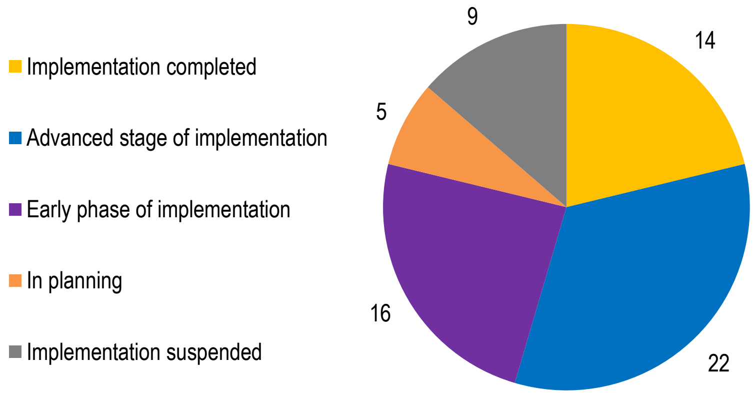
In recognition of the Global Framework for Climate Services – which advocates for the establishment of national coordination mechanisms – Switzerland founded its National Centre for Climate Services in late 2015. The centre is a concerted national effort encompassing seven federal agencies and institutes and further partners from academia committed to implementing the framework at national to subnational level and creating global synergies. It provides information to support policy-makers from national to local level as well as the private sector and society at large with a view to minimising risks, maximising opportunities and optimising costs in the context of climate change and variability. Its aim is to offer crucial services for the development of effective mitigation and adaptation measures and for instigating societal transformation. Hence, the goals of the National Centre for Climate Services are to bundle the existing climate services of the Swiss federation, to co-create new, tailor-made solutions for clients, and to act as a network agent and knowledge broker, thus boosting climate literacy, enabling decision-making processes that take climate considerations into account, and contributing to increased resilience. The services reflect the specificities and requirements of the Alpine region and its particular challenges and vulnerabilities (*www.nccs.ch*).

6.5 Progress and outcomes of adaptation action

6.5.1 State of implementation of adaptation action at the federal level

The action plan of the Swiss adaptation strategy for the period 2014 to 2019 contains 63 adaptation measures. A survey with the federal offices responsible for development and implementation of these measures shows the current state of implementation at the federal level (Fig. 88).

Fig. 88 > State of implementation of adaptation measures at federal level, 2017[43].



FOEN (2017b)

6.5.2 State of implementation of adaptation action at the cantonal level

According to Article 15 of the CO_2 Ordinance, the cantons are required to inform the Swiss Federal Office for the Environment about the measures they undertake to adapt to climate change on a five-year basis. The information shall serve as basis for the further development of the Swiss Federal Council’s adaptation strategy and for the coordination between the federal and cantonal levels. In the first reporting, which took place in 2015, all but three cantons participated (23 of 26; *FOEN*, 2016). Thus, the results provide a nearly complete overview of the state of planning and implementation of adaptation measures at the cantonal level, and of the collaboration with the federal authorities. The results of the reporting are summarised briefly in this section.

Most cantons addressed the topic of adaptation in one or the other way. 14 cantons analysed the impacts of climate change from a multi- and cross-sectoral perspective. In eleven cantons a political decision was taken to focus on adaptation at a cross-sectoral level as a complementary measure to mitigation. Eight cantons developed an adaptation strategy or an adaptation plan, i.e., Basel-Stadt (*Regierungsrat des Kantons Basel-Stadt*, 2011), Geneva (*Canton de Genève*, 2015), Grisons (*ANU*, 2015), Schaffhausen (*Kanton Schaffhausen*, 2011), Solothurn (*Amt für Umwelt Kanton Solothurn*, 2016), Uri (*Kanton Uri*, 2011), Vaud (*Canton de Vaud*, 2016), Zurich (*AWEL and IKB*, 2007). Only five small cantons reported that they did not undertake any adaptation action yet on a cross-sectoral level.

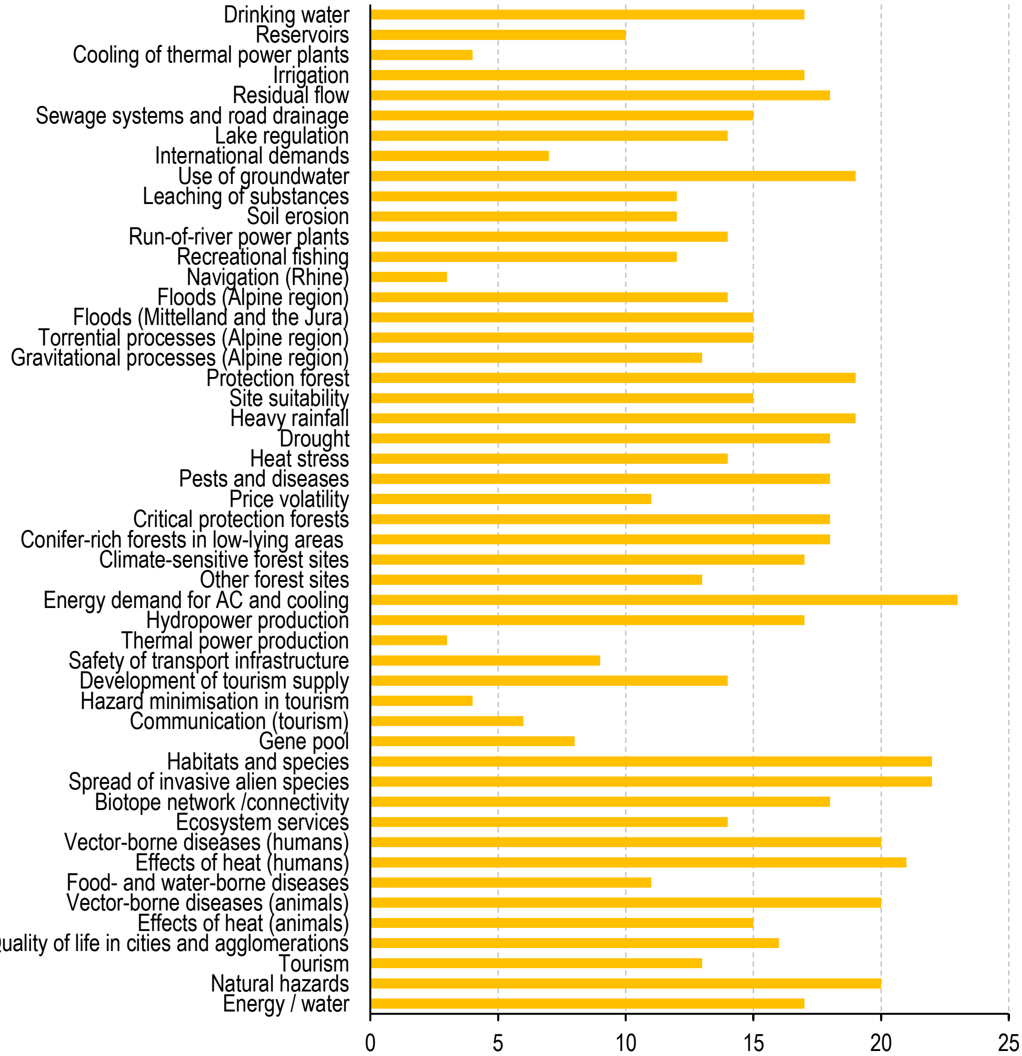
All cantons reported that they started to focus on adaptation within the different sectoral policies. The sectors integrated in the Swiss Federal Council’s adaptation strategy seem to provide a good basis, which is also valid for the cantonal level. However, not all the sectors are of the same importance in all the cantons since their exposure to climate change

[43] Due to the allocation of one measure (assessment of extreme events) to several implementing authorities and the separation of another measure into two sub-measures, the total of answers in Fig. 88 exceeds the total of measures.

varies with their geographical setting. For instance, agriculture is only important for rural cantons and tourism is primarily important for the alpine cantons.

The same is true for the fields of action as defined in the Swiss adaptation strategy. All of these are considered relevant by the cantons, but cantons put different emphasis on them according to their exposure to climate change impacts (Fig. 89). Almost all cantons consider 'Energy demand for air conditioning and cooling' in the energy sector, 'Habitats and species' and 'Spread of invasive alien species' in the biodiversity management sector, and 'Effects of heat' in the health sector as important, whereas more specific fields of action, e.g. 'Navigation (Rhine)' and 'Generation of electricity from thermal power plants', are only important for cantons with the respective infrastructure.

Fig. 89 > Relevant fields of action for adaptation, as identified by 23 cantons.



FOEN (2016)

Many cantons have developed their own adaptation measures which are complementary to the activities of the federal offices. Fifteen cantons claim to coordinate their activities with those of the Swiss government. Most cantons report that they were involved in the implementation of the adaptation measures of the federal offices, as foreseen in the action plan of the Swiss adaptation strategy. However, for some sectors the involvement is restricted to those cantons with a particular exposure, e.g., rural cantons in the case of agriculture or alpine cantons in the case of tourism.

6.5.3 Update on adaptation in the sectors most affected by climate change

Natural hazard management

Natural hazards have always had great significance and far-reaching consequences in Switzerland, because in many parts of the country they pose a major threat to human life, infrastructure and material assets. The increase in the value of infrastructure, settlement expansion in hazard prone areas and the impact of climate change all increase the potential devastating effects of already existing hazards. The main climate change factors influencing natural hazards are an increase in hydro-meteorological extreme events (frequency and intensity of heavy rainfall) and the effects of higher temperatures.

In the Swiss Federal Council's adaptation strategy (*Swiss Confederation*, 2012a), five fields of action for the sector natural hazards management are identified. These fields of action address floods in the Alpine region as well as on the Swiss Plateau and in the Jura, torrential and gravitational processes in the Alpine region, and impact on protective forests in the Alpine region.

The lessons learned and findings from the events of the last decades are the basis for current legislation and the 'Swiss natural hazards strategy' (*PLANAT*, 2004, presently under revision) of the National Platform for Natural Hazards (PLANAT). Climate change adaptation is explicitly considered in the further development and improvement of the strategy, which provides the basis for a shift in priorities in the future. The strategy of integrated risk management is consistently integrated in order to tackle and overcome the additional challenges resulting from climate change. The alpine strategy for adaptation to climate change in the field of natural hazards (*Swiss Confederation and Alpine Convention*, 2012) is consistent with this approach.

The implementation of the integrated risk management presents a major challenge. Besides ongoing measures, new measures that reduce the potential of damage due to climate change are becoming increasingly important. According to the Swiss adaptation strategy, additional efforts are necessary primarily in the following areas:

- Monitoring of natural hazard processes: New processes and their evolution as well as changes in known processes need to be recognised in due time and be closely monitored. Improved weather and discharge forecasts will provide useful data for early warning;
- Comprehensive knowledge of hazards and risks: Systematic nationwide hazard and risk assessments need to be established on a regular basis. In order to do this, a comprehensive knowledge base needs to be developed. Key elements are updated hazard maps, the development of missing hazard fundamentals and the assessment of the damage potential as well hazards and risks on a national and cantonal level;
- Protective structures designed to accommodate excess loads: Protective infrastructures need to be designed to accommodate excess loads. The overload case needs to be considered already in the planning phase. Risk based protection goals need to be defined and considered. Constant maintenance ensures the function of protective infrastructures. In addition, protective forests need to be constantly regenerated and climate-related changes need to be considered and reflected in the selection of tree species;
- Implementation of land-use planning measures: The goals and principles of living with natural hazards have to be defined and implemented on all levels of land use planning. According to the Swiss natural hazards strategy (*PLANAT*, 2004, presently under revision), the creation of new risks needs to be avoided and risk based considerations including climate change scenarios need to be applied in land use planning;
- Successful response to natural disaster (*FOCP*, 2013): Up-to-date emergency planning and emergency concepts need to be developed for all cantons and communities. They need to be regularly exercised and adapted to site specific conditions and climate induced changes. The coordination of all parties involved in the management of an emergency situation needs to be ensured. Timely early warnings allow that adequate measures are initiated in time in case of an emergency;
- Awareness, education and research in the field of natural hazards is improved: House owners, architects, planners, intervention forces and the public need to be trained and educated in the field of natural hazards. The education of local natural hazards advisors ensures that local knowledge is available for the intervention teams in the case of an emergency. Intervention and emergency teams have to be adequately trained in emergency response measures;
- Analyses of the main events and their response: Extreme events and the subsequent response activities need to be well documented and evaluated on all levels. A harmonised data collection will allow the comparison of the events and interventions in order to ensure a continuous improvement and, if needed, adaptation of the processes.

A common platform of federal agencies issuing warnings on natural hazards for the public and cantonal and/or communal authorities exists at the internet address *http://www.natural-hazards.ch*.

Weather hazard alerts

MeteoSwiss is tasked through an established federal legal framework to warn federal agencies, authorities, police forces, civil protection forces and staff organisation of the cantons (second organisational level in Switzerland) in case of dangerous weather conditions. The 'single official voice' principle for natural hazard warnings, realised together with other federal agencies, is part of this framework. MeteoSwiss is currently starting with the exploration and development of impact based warnings, a challenge which will involve all stakeholders of meteorologically triggered natural hazards. These stakeholders include all the institutions touched by the process leading from a meteorological extreme event to a potential threat to the population and infrastructures.

Biodiversity

In parallel to the national strategy regarding the adaptation to climate change, a national biodiversity strategy (*Swiss Confederation*, 2012c) has been elaborated, with an accompanying action plan recently adopted by the Federal Council (*Swiss Federal Council*, 2017). The measures contained in the action plan of the biodiversity strategy may improve the capacity of biodiversity to adapt to a modest change in climate parameters. With regard to a more pronounced warming scenario, additional measures are presented in the action plan of the national adaptation strategy. These measures include the risk assessment of the most sensitive species with regard to climate change. They target the most affected ecosystems, such as aquatic habitats and alpine areas, but also habitat connectivity, especially on vertical axes. The national adaptation strategy includes measures proposed by other sectors, in order to assess and minimise their potential negative impacts on biodiversity. Furthermore, a national strategy on invasive alien species (*Swiss Confederation*, 2016) has been elaborated.

Forests and forestry

The Swiss Federal Council's adaptation strategy (*Swiss Confederation*, 2012a) as well as the Forest Policy 2020 (*FOEN*, 2013) focus on three forest categories which are considered to be at high risk due to climate change. These fields of action are protective forests with insufficient regeneration and reduced stability (covering approximately 68 thousand hectares), forests with a high percentage of conifers in the Swiss lowlands which are susceptible to drought, wind throw and bark beetle infestations (covering approximately 50 thousand hectares), and climate-sensitive forests in the Central Alps and other parts of Switzerland which are especially drought prone or sites with large amounts of dry wood in areas at risk from forest fires, e.g. Ticino, Valais, Grisons (covering approximately 50 thousand hectares) (*Brändli*, 2010). In the meantime, the need to adapt forests to climate change has been taken up in the revised Forest Act as adopted by the Swiss Parliament in March 2016. Article 28a on 'Precautionary measures against climate change' is the first legal provision in a Swiss sector law that explicitly addresses the issue of adaptation to climate change.

Adaptation measures are currently under development, aiming at the reduction of future risks and increasing the adaptive capacity of forests, e.g. through appropriate and sufficient regeneration of forests. This includes the promotion of tree species with potentially high adaptive capacity with a view to possible future climates.

Agriculture

Adaptation measures in agriculture include the selection of crop varieties and livestock breeds which perform better under future climatic conditions. In the national plant breeding strategy (*FOAG*, 2016), climate change was identified as a key factor. Currently, a strategy for animal breeding is in preparation. Climate suitability maps for important crops and displays with regional distribution of critical levels of heat stress for dairy cows, both under current and future climate, are provided for adaptation planning.

Plant protection gains increasing importance with climate change. An action plan is being elaborated, which aims to reduce the risks in relation to the application of plant protection agents. Status reports and short-term projections of pest infestations for better pest control already exist. In the framework of the National Centre for Climate Services, a project was initiated to provide quantitative information on the proliferation and spread of insect pests that do not presently occur in Switzerland, but may become a concern in the near future. It should serve as a basis for the development and implementation of novel crop protection strategies.

Soils play a vital role in climate change adaptation. In 2014, direct payments for conservative soil cultivation were introduced. Also, the regulation on erosion prevention as part of the proof of ecological performance was strengthened. Besides that, some regional bottom-up projects under the agricultural resource programme deal with soil protection. Largely supported by the government, these initiatives are testing innovative soil management options with potential for upscaling.

The regulation on subsidies for irrigation installations was adapted. In order to qualify for financial aid, respective projects have now to meet the irrigation efficiency criteria. Additional aid is given when water-sparing technologies are used. Information on the regional distribution of water demand for irrigation as well as water supply were compiled, critical regions for water shortage were identified, and case studies on possible adaptation options in agriculture were conducted. This is a valuable base for regional water resource management.

Several measures can be taken on different levels (farm, regional, national) to cope with extreme events like drought. Compilations can be found in a report of the Swiss Federal Council on risk management in agriculture (*Swiss Confederation*, 2016a) and in a practical guidance for cantonal actors on the handling of water shortage (for a summary, see *Zahner et al.*, 2017). Within the pilot programme for climate change adaptation in Switzerland (section 6.4.2), an index-based insurance product ‘Grasland Pauschal KLIMA’[44] for drought in grassland was developed (project summary in *FOEN*, 2017, chapter 5.13). It offers a new risk management option to farmers.

Energy

Energy supply and demand in Switzerland is affected by climate change in multiple ways. The Swiss adaptation strategy (*Swiss Confederation*, 2012a) therefore includes the energy sector as an important area to be taken into consideration. The three main fields of action that have been identified as the most relevant for climate change adaptation in the energy sector are:

- Energy demand for air conditioning and cooling of buildings;
- Generation of electricity from hydropower and thermal (nuclear) plants with an open-cycle cooling system;
- Maintenance and safety of transport infrastructure.

Within these fields of action, several concrete adaptation measures have already been implemented or are being planned on a national level. Among these are:

- Studies and information campaigns about measures for maintaining pleasant ambient temperatures in buildings in a warmer climate while at the same time reducing energy need for cooling;
- Taking the changing climate into account in supervision and licensing processes for hydroelectric dams and reservoirs as well as for transmission and distribution networks for gas and electricity.

In general, the following climate change adaptation goals have been defined for the generation of electricity from hydropower:

- Securing the contribution of hydropower to maintaining the security of electricity supply;
- Making optimal use of hydropower potential under changing hydrological and water management conditions through increased cooperation among the industry players;
- Where necessary, monitoring of new climate-related safety risks (e.g. due to thawing of the permafrost).

Health

Climate change poses similar risks to human and animal health and requires similar measures to minimise these risks. This is why the Swiss adaptation strategy deals with the impacts of climate change on both, humans and animals. The focus is put on three fields of action requiring adaptation to climate change:

[44] http://www.hagel.ch/de/versicherungen/grasland

- Vector-borne diseases (humans and animals): Climate change fosters the emergence of new pathogens as well as their hosts and carriers (vectors) and alters their distribution patterns. This increases the risk of new infectious diseases in humans and animals, which can spread rapidly and could cause epidemics;
- Effects of heat (humans and animals): Heatwaves can lead to cardiovascular conditions, dehydration, overheating, impaired performance, and even to death. Summer heat increases ozone levels, which causes respiratory ailments and impairs lung function;
- Foodborne and waterborne diseases (humans): Infectious germs in water and food, in particular in dairy and meat products, thrive at higher temperatures.

The fields of action listed above are addressed with the following adaptation measures:

- Updating the recommendations to the health care services and the public on adapted behaviour during heat waves on the basis of new scientific results;
- Providing a guideline (toolbox) to cantonal and local health care services on how to deal with long lasting heat waves; coordinated approach with other federal offices; periodic dialogue between experts from the administration and from science;
- Improving and coordinating monitoring systems for vector borne diseases, potential vectors, and infectious animal diseases. Notification of selected infectious diseases based on the federal law on the control of human communicable diseases.

Since 2003, the federal and cantonal authorities have developed measures to inform the population about expected heat waves and about protective measures. Evaluations indicate that the effect of a heat wave on mortality can be significantly reduced when heat action plans are put in place and people are taking the necessary precautions (*Ragettli et al.*, 2017; *Vicedo-Cabrera et al.*, 2016).

No additional measures will be implemented for foodborne and waterborne diseases. The existing measures, i.e. water treatment and food control, are expected to be effective in dealing with a potential increase of the risk for these diseases due to climate change.

Water Management

Due to the fact that, at present, Switzerland abstracts only about five per cent of its annual precipitation for water use purposes, water quantity is not the limiting factor in the water management sector, even if the changes may turn out to be more severe than today's projections suggest. It is the change in the hydrological regimes, the rise in water temperature combined with water quality aspects and the increase of extreme events that need particular attention. Thus, eight primary and six secondary fields of action were identified (*Swiss Confederation*, 2012a). The measures in these fields of action contribute to cope with the most important cross-sectoral challenges provided by climate change. The measures aim at the following:

- Providing adequate space for rivers as well as to restore rivers in order to attenuate flood situations and to improve the ecological status of rivers;
- Developing new concepts for the storage and distribution of water in order to adjust to the changing hydrological regimes and to fulfil the needs of the society, the economy and the ecology;
- Bringing forward regional collaboration of water supply and wastewater treatment in order to avoid shortage and water quality deterioration during low flow conditions;
- Developing new technologies for cooling water use (e.g. for thermal power plants) in order to be prepared for an additional rise in temperature in the river networks;
- Checking and if necessary adapting the legislative basis in the field of water in order to meet the future challenges;
- Enforcing the implementation of transboundary water management in order to avoid interest conflicts in international river basins downstream Switzerland.

In January 2011, the revised Waters Protection Act (*Swiss Confederation*, 2012b) came into effect. It stipulates, inter alia, the spatial requirements for surface waters (space provided for waters) in order to safeguard the natural functions of the waters, flood protection and waters use. While space shall be provided for all water bodies, it is foreseen to rehabilitate about 25 per cent (4'000 kilometres) of the water courses that are currently in a bad ecological state. By 2014 the cantons realised strategic plans for the rehabilitation of streams and rivers: These will be updated every 12 years. Rehabilitation of water bodies has started but will take about 80 years for full implementation. Water bodies in a nearly natural state are more resilient to extreme events such as floods and droughts. Therefore the rehabilitation of water bodies can be seen as an important contribution towards adaptation to climate change in the fields of ecology and flood risk management.

With a strategy for water supply 2025 (*FOEN*, 2014), ten measures have been defined for a future-oriented water supply in Switzerland. The main risks for water supplying systems are driven by socio-economic trends. Nevertheless, climate pressures have been considered, too. Since about 80 per cent of the public water supply is extracted from underground waters, the improvement of groundwater protection is a focus of the strategy. With regard to climate change, obtaining water from two independent sources is a main goal for all water suppliers. This allows to extract water from the back-up resource if one groundwater body dries up, or is polluted or if an impoundment is damaged as a consequence of natural hazards.

In 2012, the Swiss Federal Council has assessed the handling of water shortage in Switzerland (*FOEN*, 2012b), recommending the cantons to further identify regions with an increased risk for droughts and water scarcity. By means of a strategic planning process, sufficient water resources should be ensured for the different requirements. Despite all efforts, a residual risk of water scarcity will always remain. Thus, with regards to extreme events, prevention and emergency planning is essential, especially for water suppliers. The Swiss Federal Office for the Environment supports the cantons and regions in the implementation of all these measures with three reports (*Dübendorfer et al.*, 2015; *Chaix et al.*, 2016; *Wehse et al.*, 2017). Furthermore, a testing platform for early detection and information of droughts has been developed (*www.drought.ch*).

Rising water temperature in the context of climate change is an additional stress factor for aquatic ecosystems and decreases the cooling capacity of water. Therefore, the necessity of adapting the legal basis for thermal water use has been analysed. As a result, minor amendments are foreseen in the next revision of the Water Protection Ordinance.

Further principles for sustainable water management with a view to climate and social change have been developed in the National Research Programme 61 (*www.nfp61.ch*) between 2010 and 2014 as well as in the project Climate Change and Hydrology in Switzerland of the Swiss Federal Office for the Environment (*FOEN*, 2012a). More hydrological principles for adaptation to climate change are being developed in the project Hydro-CH2018 (*FOEN*, 2016b) as a focus area of the National Centre for Climate Services.

Tourism

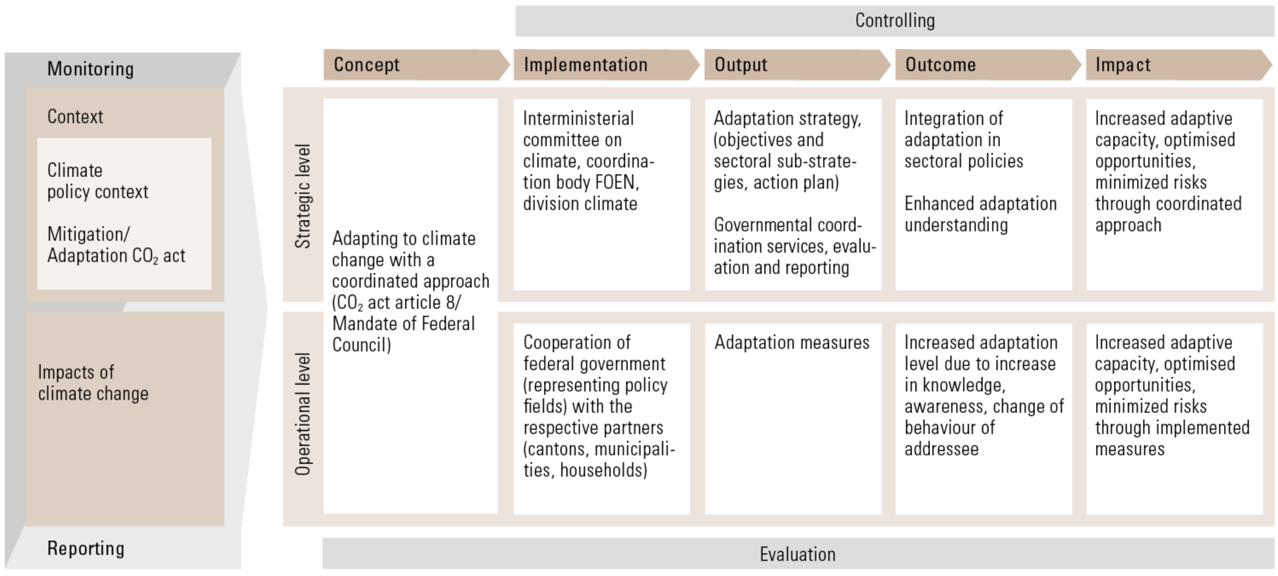
Adapting to climate change is one of the most important challenges for Switzerland as a tourist destination (*Swiss Federal Council*, 2010). Three central fields of action requiring adaptation to climate change have been identified (*Swiss Confederation*, 2012a) based on the most important impacts of climate change on Swiss tourism (*Lehmann Friedli*, 2011). These fields of action are the development of tourism supply, hazard minimisation, and communication. The identified adaptation measures within the fields of action refer to the repositioning of summer tourism as well as safeguard and development of winter sports. In addition, they correspond to information and knowledge gaps related to climate change adaptation and tourism which are to be identified and addressed. These adaptation efforts aiming at the development of tourism supply, minimisation of hazards and communication should help Switzerland to remain an attractive and successful tourist destination and to exploit its exceptional potential as a travel destination in the long term.

The 2016–2019 implementation programme on tourism policy for Switzerland focuses on continuing structured collaboration with the Swiss Federal Office for the Environment, particularly in order to ensure a coordinated approach for adaptation of tourism to climate change. This includes the follow-up of the implementation of measures identified in the action plan 2014–2019 (*Swiss Confederation*, 2014). The tourism sector itself has a key role in adapting to climate change. The options of the Swiss government are based on the federal tourism policy, tourism policy goals and the relevant legal bases for tourism policy.

6.6 Monitoring and evaluation framework

With the adoption of the action plan of the Swiss adaptation strategy by the Swiss Federal Council, the Swiss Federal Office for the Environment was mandated to report to the Swiss Federal Council on the progress made, and the effects achieved, by the end of 2017. In response to this mandate, the Swiss Federal Office for the Environment is setting up the framework for the development of an implementable, user-friendly and meaningful monitoring and evaluation system for tracking climate change adaptation in Switzerland. An impact model (see Fig. 90) forms the basis of the Swiss national system for monitoring, reporting and evaluation. The model consists of five 'evaluation objects' (concept; implementation; output; outcome; impact) and sets out the logic underpinning of the flow from one object to another. Furthermore, the model distinguishes between the strategic level (the setting up of a coordination framework for adaptation) and the operational level (the implementation of adaptation measures).

Fig. 90 > The impact model used in Switzerland.



Swiss Confederation (2014)

The impact model is a simple and effective tool to demonstrate, communicate and facilitate discussion on the complex relationships associated with climate change adaptation. It has helped to optimise the use of existing knowledge and experience of stakeholders within Switzerland and it has supported learning. However, a number of challenges were identified including (i) setting objectives and thresholds for evaluating adaptation, (ii) capturing the causality between the expected and the actual outcome of an adaptation measure, and (iii) the short time between the adoption of the action plan and its evaluation.

On the basis of the impact model, the development process of the strategy, the progress of implementation, the effectiveness of the implementation of adaptation measures and the coordination by the Swiss Federal Office for the Environment have been subject to evaluation at the federal level. Evaluation results are documented in (*Boesch et al.*, 2015; *FOEN*, 2015; *FOEN*, 2017; *Landis et al.*, 2017a) and will be used to further develop adaptation in Switzerland.

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7 Financial, technological and capacity-building support

7.1 Finance

7.1.1 Introduction

The Federal Constitution of the Swiss Confederation stipulates that Switzerland be committed to the long-term preservation of natural resources and to a just and peaceful international order. Furthermore, it states that Switzerland shall in particular promote global sustainable development and protect the natural resource base in view of alleviating poverty in the world. Support for international climate action – through a variety of channels and instruments, such as dedicated multilateral climate funds, specific multilateral and bilateral climate programmes and projects, as well as integrating low-carbon development and climate resilience into Switzerland’s development assistance – has thus been a cornerstone of Switzerland’s international engagement since the early 1990s. Regarding international climate financing, three government entities – the Swiss Agency for Development and Cooperation, the Swiss State Secretariat for Economic Affairs, and the Swiss Federal Office for the Environment – have specific roles and dedicated budgets. They cooperate closely to ensure the overall effectiveness and coherence of Swiss support for climate change adaptation and mitigation activities in developing countries and countries in transition.

Building on decades of climate-relevant work in developing countries in different areas such as energy efficiency, renewable energy, agriculture and forestry, land-use planning, disaster risk management and technology transfer, Switzerland has played an active role since the early days of international climate policy. In the international climate change arena, Switzerland underscores the relevance of a fair and equitable burden sharing among Parties, while stressing the importance of a sound regulatory framework and an attractive investment environment to achieve a low-carbon and climate-resilient development. Through its multilateral and bilateral cooperation and its membership in the governing bodies of various multilateral institutions (inter alia multilateral development banks, the Green Climate Fund, the Global Environment Facility, the Adaptation Fund, United Nations agencies) Switzerland attaches great importance to increased coherence and effectiveness in the mandate of the above mentioned multilateral climate finance institutions. Furthermore, the establishment of strategic partnerships at all policy levels and the strengthening of dialogue among all stakeholders, including the private sector and other non-governmental institutions, are key principles guiding Switzerland’s international climate change engagement.

Switzerland’s public climate finance has seen a steady increase over the past years. Standing at 175 million US dollars in 2012 the respective amount grew to 299 million US dollars in 2014 and to 330 million US dollars in 2016. This increase was partly fuelled by the decision of the Swiss Parliament in 2011 to raise the level of official development assistance to 0.5 per cent of gross national income by 2015. In addition, Switzerland’s development assistance has gradually shifted to place an enhanced focus on climate change, thus pushing the envelope of climate-relevant and climate-proofed programmes and projects in developing countries. These strategic decisions lead to a remarkable progression compared to previous efforts. Switzerland therefore considers its provided climate finance as new and additional. It represents furthermore Switzerland’s highest possible effort under budget constraints that currently also affect official development assistance spending and is therefore considered adequate by the Swiss government pursuant to Article 4, paragraph 3 of the Convention. Through its contributions to multi-annual multilateral funds, such as the Green Climate Fund and the Global Environment Facility, Switzerland is committed to providing predictable climate finance. In addition, Switzerland’s bilateral support for climate action is based on a cooperative, bilateral dialogue with the various recipient countries. Every four years the Swiss cooperation offices engage in a demand driven planning dialogue, where, contingent on the available resources, the needs and priorities of the recipient country are assessed. This programmatic procedure ensures country ownership and provides increased predictability for the partner countries, pursuant to Article 4, paragraph 3 of the Convention.

The decision adopted by the Conference of the Parties to the UNFCCC in 2010 in Cancun refers to a variety of sources including the private sector. In contrast to this decision, the financial resources reported in this section relate to financing from public sources attributable to official development assistance only. Current Swiss public investments for climate change adaptation and mitigation measures in developing countries can be found in section 7.1.6. All public funding was provided in the form of grants (no loans).

This biennial report does include bilateral, but not multilateral mobilised private climate finance. It also does not include the outflow data of public climate finance provided and mobilised by multilateral institutions. The rationale for omitting this data is informed by Switzerland's view that bilateral reporting of mobilised private finance through multilateral channels as well as bilateral reporting of the outflow data from multilateral institutions would not do justice to the complexity and the joint effort of all partners involved in multilateral institutions. However, Switzerland considers multilateral mobilised private climate finance as well as the full face value of the climate finance outflow of multilateral institutions as climate finance accountable towards the 100 billion US dollars goal. Switzerland remains very much committed to increasing its share of mobilised private finance as part of its climate finance spending. It is also keen to advance efforts at the international level to collectively capture and report on private climate finance mobilised through multilateral channels and to fully capture the outflow of public climate finance by multilateral institutions.

Switzerland has added its data on mobilised private climate finance outside of this report and the UNFCCC reporting to the joint report of the OECD and the Climate Policy Initiative on Climate Finance 2013–2014 and the 100 billion US dollars goal (*OECD*, 2015). Switzerland was part of the donor group, which provided significant methodological input to the report to measure and report mobilised private climate finance for the first time in a transparent, comparable and aggregate manner. Switzerland, together with the other donors, followed a robust methodology for the assessment of the mobilised private sector investments (*TWG*, 2015). In developing the methodology, the donor group was guided by the following principles: (i) to ensure that only finance mobilised by developed country governments is counted towards the 100 billion US dollars goal, (ii) that, where multiple actors are involved, the resulting finance is only counted once in tracking the progress, and (iii) to ensure that the reporting framework encourages and incentivises the most effective use of climate finance. The report came to the conclusion that all developed countries have jointly mobilised 12.8 billion US dollars in 2013 and 16.7 billion US dollars in 2014 from private sources.

7.1.2 Multilateral activities

Switzerland has made financial contributions to the UNFCCC secretariat, to the operating entities of the financial mechanism of the Convention, to other multilateral institutions and to international financial institutions such as the World Bank and other multilateral development banks that fund climate change adaptation, mitigation, disaster risk management, capacity building and technology cooperation programmes in developing countries. Among the international financial institutions, the largest contributions goes to the International Development Association, a substantial share of which is allocated to finance climate change action. Switzerland's total contribution to the 17th replenishment of the International Development Association was 752 million US dollars. Moreover, many international organisations, such as the United Nations Development Programme and the Consultative Group on International Agricultural Research, whose operations are co-funded by Swiss core contributions, are increasingly generating important climate benefits.

Tab. 42 and Tab. 43 highlight Switzerland's contributions to these multilateral institutions, organisations and associated programmes. Where possible, Switzerland calculated the climate relevant part of the Swiss multilateral official development assistance contributions using the climate relevant share of the portfolio for the respective organisation according to the OECD Development Assistance Committee methodology. Switzerland also cooperates with a number of multilateral institutions as implementing agency of bilateral and regional programmes and projects. The funds invested in those specific programmes are included in Tab. 44 and Tab. 45.

Green Climate Fund

As an operating entity of the financial mechanism of the Convention the purpose of the Green Climate Fund is to make a significant and ambitious contribution to the global efforts towards attaining the goal agreed by the international community to keep global warming well below two degrees Celsius. In the context of sustainable development, the Fund promotes a paradigm shift towards low-emission technologies and climate-resilient development with a focus on the most vulnerable countries. From 2013 to 2016 Switzerland contributed in total 65 million US dollars to the Green Climate Fund. The last instalment of 34 million US dollars was paid in April 2017.

Global Environment Facility

The Global Environment Facility addresses global environmental issues while supporting national sustainable development initiatives. The Global Environment Facility provides support for projects related to climate change, biodiversity, land degradation, forests, the ozone layer, persistent organic pollutants and international waters. Switzerland has supported the Global Environment Facility since its inception in 1991. To the Fifth Replenishment of the Global Environment Facility (2010–2014) Switzerland contributed roughly 114 million US dollars. Besides the 32 per cent of funds allocated for the climate change focal area in the Fifth Replenishment of the Global Environment Facility, including mitigation and adaptation measures, capacity building and technology transfer, the Global Environment Facility incorporates climate change considerations into broader programmes of the other focal areas. For the Sixth Replenishment of the Global Environment Facility (2014–2018) Switzerland contributed roughly 133 million US dollars. The contributions by Switzerland for the fifth and sixth replenishment are paid over a period of ten years. Switzerland has never been in arrears with its payments.

Least Developed Country Fund and Special Climate Change Fund

The Global Environment Facility also features two dedicated climate change funds under the UNFCCC, i.e. the Least Developed Country Fund and the Special Climate Change Fund.

The Least Developed Country Fund was established to address the special needs of the least developed countries with regard to the negative impacts of climate change. The least developed countries identified adaptation as their top priority, which is why the Least Developed Country Fund is thus far the only fund under the Climate Convention tasked specifically with financing the preparation and implementation of National Adaptation Programmes of Action (NAPAs). Unlike the Least Developed Country Fund, the Special Climate Change Fund is open to all developing country Parties to the UNFCCC, supporting adaptation measures and technology transfer. Between 2013 and 2016, Switzerland’s contributions to both funds amounted to roughly 9.5 million US dollars.

Adaptation Fund

The Adaptation Fund was established to finance concrete adaptation projects and programmes in developing countries that are Parties to the Kyoto Protocol and are particularly vulnerable to the adverse effects of climate change. Financing for the Adaptation Fund comes mainly from a two per cent levy on CERs and other units from the market-based mechanisms under the Convention. In addition, the Fund receives voluntary contributions from governments, the private sector and individuals. In 2013, Switzerland provided a supplemental contribution of 10.79 million US dollars to the Adaptation Fund in line with Article 12 of the Kyoto Protocol. Switzerland has not made any voluntary contributions to the Adaptation Fund from 2014 to 2016.

Global Facility for Disaster Reduction and Recovery

The Global Facility for Disaster Reduction and Recovery is a growing global partnership among contributing and recipient countries and several international organisations hosted by the World Bank since 2006. Its mission is to mainstream disaster risk management and climate adaptation into development strategies. The facility carries out a range of activities to support countries to build resilience, structured around five pillars of action: (i) risk identification, (ii) risk reduction, (iii) preparedness, (iv) financial protection, and (v) resilient recovery. Working as a grant-making facility, the Global Facility for Disaster Reduction and Recovery supports countries to develop capacity, generate new knowledge, and apply it to policy reforms and investments for disaster risk management. Switzerland contributed 20 million US dollars to the Global Facility for Disaster Reduction and Recovery from 2013 to 2016 with a particular focus on resilience to climate change.

Addressing the needs of developing country Parties

Relating to multilateral programming – likewise the bilateral programming – Swiss delegates always advocate for country ownership (implying country need-based programming) and impact oriented programming in the various multilateral funding institutions and governing bodies of multilateral climate finance funding schemes, in which Switzerland participates as a contributor.

All multilateral activities mentioned above ensure that their activities are endorsed by the recipient countries to ensure the projects fit within the recipient countries’ priorities and that the funded interventions are sustainable.

In addition, most multilateral institutions, which are active in the area of climate finance, have started initiatives for a better integration and alignment of their portfolio with the communicated nationally determined contributions of developing countries. The more detailed and precise the nationally determined contributions are formulated, the easier it will be for agencies to align their investments and initiatives with the national priorities of developing countries. In the past, this has been very challenging since the Biennial Update Reports, which could be used to communicate the needs and priorities of developing countries, have not been submitted on time by multiple Parties or have not been submitted at all.

7.1.3 Bilateral activities

Next to the important multilateral engagement, the bilateral programmes and projects build a key element of Switzerland's climate change cooperation. Switzerland works closely with bilateral partners to deliver effective global responses to climate change and tangible results on the ground. All activities are implemented by one of the two Swiss development agencies – the Swiss Agency for Development and Cooperation or the Swiss State Secretariat for Economic Affairs – in close cooperation with government institutions, non-governmental organisations, private sector entities and research institutions. Switzerland's bilateral and regional climate-relevant activities are: (i) generate new and relevant knowledge on climate policy, (ii) technology and implementation, (iii) harness and replicate successful practices, (iv) develop the skills and capacities of partner countries for their engagement in the international debate on climate change issues, and (v) the implementation of climate action.

In order to effectively tackle the double challenge of addressing climate change mitigation and climate change adaptation in a complementary manner, the climate change activities of the Swiss Agency for Development and Cooperation consists of four main components: (i) climate change processes and funds, (ii) climate change mitigation, (iii) climate change adaptation, and (iv) knowledge management. In total the Swiss Agency for Development and Cooperation spent roughly 447.6 million US dollars between 2013 and 2016 for bilateral climate change programmes (for further details see Tab. 44 and Tab. 45).

With the aim to foster climate-friendly growth in developing countries, the climate change portfolio of the Swiss State Secretariat for Economic Affairs is structured mainly along three areas of intervention: (i) energy efficiency and renewable energy sources, (ii) sustainable management of natural resources, and (iii) framework conditions and new market and financing mechanisms. The Swiss State Secretariat for Economic Affairs provided approximately 300.2 million US dollars between 2013 and 2016 for its global, regional and bilateral programmes and projects in climate change. In addition, it mobilised in 2016 roughly seven million US dollars from the private sector through the Swiss Investment Fund for Emerging Markets, up from 3.7 million US dollars in the reporting period 2013–2014[45].

Addressing the needs of developing country Parties

Switzerland's approach to offering bilateral support is oriented towards the needs and priorities of the receiving countries. Country-ownership is thus a key requirement. Assistance for climate action is based on a clear demonstration of demand and need by the partner country. As a general rule, all bilateral projects have to be endorsed by the partner country.

Switzerland's bilateral climate mitigation and adaptation activities are based on national strategies and priorities and are ideally reflected in the partner countries' national climate change and/or sustainable development policies. Over the next years, Switzerland endeavours to work closely with its partner countries to support the implementation of the Paris Agreement and align the partner countries' national policies, activities and needs with the Paris Agreement.

Switzerland has for example supported the Capacity Building Initiative for Transparency with one million Swiss francs in 2016. The Capacity Building Initiative for Transparency finances the build-up of institutional and human capacities in developing countries, which are committed to implement the Paris Agreement and scale-up their efforts for increased transparency. The initiative will support these in defining their needs and gaps to comply with the increased transparency framework and to fill those in an efficient and effective manner. The application procedures are the same as for the Global Environment Facility funds and ensure country ownership.

Adaptation

Switzerland has undertaken a broad range of activities to support developing countries in reducing their vulnerability to the unavoidable consequences of climate change, while also minimizing the social and economic costs by:

[45] The Swiss Investment Fund for Emerging Markets is Switzerland's development finance institution and a cornerstone of Swiss development cooperation (see *http://www.sifem.ch*). The mobilisation figure for 2013 and 2014 were reported to the OECD and the Climate Policy Initiative for their aggregate report.

- Maintaining or increasing productive capital of land (forest, agriculture) and maintaining or increasing water availability at a local level;
- Reducing vulnerability to natural hazards in highly endangered areas at the local/regional level;
- Supporting countries in defining their national and sub-national adaptation strategies and plans;
- Increasing capacity-building, technology transfer and innovation in the field of adaptation in developing and middle-income countries;
- Increasing understanding and awareness about adaptation at different levels and promoting south-south learning processes.

Besides supporting developing countries in adapting to the impacts of climate change, Switzerland has been active for many years in the prevention and reduction of disaster risks. For instance, it developed methods and tools to better integrate disaster risk reduction into project planning and project management[46].

Switzerland slightly reduced its specific support for bilateral adaptation activities from 112 million US dollars in 2013 to 102 million US dollars in 2016, due to budget cuts and a change in demand from partner countries.

Through its bilateral and multi-bilateral development cooperation, Switzerland supported several climate change adaptation related projects, such as the Indian Himalayas Climate Adaptation Programme (see Tab. 40) and:

- **Capacity Building and Twinning for Climate Observing Systems (CATCOS):** In order to build up climate resilience, decisions concerning mitigation and adaptation strategies on climate change must be based on high-quality data, collected in a sustainable manner. The Swiss Agency for Development and Cooperation funded CATCOS Project contributed to filling data gaps in regions where climate-relevant information has been missing or measurements have ceased. CATCOS supported the monitoring of the essential climate variables aerosols, greenhouse gases and glaciers in ten developing and emerging mountainous countries. To ensure the sustainable continuation of the observations, the implementation of the new measuring instruments was accompanied by a set of training activities. The respective efforts helped develop capacities of local operators and scientists in standard data processing methods, quality control, data analysis, and scientific publication. The resulting high-quality data were submitted to the respective international data centres where they were made available freely. In addition, CATCOS enhanced regional cooperation among involved actors in the respective countries to optimise the use and benefit of climate observations and services;
- **Can Tho Urban Development and Resilience Project:** Co-financed by the Swiss State Secretariat for Economic Affairs together with the World Bank, the project aims to increase the resilience of Can Tho City, Vietnam, to adverse climate change-related events by proactively addressing the two biggest threats to its socioeconomic development: flooding and uncontrolled urbanisation. Situated in the middle of the Mekong Delta, Can Tho is susceptible to flooding caused by Mekong overflow, high tides, and extreme rainfall events. The objective of the Can Tho Urban Development and Resilience Project is to reduce flood risk in the city of Can Tho, guide urban development in a risk informed way, improve connectivity between the city centre and the new low risk urban development areas, and enhance the capacity of city authorities to manage disaster risk sustainably;
- **Green Gold Project in Mongolia**: Regional climate models predict an increase in the annual air temperature of 3.5 to 4 degrees Celsius in Mongolia over the next 100 years and declining precipitation in all parts of the country, accompanied by decreasing soil moisture due to increased temperatures and dryness. Livestock herders have already started repeatedly expressing their concerns about lakes, streams and rivers drying up and declining pasture productivity. This, in turn, starts to affect pastoral land use patterns by increasing conflicts over scarce water and pasture resources. The past two decades also witnessed two severe winters when millions of livestock perished with devastating effects on the livelihoods of thousands of herder households. In response to these challenges, the Green Gold Project supported community-based rangeland management initiatives of herders aiming at reducing pasture conflicts and prevent rangeland from degradation, as well as to increase resilience and climate change adaption capacity of herders by strengthening the self-regulating feedback of socio- economic and

[46] *https://www.eda.admin.ch/deza/en/home/themes-sdc/disaster-reduction-relief-reconstruction/disaster-risk-reduction.html*

environmental system of pastoral livestock. The project helped to strengthen the capacities of Mongolian herders who are currently discussing via novel associations joint rules for pasture management with the local governments. The respective autonomous associations are, in fact, increasingly recognised by local Mongolian authorities who give them permission to manage pastures, and provide them with technical advice and financial support. Preserving and maintaining ecosystems provides the essential basis for creating sustainable income for herders. The project thus contributed to the improvement of the livelihood of 100 thousand semi-nomadic herder families in western Mongolia;

- **New Seed Initiative for Maize in Southern Africa (NSIMA):** This initiative was launched for conducting research into drought-tolerant maize varieties that can generate bigger harvests than conventional varieties, even in less fertile soil. The ultimate aim is to achieve greater food security. At the same time, NSIMA activities involve cooperation with government and private-sector stakeholders in the maize sector to encourage seed production and trade (also for small-scale producers). Maize is one of the main staple foods in Southern Africa. 70 per cent of the population covers its food requirements with maize. Maize is also an important source of income. However, droughts and poor soil often result in crop loss or even crop failure. The NSIMA is designed to give poor farmers access to seeds that are drought-tolerant and resist certain diseases and have a certain tolerance to nutrient depletion. In addition, NSIMA teams distribute newly developed maize varieties. New local seed businesses have sprung up, which has helped to generate local jobs and income. Regional cooperation between national research institutes and private seed producers has not only led to better exchanges of seeds and plants in Southern Africa, it has made a major contribution to a sustainable maize market;
- **Ensuring food security for smallholder farmers with micro insurance and microcredits:** The Rural Resilience Initiative combines four climate risk management tools, which are all aimed at preventing or reducing the impact of climate change on the population by rehabilitating irrigation systems, improving soil water retention, promoting sustainable farming practices in the fields, constructing access roads, etc. The Swiss Agency for Development and Cooperation supported project activities in Malawi, Zambia and Zimbabwe. The project provides smallholders who are most at risk from drought or floods with agricultural micro insurance. An innovative measure is that the project allows farmers to pay their insurance premiums by taking part in community work. The project also includes the installation of new weather stations in Zambia and Malawi – an important prerequisite to calculate the price of insurance premiums and better anticipate bad harvests. As a parallel measure, the project trains microcredit agencies in limiting the debt risk. The combination of micro insurance and microcredit is intended to encourage farmers to invest in agricultural activities (inputs, equipment) without fear of losing their farm the following year.

Tab. 40 > Promotion of climate change adaptation in the Indian Himalayas.

Project/programme title:
Indian Himalayas Climate Adaptation Programme.

Goal:
The project aims at strengthening the resilience of vulnerable communities in the Himalayas and to enhance knowledge and capacities of research institutions, communities, and decision-makers.

Recipient country	Sector	Total funding	Years in operation
India	Adaptation	3.75 million Swiss francs	2012–2016

Description:
The project helped to build capacity and enhance knowledge related to three pillars:
- Scientific and technical knowledge cooperation between Indian and Swiss scientific institutions;
- Adaptation measures for vulnerable communities;
- Mainstreaming adaptation policies for improved action in the Indian Himalayan Region.

The Indian Himalayas Climate Change Adaptation Programme was initiated by the Swiss Agency for Development and Cooperation in collaboration with the Department of Science and Technology, Government of India. Implementing partners included a consortium of Swiss (Geneva, Bern, Fribourg, Zurich) and Indian (Jawahrlal Nehru University, G.B. Pant National Institute of Himalayan Environment and Sustainable Development, Doon University, Himachal Pradesh Agricultural University Palampur, Birbal Sahni Institute of Palaeobotany, Lucknow) universities.

Key achievements (complementary to the paragraphs below):
- The capacities of 127 representatives from the government, non-governmental organisations and academia in Himachal Pradesh in climate change adaptation planning and implementation strengthened;
- An innovative joint research work (India and Switzerland) on vulnerability, risks and hazard assessment in Kullu district in partnership with the Department of Science & Technology, government of Himachal Pradesh was carried out;
- A common framework for integrated vulnerability, and risk assessment for all Himalayan states was developed;
- Results of joint research and common framework help enable planning and implementation of adaptation action at state level;
- Media capacity building workshops were conducted in different Indian Himalayan states with 74 journalists trained;
- Knowledge management and outreach were addressed through policy briefs with an outreach to more than 26 thousand individuals;
- Co-funding support was generated to universities/institutions for promoting a scientific dialogue on climate change impact, vulnerability & adaptation in the Himalayas;

- Technical assistance for the preparation of climate change adaptation projects was provided to Jammu Kashmir and Himachal Pradesh for National Adaptation fund on Climate Change;
- The revival of multi-stakeholder 'Himalayan Sustainable Development Forum' fostered cooperation on sustainable development across the Himalayan region.

Technology transferred/capacity building:
The Indian Himalayas Climate Adaptation Programme mainly focused on capacity building of Indian researchers, universities and institutions as well as government representatives in the field of glaciology and related areas. The project helped develop an Indo-Swiss Capacity Building Programme on Himalayan Glaciology through which 52 researchers were trained. The programme was then further developed into a full-fledged 'glaciology course' as part of a Master's curriculum in order to secure the sustainability of the efforts and achievements jointly with the two selected Indian Kashmir and Delhi Universities. The project also conducted an Indo-Swiss Collaborative Research in Kullu district. As a result of this collaborative research a synthesis report was produced (*IHCAP*, 2016).

Impact on government targets:
Through the Indian Himalayas Climate Adaptation Programme the Swiss Agency for Development and Cooperation collaborated with the Department of Science & Technology, Government of India. Indian Himalayas Climate Adaptation Programme was designed to work with existing country systems at national and state levels and directly contributed to the implementation of India's National Mission on Sustaining the Himalayan Environment. It also contributed to the implementation of the State Action Plans and to gaining access to climate finance by supporting the preparation of climate change adaptation projects for the National Adaptation Fund on Climate Change.

Swiss Agency for Development and Cooperation

Mitigation

Greenhouse gas emissions responsible for warming the planet originate from multiple sources. Therefore Switzerland's support of climate change mitigation activities in developing countries is cross-cutting, building on a variety of sectors and actors. Switzerland focuses its activities on access to modern energy infrastructure, including renewable energies, rural electrification, energy efficiency in the industry and in the building/construction sector, cleaner industrial production, and sustainable use of natural resources, namely forests and grassland. In addition, Switzerland supports its partner countries in the development and use of innovative financing and market mechanisms in climate protection such as emissions trading schemes or carbon taxes. Switzerland also assisted selected countries in developing a scientific basis for planning mitigation activities (Mitigation Action Plans and Scenarios, MAPS) – namely Peru, Chile and Brazil –, which ultimately informed the governments on the elaboration of their nationally determined contributions. Switzerland further supports developing countries in the design and implementation of ambitious policies to mitigate climate change such as clean air policies or policies to mitigate black carbon emissions. Switzerland increased its bilateral support for mitigation activities from 72 million US dollars in 2013 to 100 million US dollars in 2016.

Through its bilateral development cooperation Switzerland supports multiple climate change mitigation projects, such as the Vinnitsa Energy Efficiency Project (see Tab. 41) and the following:

- **The Transformative Carbon Asset Facility** is co-financed by the Swiss State Secretariat for Economic Affairs and supports different types of direct and indirect carbon pricing efforts by paying for verified carbon assets that result from these actions. The results-based payments could be used to support the implementing country government to enhance sectoral planning, strengthen low-carbon policy coordination and implementation, and monitor sector performance on greenhouse gas emissions. All these are necessary conditions to create a conducive environment for increasing private sector investment in low carbon technologies. Transformative Carbon Asset Facility will support the measuring, reporting and verification of nationally determined contributions by developing baselines and monitoring performance of the programmes. This support to move from carbon pricing readiness to implementation builds on the work done by the World Bank's Partnership for Market Readiness and other readiness initiatives. Piloting will also inform the international process to develop standards and agreements for future carbon crediting instruments and the transfer of mitigation assets;
- **The Pilot Auction Facility for Methane and Climate Change Mitigation** is an innovative mechanism co-financed by the Swiss State Secretariat for Economic Affairs that pioneers the use of auctions to allocate public finance for climate action efficiently. The facility demonstrates a new pay-for-performance mechanism that takes advantage of existing tools and experience developed at the multilateral level under the Clean Development Mechanism and related carbon markets to deliver financing, in the form of a price guarantee, to projects that combat climate change;
- **Climate Investment Funds**: The Climate Investment Funds support transformational, scaled-up climate action in developing countries that has the potential to leverage significant co-financing from the private sector as well as multilateral development banks and achieve strong climate and development outcomes. The Climate Investment Funds support mitigation, adaptation, and technology transfer activities and are composed of the Clean Technology Fund and the Strategic Climate Fund with its three targeted programmes: (i) the Forest Investment Programme, (ii) the Pilot Programme for Climate Resilience, and (iii) the Scaling Up Renewable Energy in Low

Income Countries Programme. Switzerland contributed 26 million US dollars to the Scaling Up Renewable Energy in Low Income Countries Programme. This programme's mandate is to scale up the deployment of renewable energy solutions in low income countries to increase energy access and economic opportunities. It currently supports 27 pilot countries, including one regional programme. Through its contribution to the Scaling Up Renewable Energy in Low Income Countries Programme Switzerland mobilised in total three million US dollars in private finance during the period 2015–2016.

Tab. 41 > Vinnitsa Energy Efficiency Project.

Project/programme title:
Vinnitsa Energy Efficiency Project.

Goal:
Improving the municipal infrastructure and its energy efficiency in the City of Vinnitsa, Ukraine.

Purpose:
To promote energy efficiency and water conservation during the use of buildings in a cost-effective way.

Recipient country	Sector	Total funding	Years in operation
Ukraine	District Heating	20.6 million Swiss francs	2011–2018

Description:
The programme consists of the following components:
- Support to the municipality of Vinnitsa with the introduction of the European Energy Award system for sustainable energy management at municipal level;
- Capacity building for the district heating utility MTE;
- Rehabilitation of district heating networks through the replacement of old pipes with pre-insulated system elements and through the introduction of individual heat substations at building level in four districts;
- Rehabilitation of existing gas-fired boiler stations and building of wood-fired boiler stations in two districts.

Strategic partners at the national level is the Ministry of Regional Development and Housing.

Expected added value of the programme:
- Demonstration effect and replication in other Ukrainian cities;
- Support to the introduction of the European Energy Award at the national level in Ukraine;
- Strengthen awareness raising on energy efficiency and sustainable energy management at the municipal level.

Technology transferred:
Not applicable.

Impact on greenhouse gas emissions/sinks:
Reduction of greenhouse gas emission will be 17 thousand tonnes per year.

Swiss State Secretariat for Economic Affairs

7.1.4 Multiple benefits of forestry

Agriculture, forestry and other land use contribute 24 per cent to total global greenhouse gas emissions. 9.5 to 10.0 per cent of total global emissions are due to land use change and forest cover loss (*IPCC*, 2014). By absorbing and storing CO_2 from the atmosphere, tropical forests are therefore of critical importance in mitigating climate change. In addition, stronger ecosystems often provide important climate adaptation benefits for livelihoods and hazard protection. However, Switzerland's activities in the field of sustainable management of forests, grasslands and soil do not only focus on mitigation and adaptation effects, but are also geared towards yielding multiple environmental, economic and social benefits. Natural resources are key for the fight against poverty, especially when forests, grasslands and soils are protected and used as a sustainable source of income for local communities. .

Through its bilateral, regional and multilateral development cooperation Switzerland supports multiple sustainable forest management and climate change-related projects, such as:

- **Forest Carbon Partnership Facility:** Through the Forest Carbon Partnership Facility at the World Bank, Switzerland supports the development and piloting of REDD+ and thus preparations for a results-based payment scheme to sustainably manage and protect forests as important carbon stocks and sinks. Apart of the financial contribution, Switzerland supported the development of Carbon Fund activities with relevant expertise;
- **Andean Forests Programme *('Bosques Andinos')*:** Andean forest ecosystems are fragile landscapes and particularly vulnerable to the combined effects of climate change, deforestation and forest degradation. At the same time, forest ecosystems potentially contribute to climate change mitigation, restoration of key ecosystem functions and reduced vulnerability of the people living in forested landscapes. In spite of their paramount importance for both human development and ecosystem stability, the Andean forests do not yet receive the necessary attention and recognition in national and international policy processes. Changing this situation is the declared goal of the Andean Forests Programme, which highlights the role of Andean montane forests for adaptation and mitigation of climate change and promotes knowledge development to address information gaps that

prevent a more robust set of policies to ensure sustainable management and conservation of the mountain forests. The programme seeks to spark regional political interest in the conservation of Andean forests and shares the experiences made at the global level;

- **Macedonia Nature Conservation Programme:** Switzerland assists Macedonia in the sustainable management of natural resources through practical application of conservation measures such as regional protected areas and integrated forest management in the Bregalnica region. Furthermore, framework conditions are improved and support is provided in implementing national legislation and the Strategy on Nature. By promoting ecologically and sustainably produced products and services, economic benefits for the local population are generated. The aim of the project is to safeguard the natural values and to promote socio-economic development that is sustainable and inclusive in the Bregalnica region;
- **Support to Forestry and Fisheries Communities in Cambodia:** Switzerland contributes to the initiative Partnership for Forestry and Fisheries implemented by a consortium of four non-governmental organisations, led by WWF Cambodia. The programme supports rural communities to secure their access to forestry and fishery resources, to improve income and food security through enhanced production practices, and to advance public dialogue on sustainable natural resource management in four least-developed provinces in the northeast of Cambodia. The aim of the project is to increase the incomes of rural and indigenous communities and households and to improve their resilience to economic and natural shocks by engaging in sustainable community-based livelihood approaches that protect their ecosystems and reduce pressure on their communal natural resource base.

7.1.5 Financial support for any economic and social consequences of response measures

Switzerland supports developing countries in the economic diversification and transformation, the creation of decent work and sustainable alternative livelihoods. For example, projects in the forest and energy sector are designed together with partner countries in order to ensure the diversification of livelihoods of local communities and local industries. Project activities usually include a policy dialogue at the local, national and regional level, striving for a sustainable transition to a low-carbon economy and sustainable development. For example the Sustainable Recycling Industries programme of the Swiss State Secretariat for Economic Affairs, with a lifespan from 2013–2018, is developing knowledge partnerships in the area of e-waste in Columbia, Peru, Ghana and Egypt. The programme supports these countries in their efforts to improve e-waste management systems. The Sustainable Recycling Industries programme focuses on a sustainable integration and participation of small and medium size enterprises from developing and transition countries in the global recycling of secondary resources. The programme organisation includes experts and builds strong local partnerships with governmental organisations, industry and the civil society. Through these and other strong capacity-building components at all levels – from local communities to government officials – Switzerland directly supports and fosters alternative livelihoods and the necessary capacities for the workforce to be ready for a transition to a low-carbon future.

7.1.6 Provision of financial resources (including under Article 11 KP)

Switzerland’s development cooperation has steadily increased over the last years. Tab. 42 to Tab. 45 give an overview on multilateral and bilateral climate-related public contributions of Switzerland. Overall, Switzerland disbursed 330.1 million US dollars in the form of grants through bilateral, multi-bilateral and multilateral channels in 2016 (up from 281 million US dollars in 2013) as public climate finance and mobilised multi-bilaterally a total of 8.5 million US dollars in private finance in 2016. Of the bilateral climate finance disbursed in 2016 102 million US dollars or 50.5 per cent went to adaptation and 100 million US dollars or 49.5 per cent to mitigation (compared to 112 million US dollars or 61 per cent for adaptation and 72 million US dollars or 39 per cent for mitigation in 2013). More details are provided in the BR CTF tables.

The data in Tab. 42 and Tab. 43 is based on support provided and the climate-specific part of the inflows is calculated based on the climate-specific imputed shares published on a year-by-year basis by the OECD Development Assistance Committee.

All contributions included in Tab. 44 are provided climate-specific and grant-based public financial contributions from Switzerland. The contributions included in Tab. 45 are climate-specific mobilised private financial contributions and provided climate-specific and grant-based public financial contributions from Switzerland. The climate-specific share of each activity is assessed based on the Rio-marker methodology and project specific reduction factors are applied. A reduction factor of 1 to 50 per cent will be applied for activities with an indirect impact on climate change adaptation or mitigation (significant marker) and a reduction factor of 51 to 100 per cent will be applied for activities with a direct impact on climate change adaptation or mitigation (principal marker). Double counting between adaptation and mitigation specific activities is excluded by netting out potential overlaps between the climate change adaptation and mitigation Rio markers. Following such an approach is necessary as the same activity may target multiple objectives and can be marked against several Rio markers, thereby reflecting the intertwined nature of the three Rio Conventions but at the same time avoiding double counting of efforts within one convention.

Tab. 42 > Switzerland's financial contributions to multilateral institutions and programmes, 2013 and 2014.

	2013		2014		2013–2014
	Core contribution	Climate-specific contribution	Core contribution	Climate-specific contribution	Average imputed share
	US dollars				
Multilateral climate change funds					
1 Global Environment Facility	30'743'789	16'909'084	31'714'211	17'442'816	55%
2 Least Developed Countries Fund	1'078'729	1'078'729	1'092'840	1'092'840	100%
3 Special Climate Change Fund	1'348'412	1'348'412	1'366'050	1'366'050	100%
4 Adaptation Fund	10'787'295	10'787'295	0	0	100%
5 Green Climate Fund	0	0	546'420	546'420	100%
6 UNFCCC Trust Fund for Supplementary Activities	214'513	214'513	211'776	211'776	100%
7 Intergovernmental Panel on Climate Change	107'873	107'873	174'854	174'854	100%
Sub-total	**44'280'611**	**30'445'906**	**35'106'151**	**20'834'756**	**64%**
Multilateral financial institutions, including regional development banks					
1 World Bank (including IDA and IBRD)	227'224'264	42'803'862	230'196'477	43'363'759	IDA: 20% IBRD: NA
2 International Finance Corporation	0	0	0	0	NA
3 African Development Bank	56'870'007	18'767'103	83'878'134	27'679'784	33%
4 Asian Development Bank	12'944'753	3'236'188	13'114'078	3'278'519	25%
5 European Bank for Reconstruction and Development	0	0	0	0	NA
6 Inter-American Development Bank	1'300'705	0	1'454'944	0	NA
Sub-total	**298'339'729**	**64'807'153**	**328'643'633**	**74'322'062**	**22%**
Specialised United Nations bodies					
1 United Nations Development Programme	64'723'767	0	65'570'388	0	NA
2 United Nations Environment Programme	4'483'955	0	4'610'800	0	NA
Sub-total	**69'207'722**	**0**	**70'181'188**	**0**	**0%**
Other					
1 United Nations Convention to Combat Desertification	647'238	0	1'004'468	0	NA
2 International Fund for Agricultural Development	10'247'930	0	10'381'978	0	NA
3 United Nations Office for Disaster Risk Reduction	606'785	0	1'229'445	0	NA
4 Consultative Group on International Agricultural Research	16'720'306	0	16'939'017	0	NA
5 Multilateral Fund for the Implementation of the Montreal Protocol	1'893'820	1'893'820	1'918'592	1'918'592	100%
Sub-total	**30'116'079**	**1'893'820**	**31'473'500**	**1'918'592**	**6%**
Total	**441'944'141**	**97'146'879**	**465'404'472**	**97'075'410**	**21%**

NA, not applicable
IBRD, International Bank for Reconstruction and Development
IDA, International Development Association

Tab. 43 > Switzerland's financial contributions to multilateral institutions and programmes, 2015 and 2016.

	2015		2016		2015–2016
	Core contribution	Climate-specific contribution	Core contribution	Climate-specific contribution	Average imputed share
	US dollars				
Multilateral climate change funds					
1 Global Environment Facility	31'433'728	22'003'610	31'250'866	21'875'606	70%
2 Least Developed Countries Fund	1'039'132	1'039'132	1'776'425	1'776'425	100%
3 Special Climate Change Fund	1'298'914	1'298'914	507'550	507'550	100%
4 Adaptation Fund	0	0	0	0	100%
5 Green Climate Fund	30'017'704	30'017'704	34'210'745	34'210'745	100%
6 UNFCCC Trust Fund for the core contribution	219'499	219'499	210'127	210'127	100%
7 Intergovernmental Panel on Climate Change	103'913	103'913	101'510	101'510	100%
8 UNFCCC Voluntary Trust Fund	270'174	270'174	253'775	253'775	100%
9 Capacity Building Initiative for Transparency	0	0	507'550	507'550	
Sub-total	**64'383'064**	**54'952'946**	**68'818'548**	**59'443'288**	**85%**
Multilateral financial institutions, including regional development banks					
1 World Bank (including IDA and IBRD)	273'455'646	49'349'219	254'705'488	45'846'988	18% IDA 19% IBRD
2 International Finance Corporation	0	0	0	0	
3 African Development Bank	73'913'420	15'396'575	77'218'231	16'094'113	19% AfDB 21% AfDF
4 Asian Development Bank	14'840'813	2'404'376	12'181'199	2'070'804	12% AsDB 17% AsDF
5 European Bank for Reconstruction and Development	0	0	0	0	34% EBRD
6 Inter-American Development Bank	1'137'231	193'329	1'367'979	232'556	17% IADB 8% IDB Special Fund
Sub-total	**363'347'110**	**67'343'500**	**345'475'897**	**64'244'460**	**19%**
Specialised United Nations bodies					
1 United Nations Development Programme	62'347'891	NA	60'905'995	NA	NA
2 United Nations Environment Programme	4'449'977	NA	4'412'233	NA	NA
Sub-total	**66'797'868**	**0**	**65'318'228**	**0**	**NA**
Other					
1 United Nations International Children's Emergency Fund	22'860'893	NA	22'332'198	NA	NA
2 United Nations Convention to Combat Desertification	721'841	NA	159'467	NA	NA
3 United Nations Office for Disaster Risk Reduction	779'349	NA	951'656	NA	NA
4 Consultative Group on International Agricultural Research	16'106'538	NA	17'053'679	NA	NA
5 International Fund for Agricultural Development	9'871'749	6'910'225	15'314'107	10'719'875	70%
5 Multilateral Fund for the Implementation of the Montreal Protocol	1'959'087	1'959'087	1'913'780	1'913'780	100%
Sub-total	**52'299'457**	**8'869'312**	**57'724'887**	**12'633'655**	**17%**
Total	**546'827'499**	**131'165'758**	**537'337'560**	**136'321'403**	**24%**

NA, not applicable
IBRD, International Bank for Reconstruction and Development
IDA, International Development Association
AfDB, African Development Bank
AfDF, African Development Fund
AsDB, Asian Development Bank
AsDF, Asian Development Fund
EBRD, European Bank for Reconstruction and Development
IADB, Inter-American Development Bank
IDB Special Fund, Inter-American Development Bank Special Fund

Tab. 44 > Switzerland's public financial contributions through bilateral and multi-bilateral channels, 2013 and 2014.

	2013		2014	
	Swiss francs	**US dollars**	**Swiss francs**	**US dollars**
Adaptation activities of the Swiss Agency for Development and Cooperation				
Programmes and projects in Africa	17'071'266	18'415'277	18'077'726	19'756'058
Programmes and projects in Asia	20'134'740	21'719'937	19'752'427	21'586'238
Programmes and projects in Europe and Commonwealth of Independent States	3'268'174	3'525'476	4'068'190	4'445'880
Programmes and projects in Latin America	23'620'287	25'479'900	20'686'114	22'606'609
Programmes and projects in the Middle East and North Africa	393'378	424'348	337'117	368'415
Global programmes and projects	11'867'894	12'802'247	16'226'445	17'732'905
Humanitarian aid adaptation programmes and projects	3'765'788	4'062'266	6'248'389	6'828'488
Sub-total	**80'121'527**	**86'429'451**	**85'396'408**	**93'324'593**
Mitigation activities of the Swiss Agency for Development and Cooperation				
Programmes and projects in Africa	6'567'791	7'084'870	8'904'831	9'731'554
Programmes and projects in Asia	8'755'229	9'444'523	9'753'662	10'659'190
Programmes and projects in Europe and Commonwealth of Independent States	505'561	545'364	545'744	596'411
Programmes and projects in Latin America	8'278'760	8'930'542	6'710'533	7'333'537
Programmes and projects in the Middle East and North Africa	200'000	215'746	0	0
Global programmes and projects	5'902'976	6'367'714	7'004'514	7'654'812
Humanitarian aid mitigation programmes and projects	0	0	39'688	43'373
Sub-total	**30'210'317**	**32'588'759**	**32'958'972**	**36'018'877**
Adaptation activities of the Swiss State Secretariat for Economic Affairs				
Programmes and projects in Africa	2'726'194	2'940'826	2'243'748	2'452'058
Programmes and projects in Asia/Oceania	2'849'874	3'074'243	1'740'483	1'902'069
Programmes and projects in Europe and Commonwealth of Independent States	7'383'615	7'964'923	3'475'077	3'797'702
Programmes and projects in Latin America	2'948'971	3'181'142	4'257'261	4'652'504
Programmes and projects in the Middle East and North Africa	155'206	167'425	752'875	822'772
Global programmes and projects	7'299'020	7'873'668	7'150'397	7'814'238
SIFEM adaptation programmes and projects	0	0	0	0
Sub-total	**23'362'880**	**25'202'227**	**19'619'841**	**21'441'343**
Mitigation activities of the Swiss State Secretariat for Economic Affairs				
Programmes and projects in Africa	5'140'862	5'545'596	5'686'586	6'214'527
Programmes and projects in Asia/Oceania	7'411'992	7'995'534	7'078'551	7'735'722
Programmes and projects in Europe and Commonwealth of Independent States	4'731'186	5'103'670	5'399'862	5'901'184
Programmes and projects in Latin America	1'999'497	2'156'916	3'209'131	3'507'066
Programmes and projects in the Middle East and North Africa	29'268	31'572	5'588'475	6'107'308
Global programmes and projects	11'895'393	12'831'911	11'213'358	12'254'404
SIFEM mitigation programmes and projects	4'667'821	5'035'316	7'667'789	8'379'665
Sub-total	**35'876'019**	**38'700'515**	**45'843'752**	**50'099'877**
Adaptation activities of the Swiss Federal Office for the Environment (Global)				
Sub-total	**432'368**	**466'408**	**379'202**	**414'407**
Mitigation activities of the Swiss Federal Office for the Environment (Global)				
Sub-total	**306'365**	**330'485**	**416'066**	**454'693**
Adaptation activities through other government entities (Global)				
Sub-total	**80'000**	**86'298**	**128'000**	**139'883**
Mitigation activities through other government entities (Global)				
Sub-total	**200'000**	**215'746**	**32'000**	**34'971**
Sub-total public bilateral adaptation	**103'996'775**	**112'184'384**	**105'523'451**	**115'320'226**
Sub-total public bilateral mitigation	**66'592'701**	**71'835'505**	**79'250'790**	**86'608'418**
Total	**170'589'476**	**184'019'889**	**184'774'241**	**201'928'644**

SIFEM, Swiss Investment Fund for Emerging Markets

Tab. 45 > Switzerland's financial contributions through bilateral and multi-bilateral channels, 2015 and 2016.

	2015		2016	
	Swiss francs	**US dollars**	**Swiss francs**	**US dollars**
Adaptation activities of the Swiss Agency for Development and Cooperation				
Programmes and projects in Africa	14'647'646	15'220'830	18'088'331	18'361'463
Programmes and projects in Asia	24'422'062	25'377'734	19'233'872	19'524'302
Programmes and projects in Europe	622'448	646'805	680'768	691'047
Programmes and projects in Latin America	20'214'621	21'005'650	22'523'954	22'864'064
Programmes and projects in the Middle East and North Africa	1'170'610	1'216'417	1'667'029	1'692'201
Global programmes and projects	9'147'897	9'505'868	9'903'974	10'053'524
Sub-total	**70'225'284**	**72'973'304**	**72'097'927**	**73'186'000**
Mitigation activities of the Swiss Agency for Development and Cooperation				
Programmes and projects in Africa	5'991'167	6'225'610	4'660'709	4'731'086
Programmes and projects in Asia	9'076'765	9'431'952	9'070'758	9'207'726
Programmes and projects in Europe	0	0	0	0
Programmes and projects in Latin America	7'154'598	7'434'568	6'414'756	6'511'618
Programmes and projects in the Middle East and North Africa	149'554	155'406	342'959	348'138
Global programmes and projects	3'883'827	4'035'807	4'918'065	4'992'327
Sub-total	**26'255'910**	**27'283'344**	**25'407'247**	**25'790'895**
Adaptation activities of the Swiss State Secretariat for Economic Affairs				
Programmes and projects in Africa	1'361'384	1'414'657	211'761	214'959
Programmes and projects in Asia	5'034'322	5'231'323	10'649'599	10'810'407
Programmes and projects in Europe	4'846'303	5'035'946	5'960'352	6'050'353
Programmes and projects in Latin America	4'270'783	4'437'905	4'366'585	4'432'520
Programmes and projects in the Middle East and North Africa	309'258	321'360	329'744	334'723
Global programmes and projects	7'025'982	7'300'919	6'479'690	6'577'533
SIFEM adaptation programmes and projects	0	0	0	0
Mobilised private adaptation finance	0	0	0	0
Sub-total	**22'848'032**	**23'742'110**	**27'997'731**	**28'420'494**
Mitigation activities of the Swiss State Secretariat for Economic Affairs				
Programmes and projects in Africa	7'055'836	7'331'942	4'475'887	4'543'473
Programmes and projects in Asia	8'660'748	8'999'656	10'873'670	11'037'862
Programmes and projects in Europe	5'377'784	5'588'225	11'506'873	11'680'626
Programmes and projects in Latin America	7'678'211	7'978'671	4'953'429	5'028'225
Programmes and projects in the Middle East and North Africa	2'057'128	2'137'627	1'674'503	1'699'788
Global programmes and projects	14'571'013	15'141'199	16'580'959	16'831'330
SIFEM mitigation programmes and projects	0	0	14'333'564	14'550'000
Mobilised private mitigation finance	1'443'513	1'500'000	8'373'560	8'500'000
Sub-total	**46'844'233**	**48'677'319**	**72'772'445**	**73'871'303**
Adaptation activities of the Swiss Federal Office for the Environment (Global)				
Sub-total	**281'885**	**292'916**	**435'531**	**442'107**
Mitigation activities of the Swiss Federal Office for the Environment (Global)				
Sub-total	**252'213**	**262'082**	**525'659**	**533'597**
Adaptation activities through other government entities (Global)				
Sub-total	**0**	**0**	**48'750**	**49'486**
Mitigation activities through other government entities (Global)				
Sub-total	**0**	**0**	**26'250**	**26'646**
Sub-total bilateral adaptation	**93'355'201**	**97'008'331**	**100'579'939**	**102'098'688**
Sub-total bilateral mitigation	**71'908'843**	**74'722'745**	**98'731'602**	**100'222'441**
Sub-total bilateral mobilised private climate finance	**1'443'513**	**1'500'000**	**8'373'560**	**8'500'000**
Sub-total bilateral public climate finance	**165'264'044**	**171'731'076**	**190'937'981**	**193'821'128**
Total public and mobilised private climate finance	**166'707'557**	**173'231'075**	**199'311'541**	**202'321'129**

SIFEM, Swiss Investment Fund for Emerging Markets

Fig. 91 > Swiss bilateral and multi-bilateral disbursed public support for climate change mitigation and adaptation activities in developing countries, 2013 and 2014.

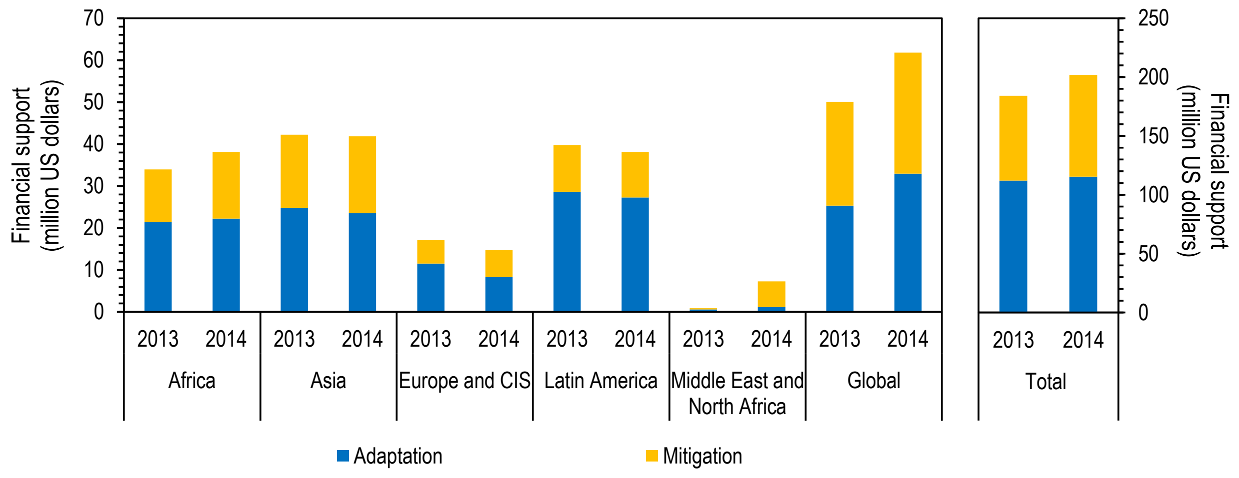
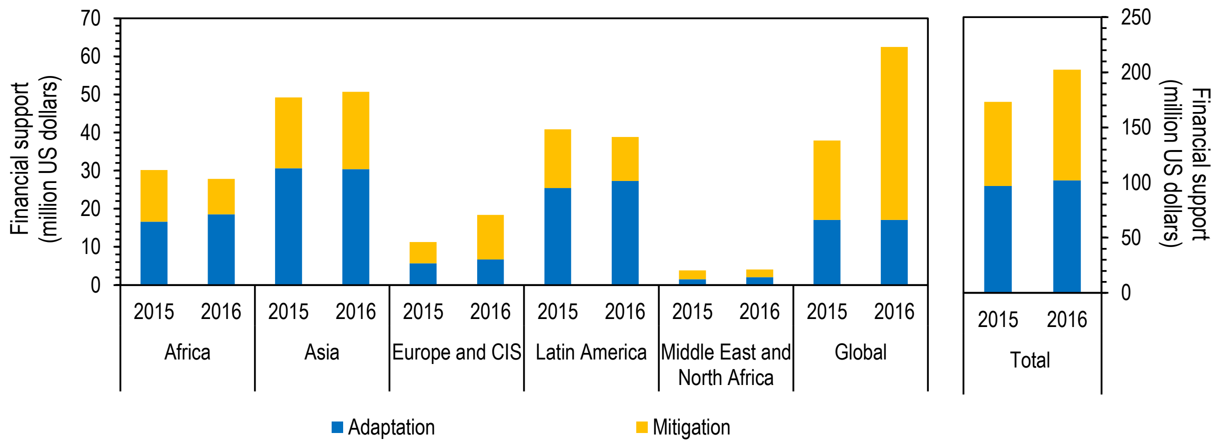


Fig. 92 > Swiss international public climate finance, including bilateral contributions and climate specific contributions disbursed to multilateral institutions, 2015 and 2016.



Tab. 44 and Tab. 45 include aggregated data per region. The BR CTF tables contain more disaggregated data on the country level, where possible. Switzerland does not provide activity-level information in the BR CTF tables. An additional administrative burden would arise and a high risk of errors when entering the data manually. In addition, Switzerland is of the view that activity-level data within the national communication and the BR CTF tables (with the current technical set-up) is difficult to read and interpret. However, given the relevance of increased transparency and to illustrate the diversity of projects, programmes and regions of Swiss support for climate action in developing countries, a full list of all climate-relevant projects is provided in a supplementary document named 'List of all Swiss projects and programmes to support climate action in developing country Parties (activity level, 2013–2016)'. The table also indicates in detail all sectors, which have benefitted from each of the activities, since it is not possible to give a clear indication of sectors in the BR CTF tables due to aggregation.

7.2 Technology development and transfer

Numerous Swiss programmes and projects, which support developing countries in their endeavours to mitigate and adapt to climate change, contain a technology development and/or transfer component. Technology development and transfer are critical means of implementation to ensure the sustainability of a project or programme. This is particularly true in the area of infrastructure financing and the development of local markets and products.

Switzerland provides support for technology development and transfer through the below mentioned activities and measures in line with its commitment under Article 10, paragraph c, of the Kyoto Protocol as well as Article 4, paragraphs 3 and 5, of the Convention.

7.2.1 Importance of and measures to promote 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 various areas 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. Some of these climate relevant Swiss private sector activities are supported by the Swiss export promotion agency 'Switzerland Global Enterprise' (*www.s-ge.com*) through its Swiss business hubs in strategic export markets. 'Switzerland Global Enterprise' is mandated by the Swiss Confederation to make information on Swiss Cleantech companies available in a publicly accessible database (*www.s-ge.com/cube*). This database may be used to identify the Swiss partners for environmentally sound solutions. Many companies registered in the database are active in developing countries. 'Switzerland Global Enterprise' is also contributing to some long-term cooperation projects aiming at the same time to add value for developing country Parties and for exporting Swiss companies. Examples of such long-term cooperation projects are described in a brochure published by the Swiss Federal Office of Energy, the Swiss Federal Office for the Environment, and the Swiss State Secretariat for Economic Affairs[47].

Another important service for private technology suppliers is the Swiss Export Risk Insurance (*www.serv-ch.com*). The Swiss Export Risk Insurance is traditionally very important for Swiss exports e.g. in the context of new hydropower schemes. Through the support of the export of climate friendly technologies by Swiss companies to developing countries, Switzerland contributes to the commitment of Parties under Article 4, paragraph 5, of the Convention.

7.2.2 Role of the public sector in technology transfer

Successful technology transfer uses the know-how, innovation and financing capacity of the private sector. Switzerland is supporting various initiatives in the area of technology development and transfer, targeting developing and transition countries as part of its development cooperation. Switzerland is convinced that the following elements need to be taken into consideration by governments to foster technology transfer and development:

- Creating a sound trade framework: Reduce custom tariffs and non-tariff barriers;
- Creating an enabling investment framework: Protect private property, intellectual property rights (IPR), reduction of administrative hurdles for companies, fight against corruption; legal stability, security, appropriate energy tariff setting, etc.;
- Strengthening 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 sharing of information in order to prepare industry and corporations in developing countries to deal with the challenges of global production chains and new technologies;
- Realising pilot and demonstration projects.

7.2.3 Measures promoting the transfer of, access to and deployment of climate-friendly technologies

In line with the above mentioned elements, Switzerland has implemented several measures to promote, facilitate and finance the transfer of, access to and the deployment of climate-friendly technologies for the benefit of developing country Parties and for the support of the development and enhancement of endogenous capacities and technologies of developing country Parties. Several of these measures are highlighted below.

Platform for the promotion of renewable energy and energy efficiency in international cooperation (REPIC)

Under the Swiss foreign policy on energy of 2008 the Swiss Federal Council has mandated the relevant ministries (i) to increase their engagement regarding promotion of renewable energy and energy efficiency in the programmes of development cooperation, (ii) to foster public private partnerships for sustainable energy projects, and (iii) to increase relevant contributions to multilateral development banks.

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[47] *https://www.s-ge.com/sites/default/files/cserver/publication/free/cleantech-broschuere-s-ge.pdf*

In line with this decision, Switzerland has deepened its interministerial coordination through a number of institutional arrangements. The interdepartmental platform on Renewable Energy and Energy Efficiency Promotion in International Cooperation (REPIC)[48] is specifically targeting technology transfer and development in the energy sector. Beyond enhancing knowledge and coherence, REPIC offers seed money, capacity building and technical advice for promising climate change initiatives during the pre-competitive phases of project development, for technology and for market testing. A project example is depicted in Tab. 46.

Tab. 46 > Platform for the promotion of renewable energy efficiency in international cooperation (REPIC).

Project/programme title:
Pilot Cycle MENA Energy Award, inspired by the European Energy Award (funded with REPIC seed money).

Purpose:
Inspired by the European Energy Award, a pilot cycle for the North Africa and Middle Eastern regions (MENA) shall be developed and introduced in Morocco; branded the 'MENA Energy Award', the project is intended to ultimately increase energy efficiency in the building sector of the target region.

Recipient country	Sector	Total funding	Years in operation
Morocco	Buildings	150'000 Swiss francs	2012–2014

Description:
The 'European Energy Award', known as 'Energy City', in Switzerland, is a label as well as a planning instrument and above all, is a process that leads municipalities to sustainable local energy policies. For North Africa a similar award has been developed and introduced in Morocco under the name 'Jiha Tinou/MENA Energy Award'. Through this pilot project, the MENA Energy Award structure was built and methodological tools (action plans, evaluation tools) were adapted to local conditions as well as applied in three different pilot municipalities.

Factors that led to project/programme's success:
The Institute for Development, Environment and Energy knew the context in Morocco very well. The Communal Labels Ltd., as the Forum European Energy Award's Secretariat, had considerable know-how in the Energy City/eea process, as well as in its introduction and adaptation for a new country. It had already accompanied numerous European countries in this process.

Technology transferred:
The European Energy Award, also known as the Energy City label, a planning instrument process that leads municipalities to (more) sustainable local energy policies.

Impact on greenhouse gas emissions/sinks:
The project achieved much success both at the national and local level. This includes designing the Jiha Tinou strategy, its pilot phase, and the MENA Energy Award Morocco-specific procedure and tools; assisting in the creation of a national governance structure; forming and assisting local Energy Teams and their local support structures; facilitating implementation of 17 demonstration projects; organising eight conferences, 14 training sessions, and 20 technical workshops; and producing 96 tools, briefing notes, and analytical papers. Given the positive feedback of the pilot phase in Morocco, the MENA Energy Award process is considered being replicated in other areas of North Africa and Middle Eastern regions, notably in Tunisia.

Cleaner production and resource efficiency in the construction sector

The building and construction sector has a large potential for climate change mitigation and adaptation measures. Switzerland has been active in this area domestically and is engaged in the transfer of technology and capacity building for multiple years.

Tab. 47 > Low Carbon Cement Project.

Project/programme title:
Low Carbon Cement Project.

Purpose:
Low-carbon cement is recognised as cement suitable for general construction; measures to establish low-carbon cement in the market as mainstream cement type are initiated.

Recipient country	Sector	Total funding	Years in operation
India, Cuba, Global	Building	4'092'000 Swiss francs	2014–2017

Description:
The project aims to enable the recognition of a new low carbon cement type (Limestone Calcined Clay Cement – LC3) as suitable for general construction and initiate its establishment in the market. It has two components:

- Undertaking research and development to establish a standard that will allow widespread application of LC3. This includes studying the composition and availability of raw material, blend proportions and mechanical properties as well as the new cements' performance and durability;
- Engaging with various stakeholders in the cement industry to inform them about the results of the research and to jointly develop the expertise for establishing LC3 as a mainstream product in the market.

Implementing Partners of the project include: Swiss Federal Institute of Technology in Lausanne, Switzerland; Indian Institute of Technology, Delhi; Indian Institute of Technology, Madras; Indian Institute of Technology, Bombay; Technology and Action for Rural Advancement, India; Centro de Investigación y Desarrollo de Estructuras y Materiales, Cuba.

Factors that led to the success of the project/programme:

- Trilateral collaboration between Indian, Swiss and Cuban universities;
- Close collaboration with public and private stakeholders; the project was able to put the subject of Low Carbon Cement on the agenda of governments as well as global cement companies;
- Strong presence at international conferences: The project introduced LC3 prominently at several national and international conferences (e.g. UNFCCC COPs,

[48] http://repic.ch/repic-en

United Nations HABITAT 3 Conference);
- Collaboration with different global initiatives and programmes. Cement Sustainability Initiative of the World Business Council on Sustainable Development and the Sustainable Building and Climate Initiative of the United Nations Environmental Programme;
- Contribution to a United Nations Environment Programme Report (2016) on Eco-efficient Cements, available at *http://www.nanocem.org/fileadmin/nanocem_files/documents/misc/2016-UNEP_Report.pdf*.

Technology transferred:
A new low carbon cement type (LC3) was researched and tested jointly between the different involved universities and institutions.

Impact on greenhouse gas emissions/sinks:
During the production process of LC3, up to 30 per cent of CO_2 emissions can be saved in comparison to ordinary Portland Cement.

Climate Technology Centre and Network

The Climate Technology Centre and Network is part of the UNFCCC Technology Mechanism. The Mechanism consists of two complementary bodies: the Technology Executive Committee, whose focus is to develop technology policies and recommendations to support country efforts, and the Climate Technology Centre and Network, which provides technology implementation at the request of developing countries. The Climate Technology Centre and Network ensures its accountability to the UNFCCC Conference of Parties through the oversight of the Climate Technology Centre and Network Advisory Board.

Tab. 48 > Climate Technology Centre and Network.

Project/programme title:
Climate Technology Centre and Network.

Purpose:
The Climate Technology Centre and Network promotes the development and transfer of climate technologies at the request of developing countries for energy efficient, low carbon and climate-resilient development.

Recipient country	Sector	Total funding	Years in operation
Global	Multi sector	4 million US dollars	2016–2019

Description:
The Climate Technology Centre and Network fosters technology development and transfer across numerous adaptation and mitigation sectors by providing three key services:
- Technical Assistance: The Climate Technology Centre and Network provides technical assistance and capacity building in response to requests submitted by developing countries via their National Designated Entities. Upon receipt of such requests, the Centre mobilises its global Network of climate technology experts to design and deliver a customised solution tailored to local circumstances;
- Knowledge Sharing: Through regional forums, publications, an online portal, and its Incubator Programme, the Climate Technology Centre and Network creates environments for capacity building and knowledge sharing on climate technology solutions. The Centre engages its Network and NDEs in highlighting technology best practices, south-south transfer examples, and learning from existing technical assistance experiences;
- Collaboration and Networking: The Climate Technology Centre and Network brings together a diverse global community of climate technology users and providers, decision makers, and funders to identify barriers, share best practices, and identify matchmaking opportunities. Under the umbrella of the UNFCCC Technology Mechanism, Network members gain the opportunity to showcase relevant technologies, policies and practices, and to facilitate their deployment in developing countries.

Factors that led to project/programme's success:
Key factors for programme success are the well-established and still growing network of climate technology experts which will help developing countries to design and develop mitigation and adaptation activities with a strong focus of technology implications. Furthermore the demand driven, bottom-up approach strengthens ownership on the side of the beneficiaries.

Technology transferred:
The main purpose of the Climate Technology Centre and Network is the provision of technical assistance, capacity building and knowledge sharing within the sphere of climate technologies. For more information see the description of the project.

Impact on greenhouse gas emissions/sinks:
The impact on greenhouse gas emissions cannot be calculated. Climate Technology Centre and Network is a mechanism that helps to design and develop projects and does not finance the concrete project implementation.

Resource Efficient and Cleaner Production

The joint Programme of the United Nations Industrial Development Organisation and the United Nations Environment Programme on Resource Efficient and Cleaner Production (RECP) aims to improve the overall resource efficiency and environmental performance of enterprises and thereby to contribute to climate change mitigation. By supporting this programme, the Swiss State Secretariat for Economic Affairs contributes to sustainable industrial development and sustainable consumption and production through the greater uptake of RECP by businesses, governments, financial institutions and other stakeholders.

Tab. 49 > Resource Efficient and Cleaner Production.

Project/programme title:
Global Programme on Resource Efficient and Cleaner Production in developing and transition countries (RECP).

Purpose:
The RECP aims at enhancing the resource productivity, competitiveness and environmental performance of small and medium enterprises in participation countries.

Recipient country	Sector	Total funding	Years in operation
Global	Multi sector	16.5 million Swiss francs	2011–2018

Description:
The objective of the RECP is to improve resource productivity and environmental performance of businesses and other organisations and thereby contribute to the promotion of sustainable industrial development and Sustainable Consumption and Production in the participating countries. The Programme includes four intermediate outcome categories each of which contribute towards the overarching outcome, both individually as well as synergistically:

- RECP Service Delivery Network: enhanced RECP services delivery capacity, through National Cleaner Production Centres, National Cleaner Production Programmes and other RECP service delivery mechanisms, leading to effective networking and peer learning within a network of competent nationally-oriented initiatives that deliver quality and value-adding RECP services which respond to the needs of enterprises and other organisations;
- Thematic RECP Applications: Implementation of RECP by businesses and other organisations with verified resource use, environmental, economic and other societal benefits;
- RECP Incentives: Mainstreaming of RECP in relevant government policy, regulations and enterprise finance, leading to an effective enabling environment for businesses to implement RECP;
- Innovation Capacity: Strengthening of national capacities for implementation of Environmentally Sound Technologies and sustainable product developments.

Factors that led to project/programme's success:

- In-plant assessments of the different resource streams offer opportunities for improvement and learning;
- Buy-in and ownership of the host country;
- Strengthened implementation capacities of national stakeholders;
- Strengthened awareness of resource efficiency issues.

Technology transferred:
Technology transfer in the context of the RECP global programme encompasses know-how and services as well as organisational and managerial procedures. Furthermore, the programme supports recipient countries to develop an institutional framework that enables the transfer of climate-related technologies. The main focus lies on technical assistance and the build-up of local know-how and expertise.

Impact on greenhouse gas emissions/sinks:
In the year 2016, the activities in the context of the RECP global programme saved or avoided emissions of about 288'440 tonnes of CO_2 equivalents.

Multilateral engagement of Switzerland in the area of technology transfer and development

Besides its bilateral projects that oftentimes contain an integrated technology development and transfer component, Switzerland also contributed to specific technology development and transfer funds such as the Climate Technology Centre and Network (four million Swiss francs, see Tab. 48), the Special Climate Change Fund (4.5 million Swiss francs as well as several other funds and multilateral organisations, which are active in the area.

7.2.4 Quantification of all activities related to technology transfer

Due to the integrated character of the bilateral technology development and transfer support measures of Switzerland, it is not possible to single out and quantify the respective components. In addition, it would not do justice to the integrated approach underpinning Switzerland's climate change interventions. Therefore, the technology development and transfer components of Swiss-funded projects are not systematically identified in this report.

There is internationally no clear understanding and no consensus on how Parties should quantify their technology transfer components within climate-relevant projects. The lack of consensus prevents a comparison of quantifiable data. Switzerland is of the opinion that qualitative information therefore provides much more content to exchange on lessons learnt and improve the technology transfer and overall development support.

If Switzerland were to isolate the technology transfer components of its climate-related activities, it would need to fundamentally redesign its entire national reporting system. An important corollary would be that all project managers both at the headquarters and in the field offices would have to estimate the technology transfer components in the planning phase of their projects. This would considerably increase the administrative burden and reduce the resources available for project implementation, ultimately diminishing the climate impact on the ground.

Based on concrete project examples (see section 7.2.3), Switzerland will therefore continue to report on its technology transfer activities in qualitative terms by emphasising their integrative character.

7.3 Capacity building

Capacity building is an essential component of almost all Swiss programmes and projects, which support developing countries in their endeavours to mitigate and adapt to climate change. Capacity building is critical for the successful and effective implementation of climate measures and helps to ensure the sustainability of any project or programme. However, in order to scale up, appropriate set-ups and corresponding tools are needed. Switzerland therefore strives to promote a cooperative model among different actors and has invested considerable efforts in developing a user-friendly tool that helps in mainstreaming climate change both at the strategic as well as at the operational level.

Due to the highly integrated character, it is not possible for Switzerland to single out the capacity-building components of all its development cooperation projects and programmes. Moreover, it would not do justice to the integrated approach underpinning Switzerland's climate change interventions. Therefore, capacity-building components of Swiss-funded projects are not systematically identified in this report. Nevertheless – and for illustrative purposes – various project examples given below showcase how the integrated approach plays out.

Environment and Social Risk Management in Sub-Saharan Africa

In most countries, businesses and individuals do not pay for the negative environmental and social effects they cause. Hence, social and environmental risks do usually not inform the development of business plans as well as daily operations. The Environmental and Social Risk Management Programme of the International Finance Cooperation aims to address this problem. The programme is based on the assumption that financial institutions can play a key role when it comes to pushing change in the market because financial institutions are in a position to influence business behaviour through their ability to allocate capital by lending money to companies.

Tab. 50 > Environment and Social Risk Management in Sub-Saharan Africa.

Project/programme title:
Environmental and Social Risk Management for financial institutions in Sub-Saharan Africa.

Purpose:
The overall objective of the programme is to increase the uptake of environmental and social standards by financial institutions in the Sub-Saharan Africa region. This is expected to lead to an improvement in environmental and social performance of local businesses in the long term.

Recipient country/region	Targeted area
Sub-Saharan Africa (Ghana, Nigeria, South Africa)	Adaptation

Description:
The programme has just started, hence an overview of the planned capacity building support is provided:

- Training and advisory services make the regulator (mainly the central bank) more effective in dealing with environmental and social issues. In particular, the regulator will be supported in revising existing and designing new environmental and social risk management policies and procedures;
- Development of material and manuals which can be used for environmental and social risk management training;
- Development of sector specific guidelines that fit the relevant country context;
- Provision of country specific environmental and social information to the public, mainly through the development of country specific portals of the FIRST for Sustainability website (*www.firstforsustainability.org*).

It is expected that those activities will lead to:

- The development of effective regulatory policies, procedures and standards in order to create an environment which is conducive to the uptake of ESRM systems;
- The build-up of relevant environmental and social expertise of local consultants in the markets of the programme countries. This expertise can be used/ purchased by financial institutions in order to implement their own Environmental and Social Risk Management Programme systems;
- Increased awareness on environmental and social risks, increased level of publicly available information on environmental and social issues as well as improved information dissemination among financial institutions and other stakeholders.

Environment and Social Risk Management in Asia

The objective of the programme is to promote the adoption, implementation and enforcement of internationally agreed environmental and social standards with a focus on boosting the corresponding audit performance and thus increase climate-friendly investments in the East Asia Pacific region. A special focus is given to Vietnam and Indonesia. The programme supports these countries in their endeavours to develop, implement and enforce a set of practical risk management guidelines applicable to financial institutions. Specific knowledge and capacity building is provided in order to develop, implement and enforce a set of practical environmental risk management guidelines, to individually assist financial institutions and to ramp up the environmental and social risk management consulting and training capacity.

Tab. 51 > Environment and Social Risk Management in Asia.

Project/programme title:
Environment and social risk management for financial institutions in Asia.

Purpose:
The purpose of the programme is to develop the capacities of financial regulators and institutions in order to create effective policies as well as sound, efficient, and responsive financial institutions that are environmentally and socially sustainable, thus helping to achieve substantial business benefits.

Recipient country/region	Targeted area
East Asia Pacific with focus on Indonesia and Vietnam	Adaptation

Description:
The programme primarily provides capacity building support for financial regulators and institutions as well as other stakeholders:

- Training and advisory services make the financial regulators more effective in dealing with environmental and social issues. In particular, the financial regulators are supported in revising existing and designing new environmental and social risk management policies and procedures;
- Within the banking sector, the programme supports the development of material and manuals for the E&S risk management training;

- For the public, specific E&S information and for consultants, in-depth advisory services are provided;
- Sector and country specific guidelines are developed.

The activities shall lead to:

- The development of effective regulatory policies, procedures and standards in order to create an environment which is conducive to the uptake of ESRM systems;
- Relevant environmental and social expertise within the banking sector, including to the benefit of consultants;
- In general, increased awareness on environmental and social risks, increased level of publicly available information on environmental and social issues as well as improved information dissemination within the banking sector and other stakeholders.

Climate, Environment and Disaster Risk Reduction Integration Guidance (CEDRIG)

While global aspirations to effectively tackle climate change both via mitigation and adaptation measures are high, the related concrete expectations appear more difficult to be met. This situation is also due to a lack of 'do-how' by many actors. This is why Switzerland has undertaken considerable efforts to develop, test and now disseminate and apply a user friendly tool that helps to mainstream climate change in strategies, programmes and projects of different concerned sectors. Moreover, acknowledging the close interlinkages between climate change, disaster risk reduction and the environment (natural resources), the Swiss Agency for Development and Cooperation has developed a comprehensive tool that integrates all three aspects.

Tab. 52 > Climate, Environment and Disaster Risk Reduction Integration Guidance (CEDRIG).

Project/programme title:
Climate, Environment and Disaster Risk Reduction Integration Guidance (CEDRIG).

Purpose:
To help integrate aspects of climate change, environmental degradation and disaster risk reduction into development cooperation at strategic, programmatic and operational levels.

Recipient country/region	Targeted area
Global	Multiple areas

Description:
CEDRIG is a practical and user friendly tool developed by the Swiss Agency for Development and Cooperation. It is meant to systematically integrate climate, environment and disaster risk reduction into development cooperation and humanitarian aid in order to enhance the overall resilience of systems and communities. CEDRIG helps to reflect whether existing and planned strategies, programmes and projects are at risk from climate change, environmental degradation and natural hazards, as well as whether these interventions could further exacerbate greenhouse gas emissions, environmental degradation or risks of natural hazards. The tool is open source and offers three independent modules.
CEDRIG follows an integrated approach to assess the risks for and the unintended potential negative impacts of a new strategy, programme or project. By its application, existing or planned interventions will become more climate, environment and risk smart. CEDRIG is divided into three parts: (i) CEDRIG Light helps to decide whether a detailed risk and impact assessment must be conducted or not, (ii) in case of a 'yes', CEDRIG Strategic is used to analyse strategies and programmes, and (iii) CEDRIG Operational is applied for projects.
A series of CEDRIG workshops have been carried out in different countries such as e.g. in Benin, Bosnia-Herzegovina, Burkina Faso, Bolivia, Morocco, Nepal, Nicaragua and Peru. In most instances, interested and concerned actors from neighbouring countries were invited to participate, too. As a result people and institutions were trained and respective strategies, programmes and projects revised by including aspects to address climate change, disaster risk reduction and the environment.

One UN Climate Change Learning Partnership (UN CC:Learn)

Tab. 53 > UN CC:Learn.

Project/programme title:
One United Nations Climate Change Learning Partnership (UN CC:Learn).

Purpose:
At the global level, the partnership supports knowledge sharing, promotes the development of common climate change learning materials, and coordinates learning interventions through collaboration of United Nations agencies and other partners. At the national level, UN CC:Learn supports countries in developing and implementing national climate change learning strategies.

Recipient country/region	Targeted area
Global with selected partner countries	Multiple areas

Description:
The UN CC:Learn is a collaborative initiative involving more than 30 multilateral organisations. It supports countries in designing and implementing country-driven, results-oriented and sustainable learning to address climate change. The initiative was launched at the 2009 Copenhagen Climate Change Summit with substantial funding from the Swiss Agency for Development and Cooperation. UN CC:Learn is included in the 'One United Nations Climate Change Action Framework' of the United Nations System Chief Executives Board for Coordination. The Chief Executives Board for Coordination framework aims at maximizing existing synergies, eliminating duplication and optimizing the impact of the collective effort of UN organisations in combatting climate change. As such UN CC:Learn directly contributes to the implementation of Article 6 of the UNFCCC on education, training and public awareness, as well as the Doha Work Programme.
So far, UN CC Learn has supported 9 pilot countries in developing and implementing their climate change learning strategies (Benin, Burkina Faso, Dominican Republic, Ethiopia, Ghana, Malawi, Niger, Indonesia, and Uganda). It has further developed a free introductory online course on climate change which is now available in English, French, Spanish, Portuguese, Khmer, Thai and Mandarin. So far over 80 thousand people have registered and more than 10 thousand have successfully completed the training with a certificate. Additional courses and training materials have been developed linked to the following thematic focus areas: Climate change science, climate finance, international climate negotiations, adaptation planning, climate change and health, climate change and forests, and climate change education for children.

7.3.1 Reporting of activities related to capacity building

As mentioned above, due to the integrated character of the bilateral capacity-building support measures of Switzerland, the necessary data to single out and quantify the respective capacity-building components is not available. In addition, a reporting of these components in isolation would not do justice to the integrated approach underpinning Switzerland's climate change interventions. Therefore, the capacity-building components of all Swiss-funded projects are not in isolation systematically identified and quantified in Switzerland's national communication or biennial report (nor in the corresponding BR CTF tables).

If Switzerland were to isolate the capacity-building components of all its climate-related activities, it would need to fundamentally redesign its entire national reporting system.

Switzerland will therefore continue to report on its capacity building activities in qualitative terms, by emphasising the integrative character based on concrete project examples.

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8 Research and systematic observation

8.1 General policy on and funding of research and systematic observation

8.1.1 Research structures and funding

According to the Federal Act on the Promotion of Research and Innovation (*Swiss Confederation*, 2012), 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[49]. 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.

Funding

Swiss research is mainly funded by the National Science Foundation, by the European Union and the European Cooperation in Science and Technology COST.

In 2017, the National Science Foundation provided funds for about 130 climate-relevant projects with a total annual budget of about 20 million Swiss francs. The average funding per project was about 150 thousand Swiss francs per year. In addition, 55 European Union research projects in the field of climate and global change, including mitigation and adaptation, receiving about 23 million Swiss francs were pursued by Swiss research institutions. Another 86 projects were funded by the European Cooperation in Science and Technology with a total amount of 15.3 million Swiss francs for all projects and their whole funding period.

In the context of the action plan ‘Coordinated Energy Research Switzerland’, which forms part of Switzerland’s Energy Strategy 2050, 72 million Swiss francs were allocated for the period 2013–2016 to build up capacities in energy research. In autumn 2016, the Swiss Parliament re-approved the newly created Swiss Competence Centres in Energy Research (SCCER) for a second period of four years (2017–2020) with a total budget of 119 million Swiss francs.

Research structures

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-related research in Switzerland can be divided into several categories:

- National research centres (Oeschger Centre for Climate Change Research, Centre for Climate Systems Modelling, Centre for Development and Environment);
- Climate-relevant energy research, including eight dedicated competence centres (SCCER);
- Individual research projects (funded by the National Science Foundation or government institutions);
- Participation in international research programmes (European Union, European Cooperation in Science and Technology, World Climate Research Programme, Future Earth) by researchers at various universities, the Swiss Federal Institutes of Technology in Zurich and Lausanne, universities of applied sciences, and private and public research organisations;
- Collaborations with international research centres and organisations (European Centre for Medium-Range Weather Forecasts, European Organisation for the Exploitation of Meteorological Satellites, World Meteorological Organisation, Intergovernmental Panel on Climate Change).

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[49] *https://www.ressortforschung.admin.ch/rsf/de/home/themen.html* (German), *https://www.ressortforschung.admin.ch/rsf/fr/home/themen.html* (French)

Oeschger Centre for Climate Change Research

The Oeschger Centre for Climate Change Research at the University of Bern is a leading institution for climate research based at the University of Bern. It was founded in 2007 and is named after Hans Oeschger (1927–1998), a pioneer of modern climate research who worked at the University of Bern. The Oeschger Centre for Climate Change Research brings together researchers from eleven institutes and four faculties and carries out interdisciplinary research that is at the forefront of climate research. Through the cooperation of the fields of natural, human and social sciences as well as economics and law ways are sought to deal with the various levels of global climate change: regionally embedded and globally linked.

The University of Bern has a tradition in climate research that spans more than 150 years and was the leading house of the former National Centre of Competence in Research Climate. Approximately 40 professors teach and conduct research in various areas that deal with questions on climate change. Approximately 35 PhD theses on climate change are submitted each year.

On the one hand, the Oeschger Centre for Climate Change Research examines the long-term development and dynamics of the climate system, as well as the present and future climate. On the other hand, the effects of climate change on important land ecosystems as well as on the economy and society are investigated. In particular, strategies are being developed to adapt to and to mitigate climate change.

Centre for Climate Systems Modelling at the Swiss Federal Institute of Technology in Zurich

In November 2008, the Swiss Federal Institute of Technology in Zurich has inaugurated the Centre for Climate Systems Modelling, a joint venture involving the National Centre of Competence in Research Climate researchers from the Swiss Federal Institute of Technology in Zurich and partner institutions. The centre's overarching and integrating theme is 'multi-scale interactions within the climate system'. The Centre for Climate Systems Modelling receives funding from the foundation of the Swiss Federal Institute of Technology in Zurich and the Swiss Federal Institute of Technology in Zurich itself, MeteoSwiss, the Swiss Federal Laboratories for Materials Science and Technology, and Agroscope Reckenholz-Tänikon.

The main objectives of the research activities at the Centre for Climate Systems Modelling are to improve the understanding of the earth's climate system, and the capability to predict it over timescales spanning from days to centuries. Processes within all the sub-components of the earth system covering a large spectrum of spatio-temporal scales are investigated. The Centre for Climate Systems Modelling provides an umbrella for and hosts a number of research projects. Ongoing research projects at the Centre for Climate Systems Modelling are:

- Swiss climate scenarios CH2018;
- Cloud-resolving climate modelling;
- High-performance computing;
- Paleo fires from high-alpine ice cores.

Centre for Development and Environment

Research at the Centre for Development and Environment at the University of Bern (earlier hosting the former National Centre of Competence in Research North-South) involves a number of topics that are relevant for climate issues, especially international collaboration in mitigation, adaptation and capacity-building actions. Its research focuses on three key areas in the essential dimensions of sustainable development: land resources, socio-economic transitions, and sustainability governance. Each of the three thematic foci is addressed by a cluster comprising related projects as well as staff members. These clusters serve as theme-focused meeting grounds for partners of the Centre for Development and Environment from research, policymaking, and development cooperation. At the same time, they anchor research in specific scientific disciplines and communities. Across these disciplines the Centre for Development and Environment offers teaching and engages in research on education for sustainable development. Thematic clusters are the following;

- Land resources;
- Socio-economic transitions;

- Sustainability governance;
- Education for sustainable development.

Activities in international research programmes and assessments

After having been temporarily excluded from participation in the new European Union research framework programme Horizon 2020 for political reasons, since 1 January 2017 Switzerland again is integrated in Horizon 2020 as an associated country, contributing to the overall European Union research budget. Thus, Swiss projects are financed directly by the European Union research institutions. At the same time, Swiss researchers can take on a leading role in any European Union research project.

Switzerland participates in various international research programmes (e.g. World Climate Research Programme, Future Earth) through individual research projects, research conducted at federal institutes and within coordinated programmes (Climate Research Centres), the operation of climate monitoring stations and networks (in collaboration with the Global Climate Observing System, GCOS) as well as maintaining calibration and data centres. In these contexts, Switzerland also plays an active role in contributing to the free and open international exchange of data and information as well as capacity building. More information on opportunities and gaps with regard to international collaboration may be found in section 8.3.

Switzerland contributes significantly to a number of ‘Global Research Projects’ of Future Earth (former ‘core projects’ of the International Geosphere Biosphere Programme, IGBP). The international project offices for the Past Global Changes (PAGES) project, the Global Mountain Biodiversity Assessment, the international research programme on biodiversity science (bioDISCOVERY) as well as the Global Land Project are all hosted by Swiss research institutions and at least partly funded by Switzerland. Swiss scientists are involved in many other Global Research Projects within Future Earth. Switzerland also contributes substantially to capacity building in transdisciplinary research methods within Future Earth through its ‘Network of Transdisciplinarity’ (td-net).

Furthermore, Switzerland is also hosting and funding the Mountain Research Initiative (MRI), a multidisciplinary scientific organisation that addresses global change issues in mountain regions around the world including developing countries. The MRI strives to support the design of integrated research strategies and programmes that further the understanding of the impacts of global change in mountain areas and that lead to tangible results for stakeholders and policy-makers.

A number of Swiss researchers were involved (many of them in leading positions) in the preparation of the fifth assessment report of the Intergovernmental Panel on Climate Change and will be involved in the preparation of the sixth assessment report (AR6) and the corresponding special reports. Presently, a Swiss professor, Prof. Dr. Andreas Fischlin, is a vice chair of Working Group II of the Intergovernmental Panel on Climate Change.

Individual research projects

The majority of research projects are individual projects funded by the Swiss National Science Foundation or by government agencies such as, e.g., the Swiss Federal Office for the Environment. For the projects funded by the Swiss National Science Foundation, the distribution of funding between the different disciplines is shown in Tab. 54.

Tab. 54 > Number of climate-relevant projects funded by the Swiss National Science Foundation in 2017, assigned to groups of scientific disciplines. Most projects are assigned to more than one group.

Mathematics, physics and chemistry	27 projects
Engineering (incl. agriculture and forestry)	41 projects
Environmental sciences	142 projects
Earth sciences	96 projects
Biological sciences and ecology (incl. biodiversity)	57 projects
Social, political, legal and economical	47 projects

Energy research

Switzerland’s energy research and development (R&D) policy aims to (i) contribute to a secure and sustainable energy supply, (ii) continue the strong position of Switzerland as a market place for energy technology, and (iii) ensure the high quality of its energy research. International cooperation and efficient implementation of research findings are a matter of priority. Within the federal administration, the support of energy research is organised by the Swiss State Secretariat for Education, Research and Innovation, the Swiss Federal Office of Energy and the Swiss Commission for Technology and Innovation. Energy R&D policy is laid down in the Federal Energy Research Masterplan (*CORE*, 2016) developed every four years by the Swiss Federal Energy Research Commission (CORE), a high-level advisory body to the Swiss government consisting of 15 members from industry, academia and politics.

By the beginning of 2018, the Swiss Commission for Technology and Innovation – currently an administrative unit of the federal administration – will be converted into Innosuisse, a new federal promotion agency for science-based innovation. Board members of Innosuisse were elected by the Swiss Federal Council in December 2016.

Energy Science Centre at the Swiss Federal Institute of Technology in Zurich

The Energy Science Centre (ESC) was founded in 2005 in order to facilitate cross-departmental collaboration, exploit synergies between complementary expertise, and strengthen research cooperation among industrial and academic partners in the energy field. In accordance with the overarching strategy of the ETH Domain[50] regarding energy science and technology, the ESC provides an umbrella for activities of the Swiss Federal Institute of Technology in Zurich in both research and teaching. It also serves as a platform for large-scale interactions with important stakeholders (industry, government, opinion leaders, and society in general).

The ESC synergistically combines key expertise in various disciplines to address large-scale problems and to engage in flagship projects. Such large, highly visible projects are centred on three large thematic areas, namely:

- Electric power generation and energy distribution;
- Energy for personal and freight transport systems;
- Energy for heating and cooling in domestic and industrial applications.

Energy Centre at the Swiss Federal Institute of Technology in Lausanne

Established in April 2006, the Energy Centre and the associated Energy Systems Management Chair of the Swiss Federal Institute of Technology in Lausanne intend to foster multidisciplinary research projects and networks to develop sustainable energy production, storage, transport, distribution and end-use systems and technologies. The main aims are:

- Facilitating and implementing strong interactions between the scientific community of the Swiss Federal Institute of Technology in Lausanne (laboratories and institutes) and the private sector (companies, etc.);
- Positioning the centre as a catalyst and partner in important R&D projects in Switzerland and abroad;
- Promoting high-quality teaching in areas related to energy issues (undergraduate and postgraduate studies, further education);
- Taking an active part in building and implementing energy-related strategies and policies in Switzerland and abroad;
- Implementing communication/information projects regarding energy issues for specific audiences;
- Disseminating energy-related information for the media.

ESI Platform at Paul Scherrer Institute

With the Energy System Integration (ESI) Platform, the Paul Scherrer Institute offers research and industry an experimental platform where promising approaches can be tested in all their complex connections and interrelations, with a focus on storing surplus power and using biomass efficiently (see also *www.psi.ch/media/overview-esi-platform*).

[50] http://www.ethrat.ch/en/eth-domain/overview

Swiss Competence Centres for Energy Research (SCCER)

Within the Energy Strategy 2050 the Swiss Parliament had approved the action plan ‘Coordinated Energy Research Switzerland’, the main goal of which was to build up capacities in energy research. As a consequence, eight Swiss Competence Centres in Energy Research (SCCER) have been established in 2014. In 2017, 1152 persons (423 of which are newly created positions) were active within the SCCER network. After 2020 it is foreseen to integrate the SCCER into the existing higher education network. In the following sections, the eight individual SCCERs are briefly presented.

Energy, Society and Transition (SCCER CREST[51]): The Competence Centre for Research in Energy, Society and Transition – CREST contributes to the energy transition in Switzerland by providing detailed, evidence-based recommendations on policies that help to reduce energy demand, foster innovation, and increase the share of renewables in a cost-efficient way. It covers the complete action area ‘economy, environment, law and behaviour’ with four lines of research that develop innovative concepts for energy policy, provide an in-depth analysis of drivers and barriers to energy efficiency, produce detailed strategies that help firms and regions in adjusting to the new energy systems, and develop novel assessment tools for policies and technological solutions. The SCCER CREST brings together research groups from almost all major Swiss research institutions and fills important gaps in the research landscape. It is one of the strongest research centres in this field worldwide, cooperates closely with partners from industry, public administration, and policy consulting, and works together closely with the technical SCCER.

Energy-Efficient Buildings and Districts (SCCER FEEB&D[52]): Buildings represent the largest share of energy demand in Switzerland. Heating, ventilation and air conditioning (HVAC) account for roughly 40 per cent of final energy demand. 32 per cent of national electricity demand is caused by buildings (HVAC, lighting, appliances, and space heating). Therefore, the goals of the Energy Strategy 2050 and those of Swiss climate policy can only be met if buildings become much more energy efficient relative to the current situation, and if the remaining energy demand is primarily met by renewable sources.

The vision of the SCCER Future Energy Efficient Buildings & Districts (FEEB&D) is to develop solutions for the Swiss building stock which will lead to a reduction of the corresponding environmental footprint by a factor of three by 2035 thanks to efficient, intelligent and interlinked buildings. The SCCER FEEB&D is paving the way to this vision by focusing on four research areas: Efficiency at Building Scale, Renewable Energy Systems from Building to District Scale, Energy Performance at Regional and National Scale, Diffusion of FEEB&D Technologies.

Mobility of the Future (SCCER Mobility[53]): The Swiss Competence Centre for Energy Research – Efficient Technologies and Systems for Mobility (SCCER Mobility) aims at developing the knowledge and technologies essential for the transition of the current fossil fuel based transportation system to a sustainable one, featuring minimal CO_2 output and primary energy demand as well as virtually zero-pollutant emissions. Innovation field A deals with components and devices: Capacity Area *CA A1* aims at new battery technologies, *CA A2* at optimal use of renewable chemical energy carriers for fuel cells and combustion engines and *CA A3* at the minimisation of vehicular energy demand (light-weighting and thermal management). Innovation field B composes of *CA B1* targeting infrastructure, logistics and ICT-systems and *CA B2* providing an integrated assessment of mobility systems. The programme aims at creating synergies at the interfaces of these five capacity areas serving as virtual research teams, composed of new and rededicated key research positions from the ETH Domain[54] and the universities of applied sciences. Many relevant Swiss and foreign companies are actively involved in various SCCER Mobility research projects.

New forms of heat and electricity storage (SCCER on heat and electricity storage[55]): The SCCER on heat and electricity storage is dedicated to research on:

[51] http://www.sccer-crest.ch

[52] http://www.sccer-feebd.ch

[53] http://www.sccer-mobility.ch

[54] http://www.ethrat.ch/en/eth-domain/overview

[55] http://www.sccer-hae.ch

- Thermal energy storage with a focus on buildings and processes by exploring advanced adiabatic compressed air storage (AA-CAES), pumped heat electric storage (PHES), high-temperature process heat;
- Advanced battery materials with focus on lithium and sodium type batteries. In terms of energy density, cost and the high explorative area of beyond lithium-ion technologies;
- Hydrogen production and storage by exploring emerging technologies in the field including redox flow batteries, radically lower cost catalysts, and high energy density liquid storage routes;
- Technology Interaction of Storage Systems exploring storage technology in a wider context to make the SCCER more powerful. Questions of technology interaction is part of the research, covering a wide range of aspects from socio-economic aspects to system integration and modelling;
- The development of advanced catalysts for CO_2 reduction (catalytic and electrocatalytic) aiming at an efficiency of >30 per cent and with a selectivity of >60 per cent for syngas/hydro-carbons.

Bioenergy Research (SCCER-BIOSWEET[56]): The SCCER-BIOSWEET develops and implements biomass valorisation technologies to make the Swiss energy turnaround happen. For 2050, the Federal Energy Strategy foresees a contribution of 100 petajoule from bioenergy to the final energy consumption. To meet this ambitious goal the current energy consumption from biomass needs to be doubled. The SCCER-BIOSWEET's research and development activities are designed accordingly. On the one hand, the technological goal is to exploit biomass resources to the highest sustainable extent. This is pursued by pushing the conversion and efficiency limits of existing bioenergy technologies, by improving the feedstock utilisation, by creating new and innovative biomass value chains, and by designing better integrated energy systems. On the other hand, the SCCER-BIOSWEET reaches out to promote alternative energy carriers, e.g. mobility or heat and power applications, and it offers knowledge to support the energy policy and market development.

Supply of electricity (SCCER-SoE[57]): The aim of the Swiss Competence Centre for Energy Research – Supply of Electricity (SCCER-SoE) is to carry out innovative and sustainable research in the areas of geo-energy and hydropower. The SCCER-SoE researches, develops, and tests new technologies and optimises existing infrastructures for energy production in the future. Working in close cooperation with the industry, the SCCER-SoE creates innovative research units, establishes technology platforms, invests in laboratories, and coordinates national as well as international research projects. These are financed by a number of different sources. As a national network, the SCCER-SoE brings together expertise from 30 Swiss scientific institutions, industrial enterprises, and federal agencies. Its activities are undertaken in coordination with the Swiss Federal Office of Energy. The SCCER-SoE is financed by the Swiss National Science Foundation and the Commission for Technology and Innovation. The latter is also responsible for the supervision of the SCCER-SoE.

Future Swiss Electrical Infrastructure (SCCER-FURIES[58]): SCCER-FURIES is the national competence centre focused on the upgrading of the Swiss electrical infrastructure. It addresses the power grid-related challenges raised by the Energy Strategy 2050 by providing the grid operators with intelligence-enhanced planning, monitoring and operation tools. The SCCER-FURIES envisions the enabling of seamless and sustainable powering of Swiss citizens' houses, businesses and communities, by developing and demonstrating with the Distribution and Transmission network operators the essential knowledge and technologies for a sustainable and stable electrical infrastructure of the future which integrates cleaner and reliable power supplies and storage facilities. Therefore, SCCER-FURIES' academic and industrial partners have identified and address the following main topics:

- Grid monitoring and dynamic control;
- Multi-terminal AC-DC transmission and distribution;
- Power electronics and switching;

56 http://www.sccer-biosweet.ch

57 http://www.sccer-soe.ch

58 http:/sccer-furies.epfl.ch

- Control of massive DG and distributed storage;
- Multi-energy grids;
- Power systems planning and architecture;
- Demand side response;
- Standardisation and grid control;
- Technologies for power systems components.

Efficiency of Industrial Processes (SCCER EIP[59]): The vision of the SCCER EIP is to develop the science and technology that allows Swiss industry to transition to a sustainable use of energy in its processes, to reduce greenhouse gas emissions and to ensure that the target to reduce total energy consumption by 14 terawatt-hours until 2050 is achieved while at the same time keeping the impacts on the economics of the corresponding processes to a minimum. The mission of the SCCER EIP is to develop novel technologies and materials that result in energy savings and to support implementation of energy efficiency.

Transport research

Swiss transport research is mainly carried out by the federal administration, the Swiss Federal Institutes of Technology in Zurich and Lausanne, and regionally by the cantonal universities. Outside the public domain, private research institutions such as consultancies and engineering companies 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 focus on external costs of transport, sustainable transport and road infrastructure construction.

Agricultural research

Research in the agriculture sector is coordinated by the Swiss Federal Office for Agriculture and to a large extent funded through the government framework research programme agriculture[60], supplemented by funding from the Swiss National Science Foundation and European Union Framework Programmes. Strategic guidance is provided by the Research Concept for Agricultural Research 2017–2020 (*FOAG*, 2016) and the Strategic Research Topics identified by Agroscope, one of which explicitly deals with climate change. The main goals of this research 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 Agroscope federal research stations, the Swiss Federal Institute of Technology in Zurich and various universities of applied sciences as well as the Research Institute of Organic Agriculture.

Forest research

Forest research in Switzerland is mainly carried out by the Swiss Federal Institute for Forest Snow and Landscape Research and the Swiss Federal Institute of Technology in Zurich. Additional forest-related research is carried out by groups at the Swiss Federal Institute of Technology in Lausanne and several universities. Applied forest research activities are carried out by the Bern University of Applied Sciences, the Zurich University of Applied Sciences and the University of Applied Sciences Rapperswil as well as by a few private institutions mainly mandated by federal or cantonal administrations. The research covers a broad variety of topics, but maintains a focus on sustainable forest management, protection against natural hazards, ecology and biodiversity. Climate impact research has started in the early 1990s, and is increasingly emphasizing adaptation measures.

To reduce uncertainty and to develop scientifically based recommendations for adaptive forest management, the Swiss government launched the 'forest and climate change' research programme[61] in 2009, which is now about to come to an

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59 http://www.sccer-eip.ch

60 https://www.ressortforschung.admin.ch/rsf/de/home/themen/forschung-nach-politischen-bereichen/landwirtschaft.html

61 https://www.wsl.ch/de/ueber-die-wsl/organisation/programme-und-initiativen/wuk.html

end. Particular emphasis was put on the influence of climate change on forest ecosystem services. High importance was also attributed to knowledge transfer of the findings on adaptive measures into existing forest management practice (*Pluess et al.*, 2016).

Key research insights are brought into forest practice and practical management by dedicated stakeholder-focused activities. The programme has provided numerous new insights into changes to Swiss forest ecosystems that are to be anticipated for the coming decades, and has considerably increased the attention of foresters to the topic of climate change, its likely impacts, and possible counter-measures. Although uncertainty persists as to which measures are to be implemented when, there is now broad agreement that the challenge of climate change needs to be taken seriously and must be considered in everyday planning activities.

Over the past years, multiple European Union projects with Swiss participation have addressed forest-related climate change impacts, among others including MOTIVE (Models for Adaptive Forest Management), BACCARA (Biodiversity and Climate Change – A Risk Analysis), ARANGE (Advanced Multi-Functional Forest Management in European Mountain Ranges), FunDivEurope (Functional Significance of Forest Biodiversity) and several actions within the European Cooperation in Science and Technology (e.g., EUMixFor, PROFOUND and SENSFOR).

The new platform SwissForestLab[62] is about to be founded. It unites all forest researchers nationally, aiming to provide a unique research platform and infrastructural network to assess the effects of a dynamically changing environment on forests and trees in Switzerland as well as worldwide. Initial research projects have been implemented in the course of 2017.

8.1.2 Systematic observation

The Global Climate Observing System (GCOS) is designed to ensure that the observations and information needed to address climate-related issues are obtained systematically and made available to all potential users, in accordance with the requirements of the UNFCCC. GCOS is co-sponsored by the World Meteorological Organisation, the Intergovernmental Oceanographic Commission (IOC) of UNESCO, the United Nations Environment Programme (UNEP), and the International Council for Science (ICSU). Switzerland’s contribution to GCOS has last been reported to the UNFCCC in the sixth national communication.

National GCOS coordination

Switzerland has a long-standing tradition of climate observation. Temperature and precipitation records extending over more than 150 years, the world’s longest total ozone series, glacier measurements dating back to the end of the 19th century and the 30-year anniversary of the World Glacier Monitoring Service form some of the highlights of the Swiss contribution to global climate monitoring. In Switzerland, the Swiss GCOS Office at MeteoSwiss is responsible for coordinating all climate-relevant measurements conducted by federal offices, research institutes, universities, and private companies. The Swiss GCOS Office also serves as the national focal point for the GCOS Programme. It was formally established at MeteoSwiss in 2006, following the Swiss Federal Council’s dispatch concerning the ratification of the Kyoto Protocol.

Since its establishment over a decade ago, the Swiss GCOS Office, together with its partner institutions, has undertaken a number of activities to coordinate climate observation in Switzerland and to ensure that a high-quality Swiss contribution to GCOS will continue to be made in the future. Activities included, for example, the elaboration of an inventory report of the most important climate observations and international data centres in Switzerland (*Seiz and Foppa*, 2007) as a basis for a request to the Swiss Federal Council for funding of the most important climate observations in Switzerland. In 2008, the Swiss Federal Council agreed to the request, hence putting selected essential climate variables and data centres on a sound financial basis. National coordination also includes the organisation of an annual national roundtable and outreach activities, such as maintaining a website (*http://www.gcos.ch*) and contributions to popular science articles.

62 http://www.envidat.ch/group/about/swissforestlab

The national climate observing system (GCOS Switzerland) also serves as the ‘observation and monitoring’ pillar for the national implementation of the Global Framework for Climate Services. The national implementation of the Global Framework for Climate Services is coordinated by the National Centre for Climate Services at MeteoSwiss (section 6.4.2).

Aligned with the schedule of the international GCOS programme and in close collaboration with its national partner institutions, the Swiss GCOS Office at MeteoSwiss has recently elaborated a new strategy for the GCOS Switzerland programme for the period 2017–2026 (*MeteoSwiss*, 2017a). While maintaining a priority on securing the most important long measurement series, particular emphasis will be put on promoting, e.g., the integration of new measurement techniques, an integrative monitoring approach across earth system cycles, and enhanced communication with stakeholders. The strategy will be implemented through actions by the entirety of the Swiss GCOS community, under the guidance of a GCOS Switzerland Steering Committee. The strategy update also involved the revision of the national GCOS Switzerland inventory report.

The following essential climate variables were newly included in the national GCOS Switzerland inventory report (*MeteoSwiss*, 2017b): river temperature, albedo, soil carbon, land surface temperature, and anthropogenic greenhouse gases. Furthermore, a new section on ancillary data (e.g. digital elevation models) was added, and a new overarching chapter on new methods of observation summarizes latest developments in climate observations (e.g. satellite observations).

8.2 Research

This section has been brought more closely in line with the structure as suggested by the revised UNFCCC reporting guidelines for preparation of national communications. Its contents were rearranged to best reflect circumstances and activities linked to the topic of research. In the following, some highlights, innovations and significant efforts in different fields are summarised.

8.2.1 Climate process and climate system studies, including paleoclimatic studies

New proxy data and reconstructions have been generated for the last millennium and the last interglacial, the so-called Eemian, which may be partly used as analogue for a 1.5 degrees Celsius warmer world (*Dahl-Jensen et al.*, 2013). In particular, it was possible to cover the entire last interglacial with an ice core drilled in Greenland, delivering insights into the local temperature evolution at that time as well as atmospheric greenhouse gas concentrations. Another highlight is a new multi-proxy reconstruction of the North Atlantic Oscillation, which also takes climate modelling results and variability into account (*Ortega et al.*, 2015). Furthermore, new proxy-based reconstructions for mid Holocene summer temperatures were produced for the Mediterranean, a highly sensitive region to forcing changes (*Samartin et al.*, 2017).

The influence of solar forcing variations on the past and future climate has been assessed in detail showing that a future grand solar minimum would reduce the greenhouse gas warming by 0.1 to 0.3 degrees Celsius. Further, research at the Oeschger Centre for Climate Change Research has provided new insights into volcanic forcing imprints on the climate system as well as socio-economic response to strong events like the Tambora eruption in 1816 (*Brönnimann and Krämer*, 2016; *Raible et al.*, 2016).

A contribution was made to extend re-analysis data further back in time in the 19th century, which was also used to assess economic losses of historic and present-day high-impact winter windstorms over Switzerland (*Welker et al.*, 2016). Further extreme weather situations for Switzerland are simulated for present day and future conditions and understanding has been gained in the governing processes.

8.2.2 Modelling and prediction, including global and regional climate models

New quantitative climate impact scenarios have been developed for Switzerland using a common data set which enables a comparison of impacts[63]. Inter alia, understanding in processes producing hail and floods over Switzerland has been

[63] http://ch2014-impacts.ch/index.php?lang=en&id=data

improved. For the latter, an end-to-end chain of models from regional climate models over hydrological and hydraulic models to risk assessment has been employed at the Oeschger Centre for Climate Change Research.

A successful joint project was the CHIRP2 project (2013–2015) funded by the Swiss Federal Institute of Technology in Zurich, which focused on the earth's water cycle and brought together the expertise of 18 partners at the Swiss Federal Institute of Technology in Zurich and three partner institutions. The project achieved significant progress in the understanding of the water cycle, including for instance, the understanding of thunderstorms and rain showers in high-resolution climate simulations or the role of ocean eddies for the exchange of energy between atmosphere and ocean (*www.c2sm.ethz.ch/research/CHIRP2.html*).

Since several years, the Centre for Climate Systems Modelling has been strongly involved in preparing weather forecast and climate codes for the next generation of high-performance computers. It has contributed to several consecutive projects of the Swiss initiative for High Performance and High Productivity Computing (HP2C) and its successor, the Platform for Advanced Scientific Computing (PASC).

8.2.3 Research on the impacts of climate change

Updated information on research activities and findings on the impacts of climate change on Switzerland is presented in section 6.2 of this report.

8.2.4 Socio-economic analysis, including analysis of the impacts of climate change and response options

Between 2010 and 2015, the National Research Programme 'Sustainable Water Management' (NRP 61)[64] developed scientific foundations and methods for the sustainable management of Switzerland's water resources. Several projects addressed the nexus between water availability, water use, climate change, and evolving needs of society and economy. Amongst these, the transdisciplinary MontanAqua project examined the water situation and water management of the Crans-Montana/Sierre (Valais) region in the Swiss Alps (*Weingartner*, 2014). Within this framework, the researchers, together with the parties involved, developed sustainable water utilisation strategies for the future. Project results indicate that by 2050 the total annual water resources available will decrease only slightly while economic development scenarios differ strongly in their implications for the challenges related to water management.

Another noteworthy focus of research are the impacts of large scale land acquisitions in South East Asia, Africa (Sierra Leone) and at the global level. The Centre for Development and Environment at the University of Bern is a founding partner of the land matrix partnership, the most comprehensive global database on land acquisition (*www.landmatrix.org*). The database contributes to more transparency and more informed discussion on extent and consequences of large scale land acquisitions, which occur, inter alia, as a consequence of climate change policies. A meta-analysis of land acquisitions based on scientific research was published in 2016 (*Oberlack et al.*, 2016). Research also investigated effects on water balance in investor and host countries of land acquisitions (*Breu et al.*, 2016).

8.2.5 Research and development of mitigation and adaptation approaches, including technologies

A number of technology oriented projects have produced innovative results:

- Electric drive system for airplanes: Evolaris Ltd, a spin-off company from the Bern University of Applied Sciences, has developed their own electric drive system for airplanes with a take-off weight of up to two tonnes. Electric flight aims at getting away from increasingly expensive fossil fuels, at reducing environmental pollution and at minimising noise. With the launch of the electric drive system evo230 at the AERO Global Show for General Aviation 2017, evolaris Ltd is able to supply a complete electric drive solution for an aircraft (*http://www.evolaris.ch*);
- An electric bus with no overhead lines: TOSA (Trolleybus Optimisation Système Alimentation) is a 100 per cent electric high-capacity bus system which refills its on-board energy storage bank thanks to the 'flash' feeding technology along its route. The TOSA bus features several advantages compared with a classic diesel bus (more ecological, more silent) while displaying more flexibility than a trolleybus. Within a demonstration project 12

[64] *http://www.nfp61.ch/en*

TOSA fully electric buses will be operated on a public transportation line in Geneva. This will be the world's fastest flash-charging connection technology taking less than one second to connect the bus to the charging point;

- CO_2 direct air capture plant: The spin-off Climeworks from the Swiss Federal Institute of Technology in Zurich provides solutions for efficiently capturing CO_2 out of ambient air. The Climeworks CO_2 capture technology is based on a cyclic adsorption/desorption process on a novel filter material ('sorbent'). During adsorption, atmospheric CO_2 is chemically bound to the sorbent's surface. Once the sorbent is saturated, the CO_2 is driven off the sorbent by heating it to 100 degrees Celsius, thereby delivering high-purity gaseous CO_2. The CO_2-free sorbent can be re-used for many adsorption/desorption cycles. Around 90 per cent of the energy demand can be supplied by low-temperature (e.g., waste) heat; the remaining energy is required in the form of electricity for pumping and control purposes. The most important application for Climeworks technology is to provide CO_2 for the production of synthetic, renewable fuels, which allows large-scale storage of renewable energy (*http://www.climeworks.com/*);
- Thermo-magnetic motor: The thermo-magnetic motor converts a percentage of the thermal energy stored in the temperature difference between two water streams into electricity. This concept allows using low-temperature waste heat for clean electricity generation. A first functional model has been built showing that this concept works at temperatures level as low as 35 degrees Celsius. A central role in this technology plays the so called 'thermic switch', which is made up of the magneto-caloric material and the ability to heat and cool the material as efficiently as possible (*www.swiss-blue-energy.ch* ;
- Sediment bypass tunnels: Sedimentation in reservoirs leads not only to a loss of energy production but also to a reduction of the reservoir capacity and to an increased flood risks. To reduce reservoir sedimentation during floods that carry high loads of sediments and suspended particles, sediment bypass tunnels are an effective and eco-friendly measure to counteract reservoir sedimentation. However, only a few of them exist globally. The Solis bypass tunnel in Switzerland was used to optimise design criteria and to test materials and their resistance against abrasion. Since the tunnel went into operation, its sediment capture efficiency and effects on downstream river bed eco-morphology are studied;
- GEMEN: The Project 'Building-Stock and Methane Distribution System' shows the application of power-to-gas technology for generating the heating demand of space heating and hot water in buildings. The impacts by substituting around 11 terawatt-hours per year of fossil CH_4 for renewable CH_4 are considered at the contemporary dwellings, which are connected to the gas distribution system. In cooperation with stakeholders potentially affected in the future like power supply companies, public authorities (for permits), and industry, based on three case studies, potentials were analysed. From a technical point of view it can be confirmed, that the implementation of power-to-gas in the building stock is feasible;
- SPEQUA – Thermal and electric storage systems in buildings and neighbourhoods: The project provides an overview of thermal and electric storage systems and their application in distributed energy supply for districts. The integration of the storage systems was simulated in an existing district in the city of Rheinfelden/Aargau, using 2010 as a starting point. The future energy consumption in the years 2035 and 2050 was calculated according to the Swiss energy strategy 2050 and a calculation model of the Swiss association of architects and engineers (SIA). The storage systems applied were assessed for energy efficiency, environmental impact and technical integration in the energy supply. The storage systems include readily available and new technologies which were investigated for their feasibility. In particular the interest was focused on their potential to cut peak electrical load and shift seasonal energy supply from summer to winter;
- Novel starch product to reduce energy and transportation impacts in the paper industry: Meyerhans Mühlen AG developed an innovative grain milling process. The resulting starch product made of wheat flour is suited for direct use in the paper industry. Compared to the established solutions, the environmental footprint of the novel products is significantly lower because its manufacturing process consumes much less energy and avoids long distance transport.

Bächinger and Meins (2015) analyse incentives and barriers for institutional investors to invest in energy efficient retrofits of properties held for investment purposes. A first analysis is based on interviews and a literature review. It shows that insufficient returns for the owners might be the main problem and that the difference between market rents and existing rents is an important driver of the returns to energy efficient retrofits. A deeper analysis shows that the market situation determines the returns from investments in energy efficiency measures, too. Especially under tight markets conditions, investments in energy efficiency might be profitable. It is interesting to note, that energy prices are not relevant for the decision whether or not to invest. This is confirmed by interviews and the model of an investment appraisal. Therefore, market conditions and the fact, that changes in energy prices (e.g. based on a CO_2 tax) do not affect returns heavily in the short run, have to be taken into account when attempting to foster investments in energy efficiency.

Research on mitigation and adaptation includes studies of how to create and preserve social capital in climate adaptation policies. As an example, the federal system of Switzerland has been assessed with respect to how social relationships are constructed between communities which are affected by climate change and the cantonal and federal administration which is responsible for the design of climate adaptation policies (*Brönnimann et al.*, 2014).

Another significant contribution is the leading role of the Centre for Development and Environment in the World Overview of Conservation Approaches and Technologies Network. The United Nations Convention to Combat Desertification has recently designated the database of the World Overview of Conservation Approaches and Technologies Network (*www.wocat.net*) as the primary recommended database for sustainable land management.

A survey in 2010 showed that adaptation research in Switzerland is performed in all sectors that are influenced by climate change. It was most common in the sectors water and land ecosystems where climate impacts seem most obvious. On the basis of the number of experts involved, research on buildings and infrastructure, agriculture and forestry and water management received most attention, followed by energy and land use research. In general, the survey exhibited that, at the time of the survey, the research community seemed to acknowledge the importance of adaptation to a quite limited extent and corresponding research should be further encouraged and supported. No recent data are available regarding the number of experts involved in sectoral adaptation research. However, as documented in *Swiss Academies of Arts and Sciences* (2016) and *FOEN* (2017), a wide range of topics are covered by projects dealing with the challenges of adapting to the impacts of climate change.

8.3 Systematic observation

Resulting from the Swiss Federal Council's decision in June 2008, several GCOS Switzerland agreements were signed between MeteoSwiss and partner institutions concerning the observation of atmospheric (e.g. CO_2) and terrestrial climate variables (e.g. snow water equivalent, permafrost) and the operation of international data centres (e.g. the World Glacier Monitoring Service). Establishing these agreements was a crucial step forward in securing long-term systematic climate observation in Switzerland. In the time period 2013–2017 new GCOS Switzerland agreements for the following essential climate variables were put in place: glaciers, lakes, phenology, and snow water equivalent.

8.3.1 Atmospheric climate observing systems

Atmospheric observations are classified into three domains, namely surface, upper air and atmospheric composition (Tab. 55). Pollen is not listed as an essential climate variable in the GCOS Implementation Plan (*WMO*, 2016), however, since its measurement has a long tradition in Switzerland, it forms an important part of GCOS Switzerland.

MeteoSwiss is responsible for the operation and maintenance of the meteorological and climatological network in Switzerland guaranteeing regular measurements over the entire country. Within the project SwissMetNet (completed in 2015), MeteoSwiss renewed its ground-based standardised stations to 157 state of the art automatic weather stations. SwissMetNet replaces previously existing networks measuring a large set of meteorological parameters. The geographical distribution of the stations represents the complex topography of the entire country.

The Swiss National Basic Climatological Network is the core of the climatological observation network and consists of 29 stations of greatest climatological importance for surface-based atmospheric observations. Eight stations of the Regional Basic Climatological Network (*Begert et al.*, 2007) including the two GCOS Surface Network stations Säntis and Grand St. Bernard belong to the Swiss National Basic Climatological Network. To adequately represent the climatology of precipitation in Switzerland, 46 additional stations for precipitation, the so called Swiss National Basic Climatological Network for Precipitation stations, complement the Swiss National Basic Climatological Network (*Begert*, 2008). The operation of all stations of the Swiss National Basic Climatological Network follows the GCOS Climate Monitoring Principles (*WMO*, 2016).

Tab. 55 > Switzerland's atmospheric observation networks. Some stations may be part of several networks.

Domain	Variable	Number of stations and observation networks
Surface	Air temperature, wind speed and direction, humidity, air pressure, precipitation	2 GCOS Surface Network 8 Regional Basic Climatological Network 29 Swiss National Basic Climatological Network 46 Swiss National Basic Climatological Network for Precipitation
	Radiation	1 Baseline Surface Radiation Network 4 Swiss Alpine Climate Radiation Monitoring Network
Upper air	Air temperature, wind speed and direction, water vapour	1 GCOS Reference Upper Air Network
	Cloud properties	26 MeteoSwiss Manual Observation Network
Composition	CO_2, other greenhouse gases, ozone, aerosols, air pollutants Anthropogenic greenhouse gas fluxes	1 station of the Global Atmosphere Watch programme 3 CO_2, 1 other greenhouse gases 2 ozone (total column, profile) 4 Swiss Alpine Climate Radiation Monitoring Network, 2 AERONET, 1 EARLINET, (aerosols: optical depth, properties, concentrations) 16 NABEL (air pollutants) 6 FluxNet, 2 Urban Flux Network
	Pollen	14 NAPOL sites

GCOS Switzerland

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. The Baseline Surface Radiation Network consists of around 55 stations worldwide and represents the surface radiation observation section of GCOS. In addition, high quality radiation measurements as part of the Swiss Alpine Climate Radiation Monitoring Network are conducted in Payerne, Locarno-Monti, Davos, and on the Jungfraujoch.

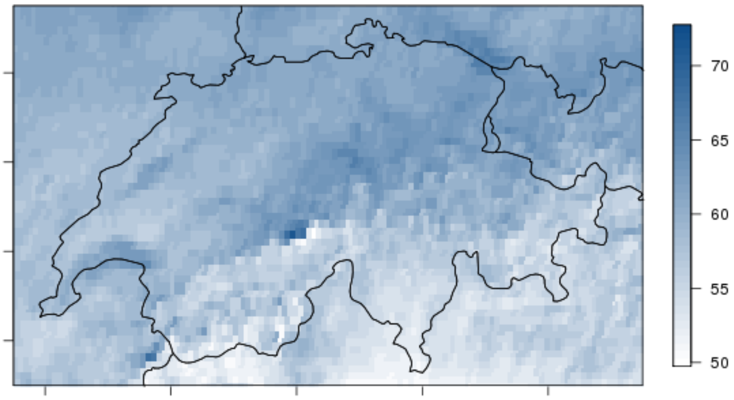
At MeteoSwiss Payerne, measurements of the atmospheric profile of temperature, air pressure, and wind have been performed for more than 50 years using radiosondes. Since 2008, upper air observations carried out at Payerne belong to the GCOS Upper Air Network (GUAN). Upon invitation from the World Meteorological Organisation, Payerne became part of the GCOS Reference Upper Air Network in 2010. The GCOS Reference Upper Air Network forms a set of selected stations worldwide that provide long-term, high-quality upper-air observing data.

Observations of cloud variables (e.g. level of cloud cover, type of cloud) are made by human observers at regular intervals at 26 stations of the MeteoSwiss Manual Observation Network. In addition measurements of microphysical properties and aerosol-cloud interactions are done at the Jungfraujoch research station. Since 2016, in addition to human observers, present weather sensors are used to measure a number of cloud variables at international airports in Switzerland. Complementing the observations by human observers, MeteoSwiss has been involved in the ESA Climate Change Initiative (CCI) on Clouds project dealing with uncertainties in the retrieval of spatial cloud information from satellite sensors. As part of its engagement in the Satellite Application Facility on Climate Monitoring (CM SAF) MeteoSwiss has developed its own fractional cloud cover climate data record from long-term Meteosat observations (Fig. 94).

Fig. 93 > MeteoSwiss station Payerne. Payerne is an important atmospheric observation site in Switzerland and belongs to the GCOS Reference Upper Air Network.

Photo: MeteoSwiss

Fig. 94 > Fractional cloud cover over Switzerland for 2015 (in per cent) developed in the framework of the Satellite Application Facility on Climate Monitoring (CM SAF).



MeteoSwiss

With regard to atmospheric composition, several measurement stations in Switzerland continue to contribute to the Global Atmosphere Watch programme of the World Meteorological Organisation. The high-altitude research station Jungfraujoch is one out of 29 stations belonging to the global network of the Global Atmosphere Watch programme. The Swiss Global Atmosphere Watch programme is coordinated by a respective office at MeteoSwiss.

The CO_2 measurements at Jungfraujoch were not guaranteed post-2008, as reported in the national GCOS inventory (*Seiz and Foppa*, 2007). On the basis of the Swiss Federal Council's decision in 2008, measurements were secured through an agreement between MeteoSwiss and the University of Bern in 2010. Since 2013, these measurements are continued in the framework of the Integrated Carbon Observing System (ICOS). Today, atmospheric measurements of greenhouse gases (including CH_4, N_2O, and F-gases) are being performed at Bern, Beromünster and Jungfraujoch. These are used for the independent verification of the Swiss greenhouse gas inventory. As from 2017, results are also documented in the National Inventory Report (annex 5).

Adding to the 'conventional' CO_2 measurement network, CO_2 fluxes are measured at six ecosystem and two urban sites. The six ecosystem sites are part of the Swiss FluxNet network, maintained by the Swiss Federal Institute of Technology in Zurich, and cover forest, grassland, and cropland sites. All Swiss FluxNet stations are part of the global FluxNet. In addition, the University of Basel maintains two stations for urban CO_2 fluxes, both contributing to the Urban Flux Network. Anthropogenic greenhouse gas fluxes are newly included in the GCOS Implementation Plan (*WMO*, 2016).

Long-term observations of total ozone and estimates of the ozone profile at the Light Climatic Observatory (LKO) in Arosa (since the beginning of last century) are also part of the Swiss contribution to Global Atmosphere Watch programme, as are measurements of ozone profiles at Payerne up to an altitude of more than 30 kilometres by radiosondes since 1968. Continuous aerosol measurements (concentrations and properties) are carried out by the Paul Scherrer Institute at Jungfraujoch station on behalf of MeteoSwiss. Measurements of aerosol optical depth are carried out at the four stations of the Swiss Alpine Climate Radiation Monitoring Network. In addition, two Swiss ground-based aerosol remote sensing stations are operated, which belong to the Aerosol Robotic Network (AERONET) programme. The Payerne Ralmo Lidar is part of the European Aerosol Research Lidar Network (EARLINET).

Measurements of air pollutants are conducted at 16 stations in the National Air Pollution Monitoring Network (NABEL). It is operated by the Swiss Federal Laboratories for Materials Science and Technology and the Swiss Federal Office for the Environment.

MeteoSwiss is responsible for operating the national pollen monitoring network (NAPOL). It comprises a total of 14 stations that are equipped with volumetric pollen traps. It covers Switzerland's main climate and vegetation regions and is operated during the vegetation period (January to September). MeteoSwiss is currently testing the implementation of automatic pollen taxa detection with air flow cytometers, providing real time data at high temporal resolution.

8.3.2 Ocean climate observing systems

As a landlocked country, Switzerland does not maintain measurements in the oceanic domain.

8.3.3 Terrestrial climate observing systems

Climate observations in the terrestrial domain are subdivided into the hydrosphere (river discharge and temperature, groundwater, isotopes, lakes, and soil moisture), the biosphere (albedo, land use, forest ecosystem, soil carbon, forest fires, land surface temperature and phenology; Tab. 56), and the cryosphere (section 8.3.4). River temperature, isotopes and phenology are not listed as essential climate variables in the GCOS Implementation Plan (*WMO*, 2016), however, since their measurement has a long tradition in Switzerland, they are an important part of the national climate observing system (GCOS Switzerland).

Tab. 56 > Switzerland's hydrosphere and biosphere observation networks.

Domain	Variable	Number of stations and observation networks
Hydrosphere	River discharge	200 federal stations (78 contributing to GTN-R)
	River temperature	79 federal stations, >400 cantonal stations
	Groundwater	> 600 NAQUA sites
	Isotopes	22 ISOT sites (13 precipitation, 9 surface water)
	Lakes	33 sites (all contributing to GTN-L)
	Soil moisture	17 sites (SwissSMEX) 6 sites (SOMOMOUNT)
Biosphere	Albedo	6 SwissMetNet station
	Land use	1 sample point/hectare
	Biomass, growth rate, ecosystem and microclimatological variables	50 study sites 18 monitoring sites (LWF)
	Soil carbon	110 EIONET
	Land surface temperature	1 Baseline Surface Radiation Network 3 SwissMetNet 2 former ASRB network 2 Urban Flux Network
	Phenology	12 (most important observation sites)

GCOS Switzerland

The Swiss Federal Office for the Environment operates various hydrological monitoring networks and provides monitoring information on discharge, temperature, water levels, and water flows. Water quality for rivers, lakes, and groundwater bodies are monitored by the Swiss Federal Office for the Environment in cooperation with the cantons, the Swiss Federal Institute of Aquatic Science and Technology (Eawag) and the Swiss Federal Institute for Forest, Snow and Landscape Research. Daily river discharge data from 78 stations are submitted to the Global Runoff Data Centre (GRDC), in support of the Global Terrestrial Network for River Discharge (GTN-R).

The national groundwater monitoring (NAQUA) is based on more than 600 stations including modules for long-term assessments of groundwater quality and quantity. The module for isotopes in the water cycle (ISOT) currently comprises 22 sites distributed throughout Switzerland and is operated by the Swiss Federal Office for the Environment. Lake level, groundwater data, and isotope analyses are partly submitted to the designated international data centres as a contribution to the Global Terrestrial Network for Hydrology (GTN-H).

Swiss lake water levels are monitored at 33 stations as part of the basic hydrological monitoring network operated by the Swiss Federal Office for the Environment. One measurement station (Chillon at Lake Geneva) was closed down in December 2014. Monthly data from 33 lakes (plus historic data from the Chillon station) contribute to the Global Terrestrial Network for Lakes (GTN-L). Measurements of lake water temperatures and lake ice are carried out as part of comprehensive water quality studies by cantonal water protection agencies, international commissions and the Swiss Federal Institute of Aquatic Science and Technology (Eawag). Lake ice thickness observations are partly carried out by municipalities or private institutions, e.g. for lake St. Moritz, whose time series since 1832 is unique for central Europe. In 2016, the Swiss Federal Institute of Technology in Zurich, in cooperation with the University of Bern and the Eawag, was tasked by MeteoSwiss to elaborate recommendations for an integrated lake ice monitoring in Switzerland, using satellites, webcams and in-situ observations.

Soil moisture as an important parameter influencing land-atmosphere interactions was included in the inventory of the most important climate observations in Switzerland in 2015. In a collaboration between the Swiss Federal Institute of Technology in Zurich, Agroscope, the Swiss Federal Institute for Forest, Snow and Landscape Research, and Meteo-

Swiss, soil moisture has been monitored in Switzerland in the framework of the Swiss Soil Moisture Experiment (SwissSMEX) project starting in 2008. The SwissSMEX monitoring network has continued to collect data since the project ended in 2011 and consists of 19 monitoring stations at 17 different sites. In addition, six stations are operated by the University of Fribourg within the SOMOMOUNT research monitoring network at medium and high altitudes.

Albedo controls the amount of radiation absorbed by the surface. The downward and reflected shortwave radiation components are recorded simultaneously at six SwissMetNet sites (section 8.3.1). While ground measurements are precise and quality controlled, they are only representative for a small area. Satellite sensors can monitor the spatial heterogeneity of ‘Land Surface Albedo’ on a regional scale. MeteoSwiss will generate this essential climate variable in a joint Meteosat retrieval in the framework of the Satellite Application Facility on Climate Monitoring (CM SAF) in the upcoming five years.

The land-use statistics of the Swiss Federal Statistical Office determines the land cover and land use of a sample point at every hectare of Switzerland, based on the interpretation of aerial photographs. To date, three surveys at the periodicity of 12 years have taken place using images from 1979–1985, 1992–1997 and 2004–2009. Since 2014, a fourth survey has been conducted considering the period 2013–2019.

Monitoring activities of the forest ecosystem are conducted in the national forest inventory surveys that register the current state and changes of the Swiss forests. After completion of the third survey period (2004–2006), the continuous survey of the fourth national forest inventory (NFI4/2009–2017) in a collaboration between the Swiss Federal Institute for Forest, Snow and Landscape Research and the Swiss Federal Office for the Environment is now in progress (intermediate results for 2009 to 2013 are available as NFI4/2009–2013).

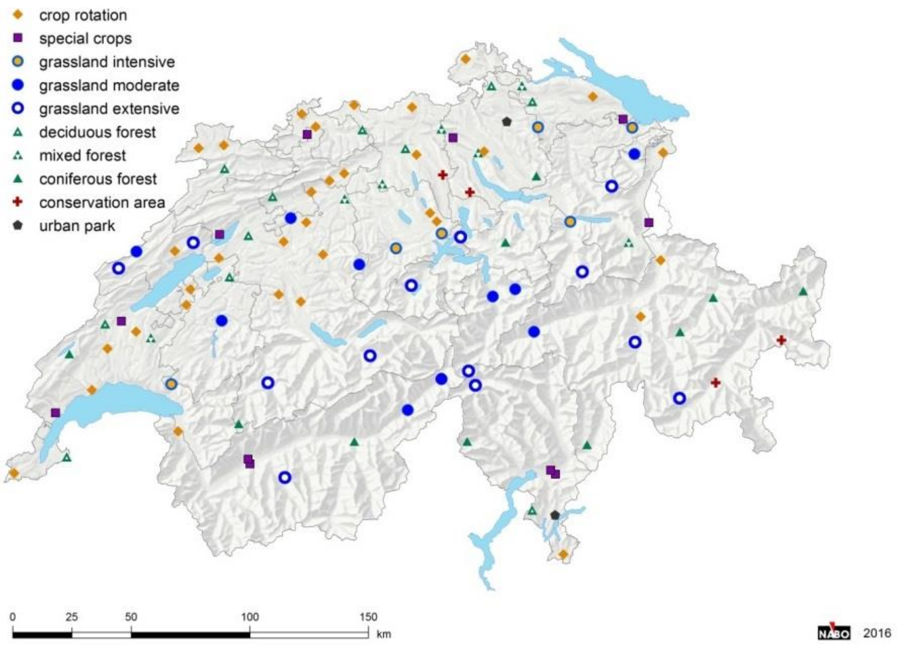
Documentation of long-term tree health (since 1985) is guaranteed at approximately 50 sites through the Sanasilva inventory. Under the Federal Long-term Forest Ecosystem Research Programme (LWF), more intensive and wide-ranging studies at 18 sites are being pursued as part of an integrated approach to forest monitoring. A database containing information and statistics on forest fires, for some areas dating back to the 19th century, is centrally managed at the Swiss Federal Institute for Forest, Snow and Landscape Research.

Soil Carbon is monitored as part of the national reference network for observing infringements of the soil (NABO), jointly by the Swiss Federal Office for the Environment and the Swiss Federal Office of Agriculture. NABO operates 110 long-term monitoring sites throughout Switzerland covering all relevant land uses (Fig. 95). The national soil carbon data are periodically sent to the Joint Research Centre JRC of the European Commission via the European Environment Information and Observation Network EIONET. The NABO measurements since 1985 are one of the longest time series of soil carbon observations in Europe.

Land Surface Temperature (LST) is retrieved from outgoing longwave radiation measurements at Payerne aerological station of MeteoSwiss as part of the Baseline Surface Radiation Network. Further measurements are done at three SwissMetNet sites, and at the Urban Flux Network sites from University of Basel. In addition, LST can be determined from satellite data in the infrared part of the spectrum. A long-term LST climate data record for Switzerland was released in 2017 as part of the MeteoSwiss contribution for the Satellite Application Facility on Climate Monitoring (CM SAF).

Observations of annual vegetation phenology are obtained through the Swiss Phenology Network (SPN). The network has been operational since 1951, is managed by MeteoSwiss and now comprises approximately 160 stations. A subset of twelve sites covering a variety of regions and elevations represents the most important phenological observations in Switzerland. Currently, the University of Bern is undertaking an evaluation of the SPN in the framework of GCOS Switzerland, to determine the most valuable phenological observation sites.

Fig. 95 > Swiss Soil Monitoring Network (NABO) – Distribution of NABO sites according to use category.



Agroscope

8.3.4 Cryosphere climate observing systems

Apart from the hydrosphere and biosphere, terrestrial climate observations also include the cryosphere (snow cover, glaciers, and permafrost) (Tab. 57).

Tab. 57 > Switzerland's cryosphere observation networks.

Domain	Variable	Number of stations and observation networks
Cryosphere	Snow cover	71 Swiss National Basic Climatological Network for Snow (including 22 GCOS Switzerland snow stations)
	Glacier mass balance and length	28 mass balance and/or volume changes, about 100 length changes
	Permafrost	28 locations (29 boreholes, 258 ground surface temperature, six geoelectrical measurements, 14 rock glaciers)

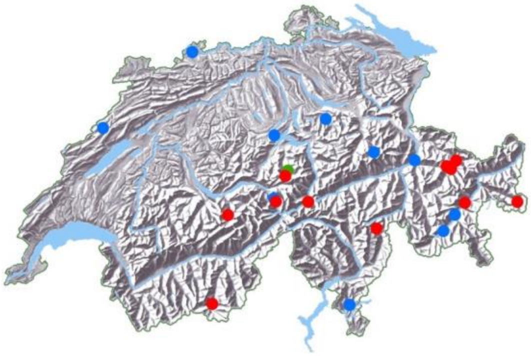
GCOS Switzerland

Records of snow cover (snow depth, new snow height, snow water equivalent), with some series dating back more than 100 years, are available from measurement networks operated by MeteoSwiss, the Institute for Snow and Avalanche Research of the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL-SLF), and other cantonal and private institutions. From the National Basic Climatological Network for Snow (*Wüthrich et al.*, 2010), a subset of 22 stations was defined as Swiss GCOS snow stations (Fig. 96). Two GCOS Switzerland agreements are in place securing the continuation of long-term snow water equivalent measurements: since 2010 the measurements in Wägital by Meteodat GmbH; and since 2015 measurements at twelve selected Swiss GCOS snow stations by WSL-SLF.

Glacier monitoring in Switzerland goes back to the 19th century. Today, more than 100 glaciers are surveyed annually. Since 2015, glacier monitoring in Switzerland is coordinated by the Glacier Monitoring Switzerland (GLAMOS) Office at the University of Zurich, which is co-funded by the Swiss Federal Office for the Environment and the Swiss Academy of Sciences. The Swiss Federal Institute of Technology in Zurich, along with the Universities of Zurich and Fribourg, are responsible for the operational implementation. Also, since 2015 GCOS Switzerland agreements between MeteoSwiss and the implementing institutions ensure a continued monitoring of the most important glaciers. The Swiss glacier monitoring network makes an important contribution to the Global Terrestrial Network for Glaciers (GTN-G).

The Swiss Permafrost Monitoring Network (PERMOS) provides a systematic long-term documentation of state and changes of mountain permafrost in the Swiss Alps. It is coordinated by the PERMOS Office at the University of Fribourg and is run in collaboration with a number of university-based partner institutes. PERMOS is co-funded by MeteoSwiss, the Swiss Federal Office for the Environment, and the Swiss Academy of Sciences based on agreements for terms of four years. In 2015 the agreement was renewed for the period 2015–2018. PERMOS contributes to the Global Terrestrial Network for Permafrost (GTN-P).

Fig. 96 > Overview of the 22 GCOS snow stations in Switzerland. In red stations operated by MeteoSwiss, in blue stations operated by WSL-SLF. The green station is jointly operated by MeteoSwiss and WSL-SLF.



MeteoSwiss

8.3.5 International activities, including support for developing countries

Participation in international activities

In 2015, the GCOS secretariat at the World Meteorological Organisation published a report on the status of the GCOS and submitted it to the UNFCCC (*WMO*, 2015). The report reviews the overall status of each essential climate variable, assesses progress against the GCOS Implementation Plan and identifies gaps. Based on its results, the GCOS secretariat submitted a new Implementation Plan (*WMO*, 2016) to the UNFCCC for adoption in 2017. Both reports were critically reviewed by the Swiss GCOS Community and comments and inputs were submitted to the GCOS Secretariat.

International data centres

In 2015, the Swiss GCOS Office published an update of the report Swiss GCOS Data in International Data Centres (*MeteoSwiss*, 2015). For each essential climate variable listed in the national GCOS inventory report (*Seiz and Foppa*, 2007), the document reports on the flow of data and the respective responsibilities. It further identifies areas of action and therefore provides the basis for future improvements regarding the availability of Swiss GCOS data at designated international data centres.

Switzerland is host to a number of important international data and calibration centres that make a vital contribution to data quality and the global standardisation of observations, both in the atmospheric and terrestrial domains.

The World Radiation Centre (WRC) at the Physical Meteorological Observatory (PMOD) in Davos serves as an international centre for the calibration of radiation and includes the WRC Solar Radiometry (WRC-SRS), the WRC Infrared Radiometry (WRC-IRS), the WCC for World Optical depth Research and Calibration Centre (WORCC), and the WCC for UV (WCC-UV). Further World Calibration Centres (WCCs) of the Global Atmosphere Watch programme of the World Meteorological Organisation include the institution for the Global Atmosphere Watch programme Quality Assurance/Scientific Activity Centre (QA/SAC Switzerland) for surface ozone, CO, CH_4, and CO_2, and the World Calibration Centre (WCC) for surface ozone, CO and CH_4 (WCC-Empa), which are both hosted by the Swiss Federal Laboratories for Materials Science and Technology.

The Global Energy Balance Archive (GEBA) database was implemented at the Swiss Federal Institute of Technology in Zurich in 1988. It incorporates various energy balance components, with a total of 19 different variables (e.g. global radiation, short- and long-wave radiation or turbulent heat fluxes). The GEBA energy balance components are of fundamental importance in understanding other processes in the climate system (including the cryosphere).

The World Glacier Monitoring Service at the University of Zurich collects standardised observations on changes in mass, volume, area, and length of glaciers as well as statistical information on the spatial distribution of perennial surface ice. Through a GCOS Switzerland agreement between MeteoSwiss and the University of Zurich, sustained operation of the World Glacier Monitoring Service has been secured since 2010. In collaboration with other international institutions, the World Glacier Monitoring Service jointly runs the Global Terrestrial Network for Glaciers (GTN-G).

Historical documentary data provide important information for studies on climate change and are a vital component of long-term systematic climate observation in Switzerland. Euro-Climhist is a database developed and operated by the University of Bern, currently containing more than 120 thousand historical documentary records for the period 1550–1864. For the coming years, an extension of the database with records on the weather and climate in Europe during the Middle Ages is planned. In 2015, a user-friendly data query platform was released (*http://www.euroclimhist.unibe.ch*). Sustained operation of Euro-Climhist is secured through a GCOS Switzerland agreement between MeteoSwiss and the University of Bern (since 2010).

Capacity building

Switzerland actively supports capacity building in emerging and developing countries by contributing to the GCOS Cooperation Mechanism to enhance the quality of climate observations globally. During the period 2011–2017, the project CATCOS (Capacity Building and Twinning for Climate Observing Systems) aimed to improve the capacity to obtain high-quality climate observations in the atmospheric and terrestrial domains, and to submit these to the designated GCOS international data centres. The project was active in ten countries in Africa, South-East Asia, South America, and Central Asia (Fig. 97). CATCOS was implemented by the Swiss Federal Laboratories for Materials Science and Technology, the Paul Scherrer Institute, the Universities of Fribourg and Zurich, and MeteoSwiss and financed by the Swiss Agency for Development and Cooperation.

Through technical and/or financial support, Swiss institutions made systematic climate observations possible in a multitude of developing and emerging countries, e.g.:

- In the framework of the Global Atmosphere Watch programme, MeteoSwiss supports weekly ozone soundings in Nairobi, Kenya. Also, regular on-site training is provided to assure the quality of the various operational ozone measurement systems on site;
- Switzerland – through the operation of the QA/SAC and WCC-Empa – is a key contributor to the quality management framework of the Global Atmosphere Watch programme. To maintain and improve the spatial coverage of atmospheric composition measurements, twinning partnerships between the Swiss Federal Laboratories for Materials Science and Technology and station operators in developing and emerging countries (e.g. Indonesia) were initiated. Focus is put on quality assurance, training of station operators, replacement of instruments and scientific support;
- The World Glacier Monitoring Service at the University of Zurich offers technical support for glacier observations, e.g. in South America and Central Asia, including assurance of compliance with international methods and standards, data quality control and training for glaciologists in the field.

Fig. 97 > Geographical overview of the CATCOS (Capacity Building and Twinning for Climate Observing Systems) stations.

MeteoSwiss

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9 Education, training and public awareness

This chapter has been brought in line with the structure as suggested by the revised UNFCCC reporting guidelines used for preparation of this national communication. Its contents were rearranged to best reflect circumstances and activities linked to the topics of climate change-related education, training and public awareness.

In Switzerland, environmental issues have a long-standing tradition as an element of public debate. To some extent, this may be related to the alpine landscapes and their natural hazards which coined the notion that precautionary measures and risk management represent the only viable strategies to maintain a high standard of living in terms of safety.

The ‘classical’ 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 rare hazards (such as heat waves and droughts) are expected to occur more often according to regional climate model projections. Over the past decade, recurrent severe weather events that may be related to a changing climate have reinforced the public perception of climate change. Impacts of exceptional weather conditions on agriculture and winter tourism are increasingly seen as potential harbingers of a shifting climate regime.

At the same time, in the political debate about more sustainable modes of energy provision as well as about drivers, trends and patterns of energy consumption, greenhouse gas emissions and climate change have become a prominent element. Next to conventional criteria such as price and security of supply, the carbon content of energy systems is now a broadly accepted criterion in the evaluation of options for shaping the future provision with, and use of, energy.

These developments reflect a general change in public perception of climate change as a reality that needs to be taken into account in politics and business (*Schwegler et al.*, 2015). However, the challenges this poses to present modes of production and consumption may not yet be fully understood. In a world of globalised markets, where flows of raw materials, goods and energy are complex and difficult to track, balance sheets at the national level have lost much of their meaning and the direct links between local decision making and global implications for the environment are weak. This underlines the importance of continuing efforts in the areas of education, training and public awareness.

9.1 General policy on education, training and public awareness

At the national level, the Swiss State Secretariat for Education, Research and Innovation is the Swiss government’s specialised agency for matters concerning education. Cantonal and communal authorities are responsible for preschool, primary and lower-secondary school (compulsory education). Upper-secondary level (post-compulsory education) is divided into vocational education and training and general education (baccalaureate schools and specialised schools).

The Swiss Confederation acts in a full regulatory capacity within the vocational education and training system. The cantons are responsible for implementation while professional organisations establish training content and create apprenticeship positions for vocational education and training programmes. The cantons are primarily responsible for general education.

With regard to continuing education and training, the allocation of responsibilities for implementation, sponsorship and funding is extremely complex. The Swiss Confederation is responsible for specifying and promoting the basic principles of continuing education and training.

The national focal point dealing with the implementation of the strategy of the United Nations Economic Commission for Europe for education for sustainable development is located at the Swiss Federal Office for the Environment. This office is actively involved in fostering integration of environmental issues in education and training programmes by providing input on priorities and financial support to specific projects. Mostly, the Swiss Federal Office for the Environment is delegating the implementation to specialised organisations such as the foundation éducation21 (see section 9.2).

In the context of the 2030 Agenda for Sustainable Development of the United Nations and the implementation of the Sustainable Development Strategy 2016–2019, the Swiss Federal Office for Spatial Development coordinates the activities related to Education for Sustainable Development.

9.1.1 Compulsory education

Switzerland has a federal education system, in which the education ministries of the 26 cantons have far-reaching competencies to decide about the school system on all levels, including curricula and learning methods. In recent years, efforts to harmonise curricula for compulsory education have been undertaken.

At present, a large majority of German speaking and bilingual cantons have endorsed the national model curriculum called ‘Lehrplan 21’, thus aligning their educational frameworks with the related requirements as set out in the Federal Constitution of the Swiss Confederation. This curriculum defines goals at all levels of compulsory education. It serves as a planning tool for schools.

Within the ‘Lehrplan 21’ curriculum, education for sustainable development is acknowledged as a cross-disciplinary theme relevant to a wide range of subjects. However, there is no systemic approach to the integration of the notion of sustainable development in the formal education system nor are there binding national guidelines concerning its integration into educators’ initial training.

As regards topics directly related to the core issues of the UNFCCC, in the national model curriculum for the lower-secondary level, weather, climate and climate change are explicitly addressed, including the study of climate change causes, impacts and mitigation options.

The French speaking cantons have elaborated their own model curriculum called ‘Plan d’étude romand’ where, again, at the lower-secondary level climate phenomena and climate change are listed among the topics to be treated in class.

In 2015, the Swiss Federal Office for the Environment mandated a nation-wide assessment of climate education at primary and secondary school level. Interviews with teaching staff and persons involved in teacher training indicated that, at present, climate change is mainly addressed by geography teachers at secondary school level, but is also frequently taken up during general education lessons at vocational schools. The assessment highlights, inter alia, the need to bring official teaching materials more in line with the lower-secondary level contents of the national model curriculums mentioned above. In general, those participating in the assessment emphasised the fact that there is a lack in practice-oriented teaching materials that facilitate the process of relating contents taught in class to everyday experiences within and outside of schools (*John et al.*, 2016).

9.1.2 Vocational education and training

The Federal Act on Vocational and Professional Education and Training (*Swiss Confederation*, 2002, Article 15) and the Ordinance on Minimum General Education Requirements in Vocational Education and Training Programmes (*Swiss Confederation*, 2006) have an explicit reference to sustainable development as a learning objective. This includes acquirement of ecological knowledge and competencies. Thus, education for sustainable development is part of the general studies curriculum for all apprentices in Switzerland. Additionally, in many of the decrees for each profession there is a reference to education for sustainable development.

The SwissEnergy programme contains measures directed at professionals from various trades, in particular the construction sector (building design, installations). One of its ambitions is to include new developments in energy technologies in vocational education, offering up-to-date training materials and accelerating knowledge transfer. In addition, the ‘Climate programme Training and Communication’ (*FOEN*, 2017a), which is developed in the framework of the second CO_2 Act, has a special focus on professions with high relevance for Switzerland’s greenhouse gas emissions (see section 9.4).

9.1.3 Public awareness

In recent years, no public awareness-raising campaigns focussing specifically on climate change and directed at the general public have been conducted by the federal authorities. Climate change is widely recognised as one of the major long-term challenges for Switzerland. This is partly due to a committed scientific community (see section 9.2.5) but also to be credited to an active scene of environmental non-governmental organisations, complemented by ecologically oriented business associations, both involved in raising awareness and stimulating public debate about climate policy (see section 9.6). Nevertheless, as emission reduction targets need strengthening and the field of adaptation gains in importance, maintaining public support for related policies and measures remains a challenge.

At the federal level, SwissEnergy is the major programme for conveying information related to energy efficiency and renewable energies to the general public. In 2016, the SwissEnergy programme launched the ‘Energy Challenge’, a nation-wide awareness raising campaign. In the near future, this programme will be supplemented by the more climate-specific measures of the ‘Climate programme Training and Communication’, where municipalities will be a target of particular interest (see section 9.5).

9.2 Resource or information centres

9.2.1 Competence centres at the national level

The Swiss Federal Office for the Environment, MeteoSwiss, and the Swiss Federal Office of Energy maintain comprehensive websites that cover aspects of climate change, climate politics and energy politics. ProClim (Forum for Climate and Global Change of the Swiss Academy of Sciences) and OcCC (Advisory Body on Climate Change), two institutions active at the interface between science, policy and the public (see section 9.2.5) supported by the Swiss Federal Office for the Environment and MeteoSwiss, maintain the web portal *https://naturalsciences.ch/topics/climate*. Extensive information on adaptation policy and action is available at *www.bafu.admin.ch/klimaanpassung* (see also section 6.4.2).

The Swiss Federal Office for the Environment and MeteoSwiss also respond to climate-related enquiries from the general public. In addition, the Swiss Federal Office for the Environment provides – on its website – access to the official documents submitted by the Swiss Confederation under the UNFCCC as well as under the Kyoto Protocol (*http://www.climatereporting.ch*) and to statistics covering a wide range of topics related to climate change (*https://www.bafu.admin.ch/bafu/en/home/topics/climate/state/indicators.html*).

MeteoSwiss provides climatological services and information including regular updates on the current state of the Swiss climate and climate change as well as climate predictions on seasonal to multi-decadal time scales (*http://www.meteoswiss.admin.ch/home/climate.html*). MeteoSwiss also co-founded and supports the Centre for Climate Systems Modelling, a network of Zurich-based institutions active in climate research (see section 8.1.1).

Education, training, and raising of public awareness are also important components of the Global Framework for Climate Services led by the World Meteorological Organisation. Switzerland founded its National Centre for Climate Services in late 2015. The parties involved in the National Centre for Climate Services include MeteoSwiss, the Swiss Federal Office for the Environment, the Swiss Federal Office for Civil Protection, the Swiss Federal Office for Agriculture, the Swiss Federal Office of Public Health, the Swiss Federal Institute of Technology in Zurich and the Swiss Federal Institute for Forest, Snow and Landscape Research. Climate services offered comprise scientific information and data on the climate of the past, present and future, as well as its consequences. The main purpose of the National Centre for Climate Services is to provide information in support of policy-makers from national to local level as well as the private sector and society at large (*http://www.nccs.ch*; see also section 6.4.2).

These information channels are supplemented with a wide spectrum of magazines, reports and newsletters published by federal agencies (e.g. *ARE*, 2013; *FOEN*, 2013; *FOEN*, 2014a; *FOEN*, 2014b; *FOEN*, 2015; *FOEN*, 2016b; *MeteoSwiss*, 2017; *FOEN and MeteoSwiss*, 2013), media releases, as well as blogs, talks and public appearances at exhibitions and meetings by representatives of the federal administration.

9.2.2 SwissEnergy programme

Under the auspices of the Swiss Federal Office of Energy, the SwissEnergy programme (see also section 4.3.2) aims at enhancing energy efficiency and increasing the share of renewable energies in the Swiss energy mix. Its main instruments are information and awareness raising activities, consulting as well as targeted support for education and training projects. The information presented in this and the following sub-sections focusses on the most climate-relevant aspects and elements of the SwissEnergy programme.

SwissEnergy sponsors projects that are implemented by partner organisations in the public and private sectors. As opposed to the earlier ‘agency model’, where tasks were delegated on a long-term basis to private sector organisations in charge of thematic clusters of projects, the ‘project model’ used since 2016 relies on fixed-term contracts with individual project partners. This has rendered the programme more flexible and responsive to changing conditions and allows to implement measures more efficiently.

Eight per cent of the programme budget (2015: 4.4 million Swiss francs) are devoted to (non-campaign-specific) communication activities, around 14 per cent of available funds (2015: 6.5 million Swiss francs) go to education and training projects (*SFOE*, 2016).

The information portal of SwissEnergy (*http://www.swissenergy.ch*) was launched in autumn 2011 and completely restructured and updated in 2016. In addition to extensive information on energy efficiency and renewable energy, the newly developed website offers individual queries, for example, on energy subsidies in a particular municipality.

One of the major and largest projects supported by SwissEnergy is the project 'SwissEnergy for Communities' (*http://www.energiestadt.ch/organisation/energieschweiz-fuer-gemeinden*). Under the umbrella of SwissEnergy for Communities, the programmes 'Energy City' (*http://www.energiestadt.ch*) and 'Energy Region' (*www.energie-region.ch*) along with the programmes 'Sustainable Neighbourhoods' (*http://www.nachhaltige-quartiere.ch*), '2000 Watt Society'*(http://www.2000watt.ch*) and 'Smart Cities' (*http://www.smartcity-schweiz.ch*) build a broad basis for pioneering projects towards sustainable development in a local to regional context. SwissEnergy for Communities closely cooperates with other partner organisations as listed further below.

The programme 'Energy City' aims to promote renewable energies, sustainable mobility and the efficient use of resources in Swiss cities, thus contributing to lower CO_2 emissions. Recently, the catalogue of measures considered under the Energy City label was expanded to encompass aspects of climate resilience as well. Communities striving for the label pass through a standardised assessment and planning process and have to undergo periodic re-examinations of measures implemented and progress made.

In order to ensure that innovations contributing to the more sustainable use of energy are well understood and related cost reduction potentials are better known, SwissEnergy bolsters the competent consulting of citizens, investors, buyers and operators of facilities, appliances and buildings. Therefore, SwissEnergy increasingly includes manufacturers and sellers of appliances and facilities in its communication efforts.

Below, organisations presently partnering with the SwissEnergy programme are listed according to their focus of activity. All partner organisations have their own information channels including targeted campaigns focussing on the services offered. Further campaigns and specific awareness raising activities implemented with support from the SwissEnergy programme are documented in section 9.5.1.

Partner organisations in the field of renewable energies and efficient energy use

- AEE Suisse (agency for renewable energies and energy efficiency), representing 22 branch organisations including 15 thousand enterprises and energy providers (*http://www.aeesuisse.ch*);
- Wood Energy Switzerland, promoting wood as an energy source (*http://www.holzenergie.ch*);
- Infrawatt, supporting operators of waste incineration plants, wastewater treatment plants and water supply systems in the assessment and exploitation of the potential for energy production (*http://www.infrawatt.ch*);
- Swiss Eole, promoting the use of wind energy (*http://www.suisse-eole.ch*);
- Swissolar, promoting the use of solar energy (*http://www.swissolar.ch*, *http://www.solarprofis.ch*);
- 'Fördergemeinschaft Wärmepumpen Schweiz' (FWS), promoting and offering support for labelled, quality-controlled heat pump systems (*http://wp-systemmodul.ch*).

Partner organisations in the buildings sector

- Minergie, an association pioneering in the establishment of standards and labels for low- to zero-energy buildings (*www.minergie.ch*);

- GEAK, an association under the auspices of the Conference of Cantonal Energy Directors, offering building checks that establish comparable figures on the energy use for room and water heating as well as electricity consumption and assist in identifying improvement potentials (*http://geak.ch*);
- SNBS (standard sustainable construction Switzerland), a network of public and private entities that has established a comprehensive concept for the development of the built environment in line with the principles of sustainability (*www.nnbs.ch*);
- Energo, a competence centre for energy efficient buildings and building services (*http://www.energo.ch*).

Partner organisations in the industry and services sectors

- Swiss Energy Agency of the Economy (*http://enaw.ch*) and Cleantech Agency Switzerland (*https://act-schweiz.ch*), two organisations assisting enterprises wishing to undergo a negotiated reduction commitment for exemption from the CO_2 levy (see section 4.2.7) or in need of support for the implementation of other measures and obligations in line with national or cantonal energy laws (e.g., the measures described in sections 4.3.4 and 4.3.5);
- PEIK, a platform promoting energy efficiency and offering reduced cost consulting to small and medium-sized enterprises (*https://kmu.peik.ch*).

Partner organisations in the transport sector

- QAED (Quality Alliance Eco-Drive), an alliance of public and private organisations collaborating in offering training sessions for economical, low emissions driving in the private and business sectors (*http://www.ecodrive.ch*);
- AutoEnergieCheck, a service offered by the Swiss association of garage owners aiming at saving energy and money in operating cars (*http://www.autoenergiecheck.ch*);
- Mobility Car Sharing, a pioneering organisation for car sharing in Switzerland (*www.mobility.ch*);
- ProVelo Schweiz, the national umbrella organisation representing the interests of cyclists and organising activities in promotion of the use of bicycles (*www.pro-velo.ch*).

9.2.3 Climate programme Training and Communication

The second CO_2 Act (Art. 41) and the corresponding CO_2 Ordinance (Art. 128/129) provide for a range of ‘soft' measures supporting the achievement of Switzerland's climate policy objectives. These are implemented under the label ‘Climate programme Training and Communication'. The programme was developed by the Swiss Federal Office for the Environment in close cooperation with the Swiss Federal Office of Energy. It supports and complements other related activities, e.g. in the context of the SwissEnergy programme (see above), and will be implemented in partnership with vocational training stakeholders, the cantons, ‘Energy City' (a long-term project under the umbrella of the SwissEnergy programme), municipalities and other interested parties.

With respect to training, the programme primarily aims at qualifying skilled workers in occupations that have a high relevance for the climate. These professionals should know and apply technologies, processes, and behaviour patterns that reduce emissions of greenhouse gases or cope with the effects of climate change. With respect to communication, the programme focuses on support for municipalities through advice and information services to assist these in actively promoting climate issues at the local level, inter alia, by sensitizing the population, associations and companies to climate and energy relevant issues and highlighting possibilities for action.

The Swiss Federal Office for the Environment as the implementing agency of the ‘Climate programme Training and Communication' may provide support to organisations offering related education and training services. The focus of the measures implemented during the first phase of operation of the ‘Climate programme Training and Communication' (2017–2020) is documented in *FOEN* (2017a) and summarised under sections 9.3.2, 9.4.2 and 9.5.2, respectively.

9.2.4 éducation 21

The foundation éducation21 coordinates and promotes education for sustainable development in Switzerland. It acts as a national competence centre for primary and secondary education. The foundation is active on national, language region and cantonal levels. Its main target groups are teachers, schools, teacher education institutions, non-governmental organisations and public authorities. A broad offering of services related to education for sustainable development – ranging from teaching materials and media to systemic development support and expertise – is available (see sections 9.3.3 and 9.4.3).

éducation21 is mandated and financed by the Swiss Conference of Cantonal Ministers of Education and seven federal offices responsible for vocational/professional education, development and cooperation, environment, combating racism, public health, food safety and spatial development (contractual framework for the period 2015–2018). Additional funds are generated, e.g., through service agreements with public and private institutions.

9.2.5 Scientific and other expert bodies contributing to the dissemination of information

The scientific advisory bodies ProClim (Forum for Climate and Global Change of the Swiss Academy of Sciences) and OcCC (Advisory Body on Climate Change) publish the latest information on research concerning climate-related questions or issues at stake in political discussions.

Initiated in 1988, ProClim is an independent organisation 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 supports 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 experts[65]. Additionally, ProClim organises the annual 'Swiss Global Change Day', where the Swiss climate change community meets and discusses latest results in climate change research.

OcCC was appointed in 1996 by the Swiss Federal Department of Home Affairs and the Swiss Federal Department of the Environment, Transport, Energy and Communication. 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. Currently, the body comprises nine scientific experts. The Swiss Federal Office for the Environment provides federal representation.

ProClim and OcCC maintain websites where a wealth of information, contact details of experts as well as links to related institutions in Switzerland and abroad can be found[66]. The two bodies are involved in translating and distributing the summaries of reports of the Intergovernmental Panel on Climate Change and manage the process of adapting the respective latest findings to the Swiss context (*Swiss Academies of Arts and Sciences*, 2016). In addition, consolidated statements by the research community directed at policy makers are produced at irregular intervals (e.g. *OcCC*, 2015; *Swiss Academies of Arts and Sciences*, 2016a).

Climate information is also made available by competence centres of research (see section 8.1.1). Some of these actively provide services to media, schools and other audiences as part of their education and outreach activities. Examples can be found at *http://www.oeschger.unibe.ch/services/teaching_material/index_eng.html* and *http://www.c2sm.ethz.ch*.

9.3 Primary, secondary and higher education

9.3.1 Education-related activities supported by the SwissEnergy programme

In the area of primary and secondary education, SwissEnergy has implemented the platform 'Unterrichtsthema Energie' (*https://www.energieschweiz.ch/page/de-ch/unterrichtsthema-energie*). At this web site, various resources including a data base containing recommended level-specific teaching materials are available for teachers. In addition, companies offering their services for lessons, projects or thematic days dedicated to energy use and climate protection are listed.

65 *http://4dweb.proclim.ch/4dcgi/proclim/en/index.html*

66 *https://naturwissenschaften.ch/topics/climate*
http://www.climate-change.ch
http://www.proclim.ch
http://www.occc.ch

Two examples of projects funded by SwissEnergy:

- The ‘Energie- und Klimapioniere’ (energy and climate pioneers) project is supported jointly with the telecom company Swisscom. Numerous examples are documented at the project web site (*https://www.energie-klimapioniere.ch*);
- ‘Energie-Erlebnistage’ (energy adventure days) are an offer for primary and secondary school classes, aiming to sensitise pupils for the more careful and conscious use of energy (*http://www.oekozentrum.ch/98-0-Bildungsangebote.html*, *http://www.energie-erlebnistage.ch*).

Presently, about 1.2 million Swiss francs per year are available for the support of projects at primary and secondary school level.

9.3.2 Measures within the ‘Climate programme Training and Communication’

In the domain of compulsory education, the programme foresees the elaboration of an educational concept focussing on the definition and illustration of good practice with regard to methods and contents of climate education at all levels. The concept shall serve as a basis for the development of practice-oriented teaching materials on the one hand and related training units for teachers on the other hand.

In addition, in order to enhance the effectiveness of educational offerings aimed at the improvement of climate-related competencies, institutions and persons active in the domain of environmental education at all levels of compulsory and general education shall be offered targeted support.

9.3.3 Services offered by éducation21

éducation21 provides teachers, school boards and other involved parties with pedagogically tested teaching materials, information, advice and expertise related to education for sustainable development.

The éducation21 web platform (*http://www.education21.ch*) features a permanently updated data base, giving access to a wide range of recommended teaching media (including CDs, DVDs, games, online media, etc.) in German, French and partially in Italian. The platform allows for targeted searching, e.g. by use of keywords explicitly addressing climate change or the ecological, social and economic issues surrounding it.

Three times per year, éducation21 publishes the magazine ‘ventuno’. Each issue is focussing on a specific aspect of education for sustainable development and highlights selected materials for use in school. In 2014 and 2015, an issue of the magazine was dedicated to the topics climate and energy, respectively. Schools and other education providers can apply for grants for school projects on education for sustainable development thematic issues.

9.4 Vocational training programmes

As mentioned in section 9.1, education for sustainable development is part of the general studies curriculum for basic vocational education and training in Switzerland, with specific guidelines contained in the Federal Act on Vocational and Professional Education and Training. The Swiss State Secretariat for Education, Research and Innovation oversees the development or the mandatory quinquennial evaluation, and possible revision, of occupation-specific regulations (ordinances, curricula). The Swiss Federal Office for the Environment and the Swiss Federal Office of Energy may, at an early stage, give their opinion about topics that should be taken into account.

To give an example, the 2015 revision of the regulation for carpenters extended the duration of an apprenticeship from three to four years. On this occasion, the integration of solar energy devices in building envelopes, and their importance in the context of Swiss climate and energy policy, were added to the curriculum. Each year, about 1200 persons start this vocational training programme. Thanks to support provided by the SwissEnergy programme, 21 training centres could be equipped accordingly and all instructors received specific training.

An important source for input are the so-called ‘Cleantech Fact Sheets’ which cover performance goals for more than 200 professions. These goals relate to measures enabling professionals to tap the potential for resource efficient techniques and processes, favouring, inter alia, the reduction of greenhouse gas emissions. Corresponding provisions have been introduced to the training regulations for highly climate-relevant professions such as logisticians or vehicle servicing personnel (*FOEN*, 2016a). On top of this, some professional organisations have begun to set up dedicated training sessions to bring their instructors up-to-date with latest developments in matters related to the protection of the environment.

At the level of advanced professional education and training, regular evaluations of regulations are not mandatory and it is up to the professional organisations if they wish to invite advice or recommendations from the competent government authorities. Thus, close collaboration is limited to those professional organisations that expect economical or image benefits from strengthening environmental matters in their training curricula and examination requirements.

An initiative of the Swiss Association of Electricity Providers (VSE) illustrates this. Since 2014, VSE offers a training programme to experts from several professions in the electricity and building sectors to become officially recognised consultants for efficient (and, thus, less greenhouse gas emitting) energy use. Elaboration of training materials was sponsored by the SwissEnergy programme.

9.4.1 Training-related activities supported by the SwissEnergy programme

In order to make best use of innovations in the energy sector, specialists have to be familiar with technological developments. In 2014, SwissEnergy launched its ‘education initiative’, a major project periodically assessing needs, supporting the development of new offers and networking the relevant stakeholders. By linking professional organisations, public authorities and educational institutions, the initiative ensures that vocational education and training offers respond to the expectations of all partners in the vocational education system.

Several focal areas have been defined and related measures addressing trainees and professionals dealing with energy have been implemented with a view to:

- Accelerating transfer of knowledge and improvement of offers at all levels of vocational education and training, inter alia, by systematically including up-to-date energy and climate issues in training materials;
- Consolidating programmes for newcomers with a different educational background – in particular for vocational fields with a lack of trainees (e.g. technical building equipment; see also *http://www.passerelle-energieingenieur.ch*, *http://www.energie-fr.ch/FR/Pages/PASSERELLE-FR.aspx*);
- Ensuring coordination and topicality of educational offers while minimising duplication of efforts through the establishment of annual round tables, facilitation of stakeholder dialogues and assessment of educational needs, in particular in the area of solar energy applications;
- Ensuring expertise regarding new regulations and their implementation in the energy sector.

SwissEnergy has supported the development and implementation of several specialised vocational education and training offers (e.g. *http://www.enbau.ch*, *http://www.mas-eddbat.ch*, *www.fho.ch/weiterbildung/energie-umwelt/mas-energiesysteme*, *www.solarteure.ch*, *https://www.suissetec.ch/de/projektleiter-in-solarmontage.html*, *www.supsi.ch/isaac/formazione.html*, *https://www.werz.hsr.ch/index.php?id=12433*, *www.fe3.ch*).

In addition, under the address *https://www.energieschweiz.ch/events-search/de-ch*, SwissEnergy presents a comprehensive calendar of continuing education offers relevant to students or professionals in the energy sector.

At the level of basic vocational education and training, SwissEnergy supports the ‘Energie- und Klimawerkstatt’ (‘Energy and Climate Laboratory’), where vocational schools and companies with trainees can participate in a project competition for students and trainees (*http://www.myclimate.org/education/climate-laboratory*).

The total budget of SwissEnergy dedicated to basic and continuing vocational education and training has been raised from 2.5 million Swiss francs in 2013 to 6.5 million Swiss francs in 2016. Annually, about 150 projects receive funds from this budget, with about 5.3 million Swiss francs in support of vocational education and training.

9.4.2 Measures within the 'Climate programme Training and Communication'

Complementing the offers under the umbrella of SwissEnergy, within this programme occupation-specific teaching and examination materials are developed and tested for use in the various training environments of basic and advanced professional education and training (companies, branch courses, specialised schools and colleges).

In line with existing procedures, occupation-specific regulations (vocational education and training ordinances) undergoing a reform or regulations established for newly defined occupations will be assessed for the need of integrating climate-relevant skills and competencies in the respective education, training and examination requirements.

A further focus lies on the promotion and strengthening of information exchange between professional organisations, education and training institutions, and companies. The aim is to enhance the transfer of climate-relevant knowledge, experiences and good practice examples amongst the specialists responsible for or involved in training programmes.

Finally, continued education and training offerings for experienced professionals working in areas of particular importance for climate change mitigation and adaptation shall be complemented by tailor-made learning units and materials such as recommendations and checklists, enabling decision-making processes that better take into account the risks and opportunities of climate change.

9.4.3 Services offered by éducation21

As far as training and continuing education for teaching staff is concerned, éducation21 closely cooperates with teacher education institutions, providing them with advice, networking support, events and training units on education for sustainable development.

In the area of vocational/professional education, éducation21 recently concluded a project for building up a network of stakeholders interested in promoting education for sustainable development in the field of vocational education and training. A second phase of the project aims at fostering and anchoring education for sustainable development among stakeholders by means of expertise and whole system support.

9.5 Awareness raising and information campaigns in the public domain

9.5.1 Campaigns and activities supported by the SwissEnergy programme

SwissEnergy uses a wide range of channels and instruments to reach its various target audiences, many of which in the three official languages:

- Nation-wide campaigns (e.g., road shows, accompanied by print and online media coverage);
- TV commercials, advertisements, video clips, apps (including educational games);
- Appearances at trade fairs and exhibitions;
- Advertorials (articles in industry publications, responding to the specific needs of the particular professional audiences);
- Annual newspaper ('Extrablatt') on topical issues and trends in renovation of buildings, mobility and renewable energy use; newsletters directed at homeowners;
- Website, social media, brochures, leaflets.

The 'Energy Challenge' (*https://energychallenge.ch*) is a major national awareness campaign which started in 2016. It focusses on the main themes of SwissEnergy (energy efficiency and renewables) and comprises, inter alia, a road show visiting numerous cities, exhibits, concerts, appearances of prominent 'ambassadors' as well as platforms for partner organisations. A dedicated web application giving access to contests and many other features was downloaded by more than 50 thousand persons. According to an evaluation, in the first year of the campaign, media coverage reached about 70 per cent of the Swiss population and 20 million kilowatt-hours of electricity were saved by persons implementing energy saving measures propagandised by the campaign.

The 2016 campaign budget included four million Swiss francs from SwissEnergy and two million Swiss francs (contributions in kind or cash) from partner organisations. Due to its success, the Energy Challenge is continued in 2017 and may not end before 2019.

Other awareness raising and consumer information activities funded by SwissEnergy include:

- The 'Energieetikette'(energy label), which, over the years, has been applied to an ever increasing number of product categories (see *https://www.energieschweiz.ch/page/de-ch/energieetiketten*);
- The 'Tage der Sonne', ('Days of the Sun'), where various applications of solar energy and related products and services are presented at the local level (*http://www.tagedersonne.ch*);
- The campaign 'CO_2 tieferlegen' ('lowering CO_2'), promoting energy efficient cars that comply with the top requirements of the energy label (less than 95 grams of CO_2 per kilometre) (*https://co2tieferlegen.ch*).

9.5.2 Measures within the 'Climate programme Training and Communication'

'Energy Cities', as described in section 9.2.2, are a successful awareness raising programme at municipality level. Beyond the traditional focus on energy efficiency and renewable energies, the 'Climate programme Training and Communication' attempts to fully exploit potential synergies between energy and climate policy and to put additional issues like climate adaptation on the 'Energy City' agenda. Thus, the catalogue of measures for attaining the 'Energy City' label has been amended, and supporting communication tools and formats will be elaborated.

To assist the numerous smaller-sized municipalities not participating in the 'Energy City' programme in tackling climate issues, the Climate programme foresees low-threshold instruments and targeted advice to local authorities. Additional materials and easy-to-use tools will be developed to complement existing communication channels and instruments and assist administration employees in reaching out to the different stakeholders.

The programme will closely cooperate with developers and providers of innovative projects aimed at target groups such as consumers, business employees, or local associations. To be eligible for support, projects should have the potential to effectively promote climate action, to reach relevant target groups, to serve as models, and be suitable for replication.

9.5.3 Other awareness raising activities at the national level

From 12 January to 15 May 2017, MeteoSwiss was present at the Swiss National Museum in Zurich with the exhibition 'The Weather – Sunshine, lightning and cloudbursts'. The exhibition aimed at making weather and climate phenomena perceptible and explaining them in detail (*https://www.nationalmuseum.ch/e/microsites/2017/Zuerich/Wetter.php*).

Within the pilot programme 'Adaptation to climate change' (see section 6.4.2), which was implemented between 2014 and 2017, several projects were dedicated to the target of raising awareness for climate change adaptation in cantons, regions and municipalities. Individual projects and their products are documented in *FOEN* (2017).

9.6 Involvement of non-governmental organisations and the private sector

After many years of public debate about climate change, its implications for society and economy, and appropriate ways of responding to the challenges linked to this, it is impossible to overlook all the private sector initiatives related to climate change in Switzerland. Thus, every attempt to summarise relevant activities is bound to be fragmentary and distorted. In the following paragraphs, some of the more visible actors and activities, as perceived from a national perspective, are listed. Inevitably, this approach fails to document the numerous initiatives at regional and local level contributing to public awareness, fostering discussions about necessary action and motivating individuals to change their behaviour as consumers, employees or citizens.

Organisations offering climate-relevant services in the area of education and training (in alphabetical order, non-exhaustive list)

- Globe (*https://www.globe-swiss.ch*);
- Greenpeace (*http://www.greenpeace.org/switzerland/de/Aktiv-werden/Jugendsolar*);
- myclimate (*http://www.myclimate.org/de/bildung*);

- Ökozentrum Langenbruck (*http://www.oekozentrum.ch/15-0-Projekte.html*; *http://www.oekozentrum.ch/98-0-Bildungsangebote.html*);
- PUSCH (*http://www.pusch.ch/fuer-schulen/umweltunterricht/energie-und-klima*; *http://www.pusch.ch/fuer-gemeinden*);
- WWF (*http://www.wwf.ch/de/aktiv/lehrer/*; *http://www.wwf.ch/de/aktiv/handelnjugend*).

Selected companies and business initiatives actively engaged in climate-relevant projects (in alphabetical order, non-exhaustive list)

- Coop (*https://www.coop.ch/de/nachhaltigkeit.html*);
- Die Post (Swiss Post; *https://www.post.ch/en/about-us/company/responsibility*);
- energie-cluster.ch (*www.energie-cluster.ch*);
- Klimastiftung Schweiz (Swiss Climate Foundation; *http://www.klimastiftung.ch/climate_foundation.html);*
- Migros (*https://www.migros.ch/de/werte/nachhaltigkeit.html*);
- SBB (SBB The Swiss Railway; *https://company.sbb.ch/de/ueber-die-sbb/verantwortung/umweltvorteil-bahn/klimaschutz.html*);
- Swiss Association for Environmentally Conscious Management (*www.oebu.ch*);
- Swiss Re Group (*http://www.swissre.com/corporate_responsibility/*);
- swisscleantech *(http://www.swisscleantech.ch/);*
- Swisscom (*https://www.swisscom.ch/en/about/company/sustainability/climate-protection.html*);
- Swisspower (*https://www.swisspower.ch/swisspower-renewables-ag-en/strategy/?lang=en*);
- Zurich Insurance Company Ltd (*http://klimapreis.zurich.ch/index.php?id=366&L=3*).

Environmental non-governmental organisations and grassroots organisations

The main Swiss organisation combining environmental and development non-governmental organisation interests and coordinating overarching campaigns in the field of climate policy is:

- Klima-Allianz (Climate Alliance Switzerland; *http://www.klima-allianz.ch*).

Several other organisations are active in specific areas or focusing on specific target groups (in alphabetical order, non-exhaustive list):

- Alliance Sud (Swiss Alliance of Development Organisations; *http://www.alliancesud.ch/en/politics/climate-and-environment/climate-policy-and-financing?f[0]=node%253Afield_classification_politics%3A519*);
- Greenpeace Switzerland (*https://www.greenpeace.ch/themen/klima*);
- SES Schweizerische Energie-Stiftung (Swiss Energy Foundation; *http://www.energie-stiftung.ch/energiepolitik-klimapolitik.html*);
- VCS Verkehrs-Club der Schweiz (Swiss Association for Transport and Environment; *http://www.vcs-ate.ch/unsere-themen*);
- WWF Switzerland (*http://www.wwf.ch/de/hintergrundwissen/klima*).

Further grassroots organisations (and business start-ups) active in the field of climate protection are:

- Ärztinnen und Ärzte für Umweltschutz (*http://www.aefu.ch*);
- Alternatibaleman (*http://www.alternatibaleman.org*);
- Eaternity (*http://www.eaternity.org*);

- fossil-free.ch (*http://fossil-free.ch/de*);
- Grands-parents pour le climat (*http://www.gpclimat.ch*);
- KlimaSeniorinnen (*http://klimaseniorinnen.ch*);
- Myblueplanet (*http://www.myblueplanet.ch*);
- oeku Kirche und Umwelt (*http://oeku.ch*).

9.7 Participation in international education, training and awareness raising activities

International activities supported by Switzerland with a strong bearing for training and capacity building are documented in sections 7.2 and 7.3. In the following, some additional activities relevant to education, training and awareness raising at the international level are listed.

éducation21

The éducation21 web portal provides information and resources on Switzerland's contribution to the international education for sustainable development community, in particular on projects and programmes led or supported by the universities of applied sciences in teacher education (*http://www.education21.ch/en/partnerships*). éducation21 also hosts the ENSI (environment and school initiative) secretariat. ENSI is an international network of experts working on education for sustainable development issues since 1986 (*http://www.ensi.org*).

Climate-KIC

Climate-KIC (*http://www.climate-kic.org*) is a public-private innovation partnership focused on climate change, consisting of companies, the academic institutions and the public sector. The Swiss Federal Institute of Technology in Zurich is amongst the core institutions of the Climate-KIC consortium. It played a key role in initiating the project and embedding it in a European multi-state context at the interface between research, knowledge transfer, capacity building and private sector involvement.

Climate-KIC is one of three Knowledge and Innovation Communities created in 2010 by the European Institute of Innovation and Technology. The European Institute of Innovation and Technology is a body of the European Union whose mission is to create sustainable growth. Climate-KIC supports this mission by addressing climate change mitigation and adaptation. Below, two Climate-KIC products in the area of education and training are highlighted.

'The Journey' is a three or five week residential, interdisciplinary and experiential learning summer school. It brings together international students and young professionals from a wide range of backgrounds to exchange with Europe's top experts from business, research, policy and academia around the challenges of climate change, whilst learning in a hands-on way to develop successful start-ups to address these. From validating an idea to understanding the market, structuring a business to building an interdisciplinary team, delivering a business plan to pitching at a final event, Climate-KIC gears participants up for the world of climate entrepreneurship. Each 'Journey' takes up to 40 participants through two to three European cities, combining local climate expertise and site visits with the tools to make an impact on the global effort to find solutions. Climate-KIC works together with various European universities that host the programme. Since its inception in 2010, over 1200 participants from across the globe have gained climate and entrepreneurial knowledge and inspiration from 'the Journey'. More than 240 business ideas have been generated, with an increasing number of these successfully continuing on to start-up programmes. The format has been held up as a best practice example of innovation in higher education by the OECD (HEI Innovate) and, in 2016, the programme also saw public recognition as a winner of the '21 solutions pour demain' campaign in France.

'The Climathon' is a 24-hour ideation format held simultaneously in cities around the world. The idea is to inspire and stimulate local solutions for local city challenges and creating a global network around climate innovation. During the 24 hours participants ideate around thematic city challenges and develop solutions, which they present at the end of the event. Winning solutions are encouraged to be implemented in the local city. In 2016 almost 60 cities participated, including the City of Zurich. All individual events are linked up digitally to allow for intercontinental collaboration.

Swiss Climate Summer School

Since many years, the Centre for Climate Systems Modelling at the Swiss Federal Institute of Technology in Zurich, together with the Oeschger Centre for Climate Change Research, sponsors and organises the Swiss Climate Summer School. The Summer School invites young researchers from all fields of climate research. The courses cover a broad spectrum of cutting-edge climate research and foster cross-disciplinary links. Each topic includes keynote plenary lectures and workshops with in-depth discussion in smaller groups (for an overview of the 2017 edition see *https://www.ethz.ch/content/dam/ethz/special-interest/usys/c2sm-dam/education/summerschool2017/SCSS_summerschool_flyer_2017.pdf*).

Partnership on Transparency in the Paris Agreement[67]

Since 2016, in the context of the Cluster Francophone of the Partnership on Transparency in the Paris Agreement, Switzerland is contributing to the organisation and implementation of regional workshops. The workshops offer the opportunity for experts from French speaking developing countries to benefit from the knowledge base of the Partnership on Transparency in the Paris Agreement by sharing experiences and receiving expert inputs related to the establishment of reports under the UNFCCC and the development of approaches for MRV of mitigation actions in line with the evolving transparency framework under the UNFCCC (*https://www.transparency-partnership.net/*; *https://www.transparency-partnership.net/activity/partnership-francophone*).

9.8 Monitoring, review and evaluation of the implementation of Article 6 of the Convention

In Switzerland, there is no formal monitoring, review and evaluation process in place for assessing the implementation of Article 6 of the UNFCCC. However, as documented in this report, implementation of Article 6 is taken into account as part of other commitments related to mitigation, adaptation and international cooperation.

Preparation and review of the national communication

The Swiss political system offers far-reaching possibilities to interested stakeholders for participation in policy-making and policy review processes (see section 2.1). In Switzerland, the preparation of national communications under the UNFCCC is not considered an element of policy-making or policy review. Rather, national communications serve as a means to give account of policy implementation towards an international audience.

Domestically, climate policy issues often are framed and discussed differently, depending on specific topics and their political context. This is also illustrated by the fact that Switzerland has two sets of different, yet consistent mitigation targets at the national level and in the context of the UNFCCC, respectively (see Annex B.3).

In practice, national communications under the UNFCCC are prepared involving a wide range of government and scientific community experts knowledgeable in the topics covered (see the imprint of the present report and earlier Swiss national communications). The content of national communications is subject to review by IDA-Klima, an interdepartmental committee on climate of the federal authorities (see section 4.1.1). The national inventory system supervisory board (NISSB) is responsible for the official consideration of Switzerland’s national communications as well as for the recommendation for official approval by the directorate of the Swiss Federal Office for the Environment.

In view of this and given the presence of three official languages in Switzerland (none of which is English), public participation in the preparation or domestic review of national communications under the UNFCCC is considered neither particularly useful nor necessary. The original report itself, and translated and printed summary versions of the report[68], are brought to the attention of the public by the Swiss Federal Office for the Environment. They may be downloaded via the website of the Swiss Federal Office for the Environment (e.g. at *http://www.climatereporting.ch*) or ordered from the Swiss Federal Office for Buildings and Logistics.

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67 Formerly known as the International Partnership on Mitigation and MRV.

68 See *http://www.bafu.admin.ch/ud-1078-e* for the summary version of Switzerland’s sixth national communication. The summary version of Switzerland’s seventh national communication is scheduled to be published in spring 2018.

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Annex A Supplementary information under Article 7, paragraph 2, of the Kyoto Protocol

Supplementary information under Article 7, paragraph 2, of the Kyoto Protocol is contained in different chapters and sections of Switzerland's seventh national communication, as detailed in Tab. 58.

Tab. 58 > Reference to chapters and sections of Switzerland's seventh national communication containing the supplementary information under Article 7, paragraph 2, of the Kyoto Protocol.

National systems in accordance with Article 5, paragraph 1	Section 3.3
National registry	Section 3.4
Supplementarity relating to the mechanisms pursuant to Articles 6, 12 and 17	Annex B.3.6
Policies and measures in accordance with Article 2	Chapter 4
International Civil Aviation Organisation	Section 4.4.1, 4.4.8 to 4.4.10
International Maritime Organisation	Section 4.4.11
Minimising adverse effects	Section 4.13
Domestic and regional programmes and/or legislative arrangements and enforcement and administrative procedures…	Tab. 14
…to meet the commitments under the Kyoto Protocol (legal authorities, cases of non-compliance, public availability of information)	Section 4.1.1, Tab. 14
…to coordinate activities relating to participation in the mechanisms under Articles 6, 12 and 17	Section 4.1.1
…to ensure the conservation of biodiversity and sustainable use of natural resources when implementing Articles 3.3 and 3.4	Section 4.7.1
Information under Article 10	
Article 10a: Programmes to improve the quality of local emission factors, activity data and/or models	Section 3.3
Article 10b: Programmes containing measures to mitigate climate change and measures to facilitate adaptation to climate change	Chapter 4, section 6.4 to 6.6
Article 10c: Transfer of technologies	Section 7.2
Article 10d: Scientific and technical research, systematic observation systems	Chapter 8
Article 10e: Education and training programmes	Chapter 9
Financial resources	Chapter 7

Annex B Third biennial report of Switzerland

B.1 Introduction

Switzerland's third biennial report is presented as an annex to Switzerland's seventh national communication. It consists of the BR CTF tables (see separate submission) and the textual part (Annex B.2 to B.7), addressing the reporting requirements according to the 'UNFCCC biennial reporting guidelines for developed country Parties'. To report the same information once only, reference to the respective chapters and sections of Switzerland's seventh national communication is provided where appropriate.

B.2 Information on greenhouse gas emissions and trends

Summary information from the national greenhouse gas inventory on emissions and emission trends prepared according to the UNFCCC Annex I inventory reporting guidelines are presented in BR CTF tables 1(a) to 1(d), as well as in Switzerland's seventh national communication (chapter 3, sections 3.1 and 3.2). The presented data cover the period from 1990 to 2015 and are fully consistent with that provided in the most recent annual inventory submission of April 2017.

Summary information on Switzerland's national inventory arrangements, including changes since the second biennial report, are also presented in Switzerland's seventh national communication (chapter 3, section 3.3). As required by the 'Guidelines for the preparation of the information required under Article 7 of the Kyoto Protocol', information on the national registry is further reported in Switzerland's seventh national communication (chapter 3, section 3.4).

B.3 Quantified economy-wide emission reduction target

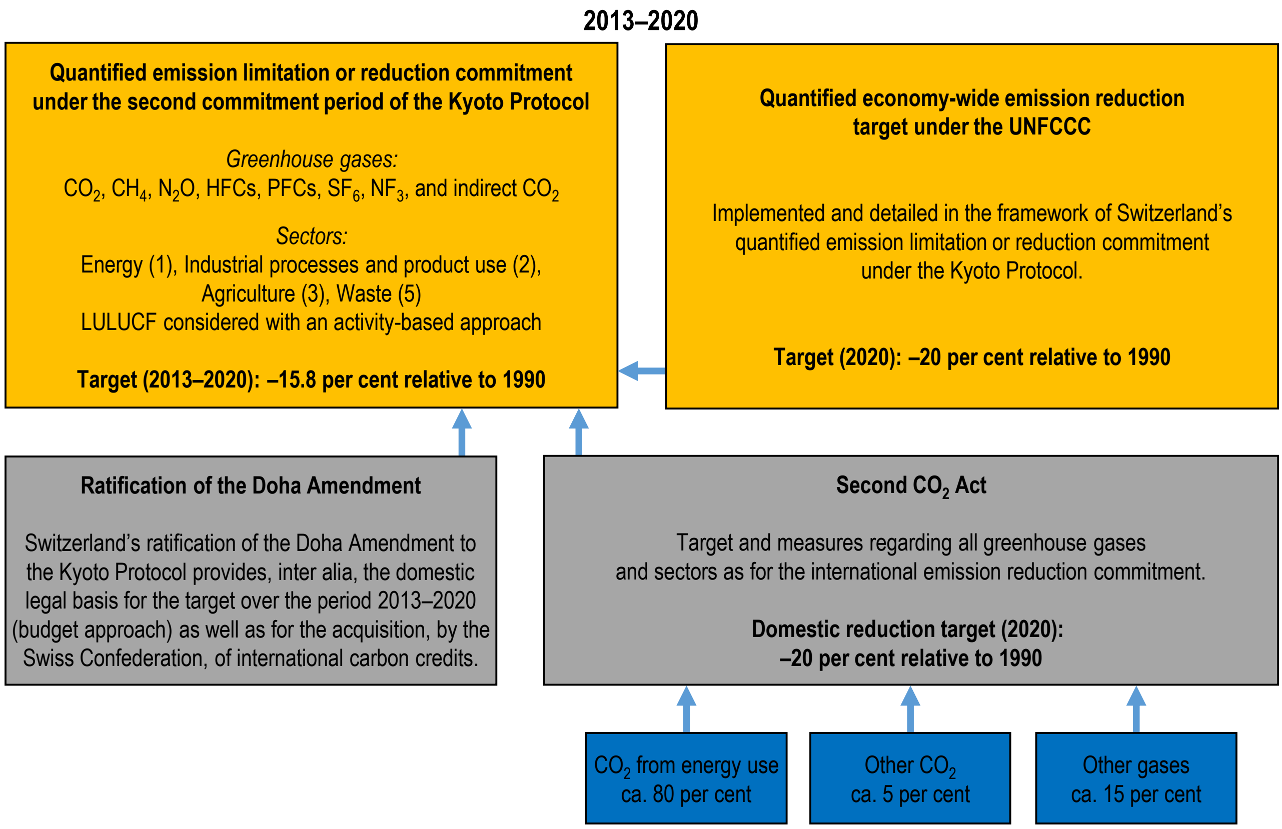
B.3.1 General information

While all information regarding Switzerland's emission reduction commitment is summarised in BR CTF table 2, this section provides further background information in textual form.

By ratifying the UNFCCC in 1993, Switzerland committed to contribute to the stabilisation of greenhouse gas emissions at a level that prevents dangerous anthropogenic interference with the climate system. Switzerland's quantified economy-wide emission reduction target under the UNFCCC is – in a consistent manner – implemented under the Kyoto Protocol, making Switzerland's emission reduction commitment internationally binding. Accordingly, Switzerland, in 2003, ratified the Kyoto Protocol, which entered into force in 2005. In this context, Switzerland made a quantified emission limitation or reduction commitment of 92 per cent of the base year (1990) level for the first commitment period of the Kyoto Protocol (2008–2012). For the second commitment period of the Kyoto Protocol (2013–2020), Switzerland is continuing its emission reduction efforts and has submitted its instrument of acceptance of the Doha amendment to the Kyoto Protocol on 28 August 2015. Therewith, Switzerland entered into a quantified emission limitation or reduction commitment of 84.2 per cent of the base year (1990) level for the second commitment period of the Kyoto Protocol (2013–2020). This quantified emission limitation or reduction commitment implements and details in a consistent manner Switzerland's quantified economy-wide emission reduction target of 20 per cent below the emissions of the year 1990, to be reached by 2020. Switzerland's targets are unconditional under both the UNFCCC and the Kyoto Protocol[69]. The international emission reduction commitment is implemented nationally by means of the second CO_2 Act and the corresponding policies and measures (for details see chapter 4 of Switzerland's seventh national communication). Based on the second CO_2 Act and in consistency with the international emission reduction commitment, Switzerland's national target is a reduction of domestic greenhouse gas emissions by at least 20 per cent by 2020 relative to 1990 levels (in contrast, Switzerland's international emission reduction commitment allows for the supplemental use of international carbon credits). An overview of Switzerland's current national and international emission reduction commitment is provided in Fig. 98.

[69] However, as part of a global and comprehensive agreement for the period beyond 2012, Switzerland reiterated its conditional offer to move from its target of a 20 per cent emission reduction by 2020 compared with 1990 levels to a 30 per cent emission reduction, provided that other developed countries commit themselves to comparable emission reductions and that developing countries contribute adequately according to their responsibilities and respective capabilities (see FCCC/SB/2011/INF.1/Rev.1).

Fig. 98 > Switzerland's current national and international emission reduction commitment. The national target under the second CO_2 Act, Switzerland's quantified economy-wide emission reduction target under the UNFCCC, as well as Switzerland's quantified emission limitation or reduction commitment under the second commitment period of the Kyoto Protocol are aligned and, thus, consistent. LULUCF: Land use, land-use change and forestry.



To look ahead, Switzerland has been committing to the following nationally determined contribution (NDC) in the framework of the Paris Agreement[70]:

- Switzerland commits to reduce its greenhouse gas emissions by 50 per cent by 2030 compared to 1990 levels, corresponding to an average reduction of greenhouse gas emissions by 35 per cent over the period 2021–2030. By 2025, a reduction of greenhouse gases by 35 per cent compared to 1990 levels is anticipated. International carbon credits will partly be used.

B.3.2 Base year

As mentioned above, the base year is 1990 for all sectors and gases covered. For the second commitment period of the Kyoto Protocol, Switzerland's base year emissions are defined in Switzerland's Second Initial Report under the Kyoto Protocol (in particular in the update following the in-country review by an expert review team coordinated by the UNFCCC secretariat, see also FCCC/IRR/2016/CHE). The respective base year emissions are relevant for Switzerland's quantified emission limitation or reduction commitment under the second commitment period of the Kyoto Protocol, Switzerland's quantified economy-wide emission reduction target under the UNFCCC as well as for Switzerland's national target under the second CO_2 Act.

B.3.3 Gases and sectors covered

In the international context, Switzerland's quantified economy-wide emission reduction target under the UNFCCC as well as Switzerland's quantified emission limitation or reduction commitment under the Kyoto Protocol cover the full set of reported greenhouse gases (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, and NF_3). All targets also include indirect CO_2

[70] Switzerland deposited its instruments of ratification on 6 October 2017 with the Depositary, leading to the entry into force of the Paris Agreement for Switzerland on 5 November 2017.

emissions, as long as the indirect CO_2 emissions are of fossil origin and not already considered under the direct CO_2 emissions (e.g. when an oxidation factor of 100 per cent is applied, see also section 3.2.4 of Switzerland's seventh national communication). All targets include the emissions from the sectors energy (1), industrial processes and product use (2), agriculture (3), and waste (5). Land use, land-use change, and forestry is considered with an activity-based approach (Articles 3.3 and 3.4). All emissions (in particular also indirect CO_2 emissions) from sector 'Other' (6) are not included. The second CO_2 Act covers the same gases and sectors as relevant for the international reduction commitments.

B.3.4 Global warming potential values

Switzerland consistently uses the global warming potential values listed in the column entitled 'Global warming potential for given time horizon' in Table 2.14 of the errata to the contribution of Working Group I to the fourth assessment report of the Intergovernmental Panel on Climate Change (*IPCC*, 2007), based on the effect of greenhouse gases over a 100-year time horizon. These global warming potential values are also reflected in Annex I of the Ordinance on the Reduction of CO_2 Emissions (CO_2 Ordinance; *Swiss Confederation*, 2012) for the period 2013–2020.

B.3.5 Approach to counting emissions and removals from the land use, land-use change and forestry sector

According to Article 3.7 of the Kyoto Protocol, the land use, land-use change and forestry sector is only included in the calculation of the assigned amount in case this sector constituted a net source of greenhouse gases in 1990. In Switzerland, the land use, land-use change and forestry sector was a net sink in 1990 and is therefore excluded from the base year level and target.

With regard to Switzerland's emission reduction commitment, the land use, land-use change and forestry sector is accounted for with an activity-based approach. Under Article 3.3 of the Kyoto Protocol, Switzerland accounts for afforestation, reforestation as well as deforestation, and under Article 3.4 of the Kyoto Protocol for forest management. Accordingly, Switzerland consistently applies the rules to counting emissions and removals from the land use, land-use change and forestry sector as established under the Kyoto Protocol. Importantly, the sum of emissions/removals for activities under Articles 3.3 and 3.4 needs to be further offset against Switzerland's forest management reference level and the technical corrections to the forest management reference level in order to get the accounting quantity. Further, the forest management cap[71] will need to be considered for the final accounting at the end of the commitment period.

B.3.6 Use of international market-based mechanisms

Switzerland's climate policy generally aims at domestic reductions of greenhouse gas emissions. However, Switzerland will use international carbon credits generated from the flexible mechanisms under the Kyoto Protocol – i.e. mainly CERs, but potentially also ERUs and units from other marked-based mechanisms – to compensate for some of its emissions over the period 2013–2020. Carried-over units, i.e. units carried over from the first to the second commitment period, may also be used. While the possible scale of contributions of international carbon credits needed by Switzerland in order to reach its emission reduction targets for the second commitment period is unknown, further details on the modalities pertaining to the supplemental use of international carbon credits are given in the following:

- The second CO_2 Act defines Switzerland's 20 per cent reduction target (by 2020, relative to 1990) as domestic. However, international carbon credits will play a role in the case of (i) the obligation to offset emissions from gas-fired combined-cycle power plants (section 4.3.6 of Switzerland's seventh national communication), (ii) the emissions trading scheme (section 4.2.6 of Switzerland's seventh national communication), (iii) negotiated reduction commitments (for exemption from the CO_2 levy, section 4.2.7 of Switzerland's seventh national communication), and (iv) the partial compensation of CO_2 emissions from motor fuel use (section 4.4.5 of Switzerland's seventh national communication). For the latter three measures, international carbon credits will only be used in case agreed or set targets are not achieved (i.e. as part of the sanction mechanism to enforce the law);
- Switzerland will use additional international carbon credits recognised under the Kyoto Protocol to meet the differences between the approaches used under national legislation (i.e. emission reduction target defined for the

[71] The forest management cap corresponds to 3.5 per cent of base year emissions excluding land use, land-use change and forestry times eight. For Switzerland the cap thus amounts to 15'037'884 tonnes of CO_2 equivalents for the entire commitment period 2013–2020.

year 2020) and under the Kyoto Protocol (i.e. ‘carbon budget’ approach used to calculate the quantified emission limitation or reduction commitment for the period 2013–2020). International carbon credits to be used for this purpose are also available from the Climate Cent Foundation (section 4.4.4 of Switzerland’s seventh national communication), which is obligated to use excess revenues from the period 2005–2012 for the acquisition of international carbon credits and to hand these over to the government;

- In case the Swiss Federal Council further increases the reduction target in order to comply with international agreements, parts of the additional reductions in greenhouse gas emissions may be achieved through measures carried out abroad;
- Switzerland is applying quality requirements to determine the eligibility of international carbon credits. These quality requirements are stipulated in Annex II of the CO_2 Ordinance[72] and detailed in a fact sheet[73] published by the Swiss Federal Office for the Environment;
- In Annex II of decision 2/CMP.8 Switzerland made a clear political declaration relating to AAUs carried over from the first commitment period of the Kyoto Protocol. Accordingly, under the Swiss domestic legislation applicable during the second commitment period, Switzerland will not use carried-over AAUs transferred from other Parties for compliance under Article 3 of the Kyoto Protocol for the second commitment period. Switzerland will adhere to arrangements in other countries relating to the transfer of AAUs under any arrangement that may link Switzerland’s emissions trading scheme with the emissions trading schemes of other countries. Switzerland may use some of its own carried-over AAUs.

B.3.7 Any other information

As Switzerland’s quantified economy-wide emission reduction target under the UNFCCC is – in a consistent manner – implemented under the Kyoto Protocol, Switzerland follows the accounting rules implemented and detailed in the framework of its quantified emission limitation or reduction commitment under the Kyoto Protocol.

B.4 Progress in achievement of quantified economy-wide emission reduction targets and relevant information

B.4.1 Mitigation actions and their effects

Information on Switzerland’s mitigation actions, including on the policies and measures implemented or planned to be implemented since the last national communication or biennial report to achieve the emission reduction commitment, is summarised in BR CTF table 3. Chapter 4 of Switzerland’s seventh national communication provides details for each policy and measure, in particular also regarding the estimated mitigation impacts and, if applicable, a further strengthening of the policy and measure in the future.

Information on Switzerland’s domestic institutional arrangements, including institutional, legal, administrative and procedural arrangements used for domestic compliance, monitoring, reporting, archiving of information and evaluation of the progress towards the economy-wide emission reduction target is provided in section 4.1.2 and 4.1.3 of Switzerland’s seventh national communication.

Detailed information on the assessment of the economic and social consequences of response measures is presented in section 4.13 of Switzerland’s seventh national communication.

B.4.2 Estimates of emission reductions and removals and the use of units from the market-based mechanisms and land use, land-use change and forestry activities

Detailed information on progress in the achievement of the quantified economy-wide emission reduction targets is provided in BR CTF table 4. The following points are noteworthy:

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[72] http://www.admin.ch/opc/en/classified-compilation/20120090/index.html#app2

[73] https://www.bafu.admin.ch/dam/bafu/en/dokumente/klima/formular/qualitaet_von_imauslanderzieltenemissionsverminderungen.pdf

- Base year emissions (without land use, land-use change and forestry) are indicated in BR CTF table 4 according to the report on the review of the report to facilitate the calculation of the assigned amount for the second commitment period of the Kyoto Protocol of Switzerland (FCCC/IRR/2016/CHE). Due to recalculations, the relevant base year emissions slightly differ from the respective values provided in Switzerland's most recent greenhouse gas inventory (as presented e.g. in BR CTF table 1);
- Base year emissions include emissions of all greenhouse gases (including indirect emissions of CO_2) from the sectors energy (1), industrial processes and product use (2), agriculture (3), and waste (5). See section B.3 for more details;
- The contribution from LULUCF (i.e. KP-LULUCF for Switzerland) corresponds to the sum of emissions/removals for activities under Articles 3.3 and 3.4, offset against Switzerland's forest management reference level and the technical corrections to the forest management reference level. The forest management cap will be considered for the final accounting at the end of the commitment period;
- Switzerland will account for contributions from market-based mechanisms (including carried-over units as detailed below) at the end of the commitment period, therefore no annual numbers can be provided. However, as recommended by the ERT during the last review, Switzerland reports the amount of units from market-based mechanisms on the party holding accounts in the national registry at the end of 2016 as a provisional estimate. Consequently, the contributions from market-based mechanisms for the preceding years are included in the provisional estimate for 2016 and, thus, reported as 'IE'. The values provided for 2016 are composed as follows: (i) number of units on the party holding accounts at the end of 2016 (15'297 CERs, see Tab. 13 of Switzerland's seventh national communication or Table 4 of RREG1_CH_2016_2_1), (ii) number of carried-over units from the first to the second commitment period of the Kyoto Protocol according to Table 2 of the report upon expiration of the additional period for fulfilling commitments by Switzerland (5'794'523 AAUs, 1'821'654 CERs), whereby the carried-over units on entity holding accounts are subtracted (181'123 CERs, see Tab. 12 of Switzerland's seventh national communication or Table 4 in RREG1_CH_2016_1_2), and (iii) there are currently no units on the retirement account for the second commitment period.

B.5 Projections

Information – including supporting documentation – on updated projections for the years 2020 and 2030 are presented in BR CTF tables 5 and 6(a) to 6(c), as well as in chapter 5 of Switzerland's seventh national communication. Changes in the model or methodologies used for the preparation of projections are detailed in section 5.3.8 of Switzerland's seventh national communication.

B.6 Provision of financial, technological and capacity-building support to developing country Parties

Information regarding the provision of financial, technological and capacity-building support to developing country Parties is provided in BR CTF tables 7, 8, and 9, as well as in chapter 7 of Switzerland's seventh national communication.

B.6.1 Finance

How Switzerland ensures that the resources it provides effectively address the needs of developing countries with regard to climate adaptation and mitigation is reported sections 7.1.2 and 7.1.3 of Switzerland's seventh national communication.

The information on the financial support provided for the purpose of assisting developing countries to mitigate greenhouse gas emissions and adapt to adverse climate change is reported in section 7.1 of Switzerland's seventh national communication. The quantitative information on the financial support for developing countries for climate change adaptation, mitigation, technology transfer and capacity building through bilateral and multilateral channels is reported in section 7.1.6 of Switzerland's seventh national communication as well as in BR CTF tables 7(a) and 7(b).

Section 7.1.5 of Switzerland's seventh national communication reports on information on financial support of Switzerland for developing countries in the area of economic and social consequences of response measures.

How Switzerland determined how the resources it provided are new and additional is highlighted in section 7.1.1 of Switzerland's seventh national communication as well as the documentation box of BR CTF tables 7(a) and 7(b).

Switzerland also reported on private financial flows which were leveraged by its bilateral climate finance towards mitigation and adaptation activities in developing countries. The respective information is reported in section 7.1.1 of Switzerland's seventh national communication. The quantitative information is included in BR CTF table 7(b).

The types of instruments used in the provision of the Swiss assistance to developing countries is included in BR CTF tables 7(a) and 7(b) and their documentation box.

B.6.2 Technology development and transfer

The information on measures taken by Switzerland to promote, facilitate and finance the transfer of, access to and deployment of climate-friendly technologies for the benefit of developing countries, and for the support of the development and enhancement of endogenous capacities and technologies of developing countries is included in section 7.2 of Switzerland's seventh national communication.

Switzerland provides information in textual format in section 7.2.3 of its seventh national communication on some selected projects/programmes that promote the transfer of, access to and deployment of climate-friendly technologies in tabular format as well. Switzerland is not able to complete the BR CTF tables 8 and 9 according to the guidelines. The detailed explanation for this can be found in section 7.2.4 of Switzerland's seventh national communication.

B.6.3 Capacity building

How Switzerland has provided capacity-building support that responds to existing and emerging capacity-building needs identified by developing countries in the areas of mitigation, adaptation, technology development and transfer can be found in section 7.3 of Switzerland's seventh national communication.

B.7 Other reporting matters

Switzerland's domestic arrangements established for the process of the self-assessment of compliance with emission reductions in comparison with emission reduction commitments are addressed in section 4.1 of Switzerland's seventh national communication. This section also presents the establishment of national rules for taking local action against domestic non-compliance with emission reduction targets (sector-specific interim targets, proposition of additional policies and measures, automatic increase of the CO_2 levy on heating and process fuels, sanction mechanisms for various policies and measures, etc.).

Annex C Responses to recommendations and encouragements

Tab. 59 and Tab. 60 list the recommendations and encouragements from the 'report of the technical review of the sixth national communication of Switzerland' (FCCC/IDR.6/CHE) and the 'report of the technical review of the second biennial report of Switzerland' (FCCC/TRR.2/CHE). To each of the recommendations and encouragements a brief response is provided, with reference to the respective section in Switzerland's seventh national communication and third biennial report where appropriate.

Tab. 59 > Responses to recommendations of previous reviews.

Recommendation	Response	Reference to chapter/section of Switzerland's seventh national communication
'Report of the technical review of the **sixth national communication** of Switzerland' (FCCC/IDR.6/CHE)		
24. However, the NC6 does not include some information required by the UNFCCC reporting guidelines on NCs on domestic and regional legislative enforcement and administrative procedures that Switzerland has in place to meet its commitments under the Kyoto Protocol, including procedures for addressing cases of non-compliance under domestic law. Furthermore, Switzerland did not report any provisions to make information on these enforcement and administrative procedures publicly accessible. However, during the review, Switzerland provided comprehensive information on enforcement and administrative procedures at the level of individual instruments and measures together with information on the legal basis for enforcement and administrative procedures, including responsibilities for the implementation of enforcement procedures. The ERT commends Switzerland for the additional information provided and recommends that Switzerland, to increase transparency, include this information in its next NC, together with information on how Switzerland is making the information on these procedures available to the public.	The relevant information is now described in detail in Switzerland's seventh national communication. In particular, Switzerland presents the legal centrepieces implementing domestic climate policy, as well as an overview of enforcement and administrative procedures for core policies and measures (in tabular format), including information regarding the sanction mechanisms in the case of non-compliance. The website of the Swiss Federal Office for the Environment makes information regarding legislative arrangements and enforcement and administrative procedures publicly accessible. In particular, the Swiss Federal Office for the Environment publishes recommendations on the implementation of the legal provisions in cases where more detailed information is necessary.	4.1.1 Tab. 14
57. The NC6 includes information on how Switzerland promotes and implements the International Civil Aviation Organisation decisions to limit emissions from aviation bunker fuels. The ERT notes the national circumstances of Switzerland regarding maritime transport; however, the ERT recommends that Switzerland also identify the steps it has taken to promote and/or implement any decision by the International Maritime Organisation (IMO) to limit or reduce GHG emissions from marine bunker fuels and provide this information in its next NC to increase transparency.	The Swiss Maritime Navigation Office provided further details regarding the steps Switzerland has taken to promote and/or implement any decision by the International Maritime Organisation (IMO) to limit or reduce greenhouse gas emissions from marine bunker fuels. The respective information is now provided in Switzerland's seventh national communication.	4.4.11
81. The effects of PaMs implemented before 2010 are not taken into account in the 'with measures' and 'with additional measures' scenarios for 2020 and 2030. Although Switzerland reports the total effect of PaMs in 2010, the ERT noted that the figure is derived with a different method than that for the 2030 scenario. The total effect of domestic measures is estimated between 3.9 and 5.3 Mt CO_2 eq per year (2010). A detailed estimation of the effect of the different measures in 2010 was communicated during the review. However, this additional information does not provide the effect of PaMs by gas for 2010 and earlier years. The ERT recommends that Switzerland report the historical total effect of its PaMs in accordance with the UNFCCC reporting guidelines on NCs in its next NC. The ERT also recommends that the Party use a consistent approach for estimating the total effect of implemented and adopted PaMs, by sector and by gas, for past and future years.	The historical total effect of Switzerland's policies and measures has now been estimated in accordance with the UNFCCC reporting guidelines. For both past and future years, the total effect of policies and measures is based on the difference between the WOM and WEM scenarios, and the total effect of implemented and adopted policies and measures is also shown by gas.	5.2
89. During the review, Switzerland explained that it takes into account the need for adequacy and predictability in the flow of financial resources by (1) making more funds available over time and by mobilizing the private sector to carry out climate-friendly investments in developing countries, and (2) through, for example, the Swiss Parliament's decision in 2011 to increase the level of official development assistance (ODA) to 0.5 per cent of gross national income (GNI) by 2015, which took into consideration the need for Switzerland to honour its fast-start finance commitment and thus guarantees that more funds will be devoted to cooperation on climate change. The ERT commends Switzerland for its increased financial support to developing countries and recommends that Switzerland include a clarification on how it has determined that the financial resources it has provided are "new and additional" in its next NC. In addition, the ERT encourages Switzerland to provide information on how it has taken into account the need for adequacy and predictability in the flow of financial resources to developing countries, pursuant to Article 4, paragraph 3, of the Convention, in its next NC.	This recommendation was taken into account. A paragraph addressing the issues raised was included in the introduction part of section 7.1 of Switzerland's seventh national communication. Switzerland's public climate finance has seen a steady increase over the past years. Standing at 175 million US dollars in 2012 the respective amount grew to 299 million US dollars in 2014 and to 330 million US dollars in 2016. This increase was partly fuelled by the decision of the Swiss Parliament in 2011 to raise the level of official development assistance to 0.5 per cent of gross national income by 2015. In addition, Switzerland's development assistance has gradually shifted to place an enhanced focus on climate change, thus pushing the envelope of climate-relevant and climate-proofed programmes and projects in developing countries. These strategic decisions lead to a remarkable progression compared to previous efforts, therefore Switzerland considers its provided climate finance as new and additional. It represents furthermore its highest possible effort under budget constraints that currently also affect official development assistance spending and is therefore considered adequate by the Swiss government	7.1.1 Documentation box of BR CTF tables 7(a) and 7(b)

	pursuant to Article 4, paragraph 3, of the Convention. Through its contributions to multi-annual multilateral funds such as the Green Climate Fund and the Global Environment Facility Switzerland is committed to providing predictable climate finance. In addition, Switzerland's bilateral support for climate action is based on a cooperative, bilateral dialogue with the various recipient countries. Every four years the Swiss cooperation offices engage in a demand driven planning dialogue, where contingent on the available resources and the needs and priorities of the recipient country are assessed. This ensures country ownership. Through this programming procedure also provides increased predictability for the partner countries, pursuant to Article 4, paragraph 3, of the Convention.	
'Report of the technical review of the **second biennial report** of Switzerland' (FCCC/TRR.2/CHE)		
13. In CTF table 2(b), Switzerland indicated that the LULUCF sector is not covered in the quantified economy-wide emission reduction target, while in CTF table 2(d), it is indicated that the contribution of LULUCF is calculated using an activity-based approach. In addition, Switzerland reported in the BR2 (chapters 2.2.1 and 2.2.3) and in the custom footnote to table 2(f) that the LULUCF sector is included and accounted for using the activity-based approach. In order to enhance the transparency of reporting, the ERT recommends that Switzerland in its next biennial report (BR) provide consistent information in CTF tables 2(b) and 2(d) and the BR on the inclusion of LULUCF in the description of its quantified economy-wide emission reduction target.	Switzerland's quantified economy-wide emission reduction target indeed covers the contribution of LULUCF, calculated using an activity-based approach. This information is now provided consistently in BR CTF tables 2(b) and 2(d) and in the textual part of Switzerland's third biennial report.	BR CTF table 2(b) BR CTF table 2(d) Annex B.3.3 Annex B.3.5
21. The ERT noted that the BR2 and CTF table 3 did not provide information on mitigation actions that Switzerland plans to implement, with the exception of the inclusion of the aviation sector in the European Union Emissions Trading System (EU ETS) (prior linkage between the Swiss emissions trading scheme and the EU ETS is a prerequisite for this measure to become effective); however, the Party stated in its BR2 that, in case of non-compliance with sector-specific interim targets, additional measures will be put in place in accordance with the national rules for taking action against non-compliance. During the review, in response to a question raised by the ERT, the Party provided additional information stating that it plans to further strengthen already implemented measures in order to deliver additional GHG emission reductions. The ERT recommends that Switzerland include information on mitigation actions it plans to implement, in its next BR, in order to improve transparency.	Switzerland's future climate policy is mostly based on a strengthening of existing and, thus, time-tested policies and measures. For each measure where there is a plan for a strengthening in the future (i.e. in the legislation planned to enter into force after 2020), the planned strengthening is discussed at the same place where the measure is presented (under the subtitle 'planned strengthening'). Completely new planned measures are discussed separately, e.g. the third CO_2 Act (section 4.2.4), the inclusion of aviation in the emissions trading scheme (section 4.4.8), or the carbon offsetting and reduction scheme for international civil aviation (CORSIA) (section 4.4.10).	See presentations of policies and measures in section 4.2 to 4.8. BR CTF table 3 also contains the respective indicators for the status of implementation ('planned', 'strengthening planned', 'continuation planned').
22. The BR2 and CTF table 3 do not include estimations of the impacts for some of the mitigation actions in the energy, agriculture and LULUCF sectors. During the review, in response to a question raised by the ERT, Switzerland provided additional information that, owing to the complexity, inter-linkages and type (e.g. informational) of individual mitigation actions, particularly in the agriculture sector and the LULUCF sector, it is difficult to estimate their impacts. To enhance the transparency of the reporting, the ERT recommends that Switzerland, in its next BR, estimate the impacts of mitigation actions that were not estimated in CTF table 3, or explain in more detail the reasons why those impacts could not be estimated.	For each measure, an estimation of the impact is now provided, or it is explained in detail why the impact could not be estimated.	See presentations of policies and measures in section 4.2 to 4.8. There is a separate paragraph entitled 'Estimate of mitigation impact' for each policy and measure.
34. The ERT noted that information reported by Switzerland in CTF table 4 on the contribution from LULUCF is not consistent with the information reported in CTF tables 4(a)I and 4(a)II on mitigation actions relevant to the counting of emissions and removals from the LULUCF sector. The information provided in CTF table 4 on the contribution from LULUCF includes removals as reported in CTF table 1, following the land-based approach under the Convention. However, CTF table 4(a)I includes notation key "NA" (not applicable) for all fields in the table. Consistent with the information provided in the custom footnote to CTF table 4(a)I, CTF table 4(a)II includes values for 2013 using the activity-based approach, which was selected by Switzerland to calculate the contribution of LULUCF towards its target. To enhance the transparency of the reporting, the ERT recommends that Switzerland, in its next BR, provide the correct values in CTF tables 4 and 4(a)II for the contribution from LULUCF based on the activity-based approach.	In its third biennial report, Switzerland again provides values consistent with the activity-based approach in BR CTF table 4(a)II, while BR CTF table 4(a)I still includes the notation key 'NA' for all fields. In BR CTF table 4, Switzerland now provides numbers consistent with the activity-based approach as shown in BR CTF table 4(a)II. As described in the footnotes of BR CTF table 4, the values shown correspond to the accounting quantity, i.e. the sum of emissions/removals for activities under Articles 3.3 and 3.4 offset against Switzerland's forest management reference level and the technical corrections to the forest management reference level in order to get the final contribution from LULUCF (i.e. KP-LULUCF for Switzerland) for each year.	Annex B.4.2 BR CTF tables 4, 4(a)I and 4(a)II
35. The BR2 and CTF table 4(b) do not include the information on quantity of units from market-based mechanisms under the Convention or other market-based mechanisms as required by the UNFCCC reporting guidelines on BRs. In response to a question raised by the ERT during the review, Switzerland stated that it will account for contributions from the market-based mechanisms at the end of the commitment period and therefore no annual quantity of units was provided. In this regard, the ERT reiterates the recommendation made in the report of the technical review of its BR1 that Switzerland, in its next BR, reports the amount of units from market-based mechanisms on the Swiss state accounts in the national registry at the end of every year as a provisional estimate, to	Switzerland now reports the amount of units from market-based mechanisms on the party holding accounts in the national registry as a provisional estimate for the contribution of units from market-based mechanisms. In order to get the most accurate provisional estimate, Switzerland (i) exclusively considers the values reported for the year 2016 in order to avoid double counting of units ('IE' is reported for preceding years), (ii) carefully excludes units on entity holding accounts, and (iii) considers carried-over units from the first to the second commitment period of the Kyoto Protocol available on the party holding accounts.	Annex B.4.2 Footnotes in BR CTF table 4(b)

increase the transparency of its reporting.		
40. Information reported by Switzerland on the total GHG emission projections under the WEM, 'without measures' (WOM) and 'with additional measures' (WAM) scenarios is not entirely transparent, as values reported in table 24 of the BR2 differ from those reported in CTF tables 6(a), 6(b) and 6(c). The discrepancy refers to values for domestic compensation (expressed as negative values), which are the result of the implementation of partial compensation of CO_2 emissions from transport fuel use (see para. 30 above). The ERT noted that these values were not included in the total GHG emissions in the corresponding CTF tables, in contradiction with the first custom footnote to CTF table 6(a), which states that domestic compensation is included in the total, but not allocated to any of the sectors or gases. In the BR2 (table 24), domestic compensation is included in the totals (see also figure 14 in the BR2, which shows how domestic compensation influences total emissions). In response to a question raised by the ERT during the review, Switzerland stated that the observed difference between these values concerns only total emissions. To increase transparency, the ERT recommends that Switzerland provide consistent values for the projected total GHG emissions in the next BR and CTF tables and provide further clarification on the accounting of domestic compensation in projections.	Switzerland now consistently includes the effect of domestic compensation in the totals presented in BR CTF table 6 of its third biennial report and chapter 5 of its seventh national communication. In contrast to the last submission, the effect of domestic compensation is now directly considered by the model applied and does not appear separately anymore. Explanation on the accounting of domestic compensation in projections is provided under the model description and the corresponding studies.	5.3.1 BR CTF table 6
63. The ERT noted that the information provided in the BR2 does not explicitly describe how the Party seeks to ensure that the provided resources effectively address the needs of developing country Parties with regard to climate change adaptation and mitigation, as required by the UNFCCC reporting guidelines on BRs, although it could be concluded from the BR2 that resource effectiveness is an important element of Swiss financial support (e.g. close cooperation between agencies, using a target-oriented approach and the structure of mitigation actions portfolio as mentioned in chapter 5.3. in the BR2). During the review, in response to a question raised by the ERT, the Party provided additional information, stating that support is provided on a demand basis and that it is built upon the needs specified in the strategic documents of the recipient countries. The ERT therefore reiterates the recommendation made in the report of the technical review of the BR1, that the Party, in its next BR, provide information, to the extent possible, on the approaches used to ensure that the resources provided effectively address the needs of non-Annex I Parties regarding climate change adaptation and mitigation to increase the completeness of its reporting.	This recommendation was taken into account: Switzerland has included a particular section in its seventh national communication and its third biennial report to provide specific information on the approaches used to ensure that resources provided effectively address the needs of developing country Parties regarding climate change adaptation and mitigation.	Annex B.6.1 7.1.2 and 7.1.3 (sub-heading 'Addressing the needs of developing country Parties')
64. Some of the information provided by Switzerland has not been entirely reported in accordance with the UNFCCC reporting guidelines on BRs, which makes it difficult for the ERT to understand the support activities. For example, there is a lack of information on the specific sectors that benefited from the financial support, because all supported activities are identified as cross-cutting for all sectors in CTF tables 7(a) and 7(b). During the review, in response to a question raised by the ERT, Switzerland explained that, for the purposes of the BR, it aggregated the project-level data from its database (as reported to the OECD) on a country level. The Party assumed that such reporting would improve the readability of the data (aggregate view per country rather than at the project level). The Party further explained that various economic sectors, if not all, in most countries that received support had benefited from the support for climate change mitigation and adaptation activities. Therefore, under the column 'Sectors' in CTF table 7(b), Switzerland indicated as cross-cutting all individual programme or project activities. The ERT recommends that Switzerland, in its next BR, provide information on the specific sectors that have benefited from the financially supported activities.	The recommendation has been addressed: Switzerland's seventh national communication includes aggregate data per region in tabular format. The BR CTF tables contain more disaggregated data on the country level, where possible. Switzerland does not provide activity-level information in the BR CTF tables. An additional administrative burden would arise and a high risk of errors when entering the data manually. In addition, Switzerland is of the view that activity-level data within the national communication and the BR CTF tables (with the current technical set-up) is difficult to read and interpret. However, given the relevance of increased transparency and to illustrate the diversity of projects, programmes and regions of Swiss support for climate action in developing countries, a full list of all climate-relevant projects is provided in a supplementary document. The table also indicates in detail all sectors, which have benefitted from each of the activities, since it is not possible to give a clear indication of sectors in the BR CTF tables due to aggregation.	7.1.6 (Tab. 44 and Tab. 45) BR CTF table 7(b)
65. In CTF tables 7(a) and 7(b), Switzerland reported only on funds provided, although in the BR2, it provided information on its pledge of approximately USD 100 million to the Green Climate Fund, where the first instalment was already formalised and disbursed. During the review, in response to a question raised by the ERT, Switzerland explained that it only reported on funds it has provided for consistency reasons, because they are the funds that have actually been released from Switzerland's accounts to its partners according to the national accounting system, and partner countries have shown greater interest in disbursed funds. It also explained that there is always a time lag between funds committed (signed contracts) and disbursed, and that, in general, Switzerland does not track any pledged funds, which are not legally binding, except to multilateral agencies and funds. The ERT therefore recommends that Switzerland provide in the next BR, additional information on its committed and/or pledged funds to enhance the transparency of its reporting.	As highlighted in the documentation box of BR CTF tables 7(a) and 7(b) only disbursed funds are reported, except for private sector mobilised funds, which are reported at commitment level. The explanation is the following: Because it can take several years to disburse a commitment, Switzerland is not reporting on its committed bilateral, regional, multi-bilateral and multilateral contributions. The double reporting would be very burdensome, might be confusing and it would not be consistent with the reporting in the past. As for the private finance mobilised: it is reported, based on the point of commitment, because Switzerland is not in the position to monitor the disbursement of funds outside of its own accounts. Further details can be found in the documentation box of BR CTF tables 7(a) and 7(b).	Documentation box of BR CTF tables 7(a) and 7(b)
66. In addition, the ERT noted that Switzerland in its BR2 did not provide information on financial support for assisting non-Annex I Parties to address any economic and social consequence of response measures, where appropriate. In response to a question raised by the ERT during	The recommendation was addressed and a specific section on the support for any economic and social consequences of response measures was included.	7.1.5 Annex B.6.1

the review, Switzerland explained that this information is provided in the annual inventory submissions. To enhance transparency, the ERT recommends that Switzerland provide in the next BR information on financial support for assisting non-Annex I Parties to address any economic and social consequence of response measures.		
80. In addition to the explanations mentioned in paragraphs 78 and 79 above, Switzerland, in the footnote to CTF table 8, states that most projects funded by Switzerland include technology transfer and capacity-building components. However, because they form an integral part of a project, it is not possible to account for them separately. Nevertheless, the ERT, taking into consideration its note expressed in paragraph 59 above, reiterates the recommendations made in the report of the technical review of the BR1, that Switzerland, in its next BR, report on its measures to promote, facilitate and finance the transfer of, access to and deployment of climate-friendly technologies for the benefit of non-Annex I Parties, and for the support of the development and enhancement of endogenous capacities and technologies of non-Annex I Parties, as well as on the measures and activities related to technology transfer implemented or planned since Switzerland's last NC or BR, by filling in CTF table 8 and providing the related textual information in the BR.	Due to the integrated character of the bilateral technology development and transfer support measures of Switzerland, it is not possible to single out and quantify the respective components. In addition, it would not do justice to the integrated approach underpinning Switzerland's climate change interventions. Therefore, the technology development and transfer components of Swiss-funded projects are not systematically identified in this report. There is internationally no clear understanding and no consensus on how Parties should quantify their technology transfer components within climate-relevant projects. This lack of consensus would therefore also not allow for a comparability of quantified data. Switzerland is of the opinion that qualitative information provides much more content and potential to exchange on lessons learnt and improve the technology transfer and development support overall. If Switzerland were to isolate the technology transfer components of its climate-related activities, it would need to fundamentally redesign its entire national reporting system. Switzerland will therefore continue to report on its technology transfer activities in qualitative terms, by emphasizing the integrative character based on concrete project examples. Therefore, Switzerland has not completed BR CTF table 8.	7.2.4 Annex B.6.2
83. In addition to the explanation mentioned in paragraph 79 above, Switzerland, in the footnote to CTF table 9, states that most projects funded by Switzerland include technology transfer and capacity-building components. However, because they form an integral part of a project, it is not possible to account for them separately. Nevertheless, taking into consideration its note expressed in paragraph 59 above, the ERT reiterates the recommendations made in the report of the technical review of the BR1, that Switzerland, in its next BR, provide a description, to the extent possible, on how it has provided capacity-building support for mitigation, adaptation, and technology development and transfer, by filling in CTF table 9 and providing the related textual information in the BR.	Due to the integrated character of the bilateral capacity-building support measures of Switzerland, it is not possible to single out and quantify the respective components. In addition, it would not do justice to the integrated approach underpinning Switzerland's climate change interventions. Therefore, the capacity building components of all Swiss-funded projects are not systematically identified in this report. If Switzerland were to isolate the capacity-building components of all its climate-related activities, it would need to fundamentally redesign its entire national reporting system. Switzerland will therefore continue to report on its capacity building activities in qualitative terms, by emphasising the integrative character based on concrete project examples. Therefore Switzerland has not completed BR CTF table 9.	7.3.1 Annex B.6.3

Tab. 60 > Responses to encouragements of previous reviews.

Encouragement	Response	Reference to chapter/section of Switzerland's seventh national communication
'Report of the technical review of the **sixth national communication** of Switzerland' (FCCC/IDR.6/CHE)		
14. Switzerland has provided a summary of information on GHG emission trends for the period 1990–2011. This information is consistent with the 2013 national GHG inventory submission of April 2013. However, the ERT noted that there is some inconsistency with the first biennial report (BR1) in which GHG emissions and emission trends are based on the submission of September 2013. The difference is 153 kt CO_2 eq, or 0.3 per cent, in 2011 of total GHG emissions in Switzerland. The difference is explained in the common tabular format tables. The ERT encourages Switzerland to harmonise the reported GHG emission figures in its next biennial report and national communication (NC).	Switzerland's seventh national communication and third biennial report present harmonised greenhouse gas emission figures covering the years 1990–2015, which are based on the national inventory report and reporting tables (CRF) submitted in April 2017.	Full national communication and biennial report, in particular chapter 3 and Annex A.
33. The NC6 does not include some information required by the UNFCCC reporting guidelines on NCs on the costs of PaMs and on the non-greenhouse gas mitigation benefits of PaMs. The ERT notes that some PaMs, such as the building programme under the CO_2 levy and the Climate Cent, include resources for their implementation. The ERT encourages Switzerland to include information on the costs of PaMs and on the non-greenhouse gas mitigation benefits of PaMs in its next NC.	Switzerland is not in a position to comprehensively report on the costs and non-greenhouse gas mitigation benefits of every single policy and measure. However, a separate section in Switzerland's seventh national communication now discusses the challenges regarding the reporting of this information and provides, where possible, the requested information.	4.9
42. Due to the incident at the Fukushima Daiichi nuclear power plant, in 2011, Switzerland decided to gradually phase out the generation of electricity from nuclear power. This decision triggered a significant adjustment of Switzerland's energy policy and also projects a partial shift towards highly efficient fossil fuel electricity production. Three allowances for building new nuclear power plants (at the end of the current power plant lifetimes) were revoked by the federal government. In the future, a significant share of the phased out nuclear-generated electricity will be	As a consequence of Switzerland's far-reaching decision to progressively withdraw from nuclear energy sources, the Swiss Federal Council has developed the Energy Strategy 2050, aiming at significantly developing the existing potential for energy efficiency and at exploiting the potential of hydropower and the new renewable energies (sun, wind, geothermal, biomass). The Energy Strategy 2050 sets a number of priorities to assure the future electricity supply, such as reduction in energy consumption,	4.3.1

replaced by new and additional renewable electricity production and highly efficient natural gas electricity production, and above all, by energy efficiency. In 2008, Switzerland implemented an obligation to offset emissions from gas fired combined cycle power plants. Additional fossil fuel electricity production in Switzerland will require a 100 per cent offset of emissions through domestic and international mechanisms. The ERT encourages Switzerland to improve transparency in its next NC by providing more information on PaMs that will ensure penetration of renewable energy and energy efficiency in order to meet electricity demand during and after the nuclear phase out.	broadening of the portfolio of energy sources used, expansion and restructuring of the electricity transmission grid as well as energy storage. As part of the Energy Strategy 2050, emphasis is placed on increased energy savings (energy efficiency), the expansion of hydropower and new renewable energies. The first bundle of measures is stipulated in the totally revised Energy Act as well as in changes of various other laws which will all enter into force on 1 January 2018.	
67. In general, Switzerland presented relevant information on factors and activities that affect emission levels for each sector for the years 1990 to 2030 in its NC6. However, the ERT noted that although Switzerland did provide some relevant information on the factors and activities influencing GHG emissions from the transport sector, other relevant factors for this sector were not sufficiently described to fully understand the projected evolution of emissions. The ERT therefore encourages Switzerland to provide a more complete assessment and description of, for example, the differences in fuel prices between Switzerland and neighbouring countries influencing ‘tank tourism’ and trends in the evolution of passengers by car in its next NC.	As now explained under the model description, it is assumed that ‘tank tourism’ remains at the level of 2015 for future years, as justifiable estimates for the future exchange rate for the Swiss franc to the Euro are not available. The road traffic model used to derive the projections for the transport sector directly targets vehicle kilometres, i.e. passengers per vehicle are not quantified for this exercise. In addition, the section containing the methodology used to derive Switzerland’s greenhouse gas emission scenarios has been extended considerably, now providing abundant details of any kind.	5.3.1
70. The NC6 does not include a sensitivity analysis of the key assumptions (e.g. phasing out of nuclear power, international energy prices). In addition, in the ‘with additional measures’ scenario, biofuels in transport are introduced: up to 20 per cent by 2020 and 33 per cent by 2030. The ERT noted that the EU has recently decided to reduce the use of biofuels because the conversion factor to transform energy coming from the sun in crops (photosynthesis) is very low (less than 0.5 per cent) and the yield of the conversion of crops in biofuel is poor. Thus the ERT encourages Switzerland to include a sensitivity analysis of the key assumptions and on the future levels of biofuels in transport.	Switzerland performed a detailed sensitivity analysis in the context of the development of the new greenhouse gas emission scenarios for the energy sector. In the new scenarios, the future use of biofuels in transport are assumed to be considerably lower compared to previous estimates (see section 5.3.1). Provided the limited contribution of biofuels to total use of fuels in transport, the contribution of the estimates of biofuel use in transport is believed to play a minor role regarding the uncertainty of the projections of total greenhouse gas emissions.	5.3.1 5.3.9
89. During the review, Switzerland explained that it takes into account the need for adequacy and predictability in the flow of financial resources by (1) making more funds available over time and by mobilizing the private sector to carry out climate-friendly investments in developing countries, and (2) through, for example, the Swiss Parliament’s decision in 2011 to increase the level of official development assistance (ODA) to 0.5 per cent of gross national income (GNI) by 2015, which took into consideration the need for Switzerland to honour its fast-start finance commitment and thus guarantees that more funds will be devoted to cooperation on climate change. The ERT commends Switzerland for its increased financial support to developing countries and recommends that Switzerland include a clarification on how it has determined that the financial resources it has provided are “new and additional” in its next NC. In addition, the ERT encourages Switzerland to provide information on how it has taken into account the need for adequacy and predictability in the flow of financial resources to developing countries, pursuant to Article 4, paragraph 3, of the Convention, in its next NC.	This encouragement was taken into account: A paragraph addressing the issues raised by the ERT was included in the introduction part of section 7.1 of Switzerland’s seventh national communication. Switzerland’s public climate finance has seen a steady increase over the past years. Standing at 175 million US dollars in 2012 the respective amount grew to 299 million US dollars in 2014 and to 330 million US dollars in 2016. This increase was partly fuelled by the decision of the Swiss Parliament in 2011 to raise the level of official development assistance to 0.5 per cent of gross national income by 2015. In addition, Switzerland’s development assistance has gradually shifted to place an enhanced focus on climate change, thus pushing the envelope of climate-relevant and climate-proofed programmes and projects in developing countries. These strategic decisions lead to a remarkable progression compared to previous efforts, therefore Switzerland considers its provided climate finance as new and additional. It represents furthermore its highest possible effort under budget constraints that currently also affect official development assistance spending and is therefore considered adequate by the Swiss government pursuant to Article 4, paragraph 3, of the Convention. Through its contributions to multi-annual multilateral funds such as the Green Climate Fund and the Global Environment Facility Switzerland is committed to providing predictable climate finance. In addition, Switzerland’s bilateral support for climate action is based on a cooperative, bilateral dialogue with the various recipient countries. Every four years the Swiss cooperation offices engage in a demand driven planning dialogue, where contingent on the available resources and the needs and priorities of the recipient country are assessed. This ensures country ownership. Through this programming procedure also provides increased predictability for the partner countries, pursuant to Article 4, paragraph 3, of the Convention.	7.1.1 Documentation box of BR CTF tables 7(a) and 7(b)
91. Switzerland has reported information on the assistance it has provided to developing country Parties that are particularly vulnerable to the adverse effects of climate change to help them to meet the costs of adaptation to those adverse effects. Furthermore, Switzerland has provided information on other financial resources related to the implementation of the Convention provided through bilateral, regional and other multilateral channels, including the Global Environment Facility (GEF). In reporting the financial resources through bilateral and regional channels, table 1 in the NC6 does not follow table 5 of the UNFCCC reporting guidelines on NCs. This issue was also raised in the previous review report. During the review, Switzerland explained that the reporting entities manage this information in ways that do not align exactly with table 5. The ERT reiterates the encouragement for Switzerland to provide more	Switzerland is following the format of the tables as outlined in the UNFCCC biennial reporting guidelines also for the national communication to ensure the consistency of data between the biennial report and the national communication and because the granularity and details requested in the UNFCCC biennial reporting guidelines. Therefore, the transparency can be increased and it would not add any value to report the same data in two reporting formats.	7.1.6 (Tab. 42 to Tab. 45)

transparent information on bilateral assistance and provision of financial resources as listed in table 5 of the UNFCCC reporting guidelines on NCs in its next NC, in order to more easily identify trends in the provision of financial resources to developing countries and supported sectors.		
95. The NC6 also mentions Switzerland's Global Programme Climate Change, which includes as a focus area increasing technology transfer and innovation in developing and threshold countries in the field of mitigation. The ERT noted that the initiatives to promote private engagement in technology transfer mentioned in the NC5, such as Business Network Switzerland and the Swiss export insurance scheme, were not mentioned in the NC6. During the review, Switzerland confirmed that these initiatives continue. The ERT encourages Switzerland to enhance its reporting on the ways in which it encourages private activities related to the promotion, facilitation and financing of the transfer of, or access to, environmentally sound technologies, in its next NC.	This encouragement has been addressed and the private activities related to the promotion, facilitation and financing of the transfer of, or access to, environmentally sound technologies have been integrated again.	7.2.1
96. In its NC6, Switzerland has provided information on the fulfilment of its commitments under Article 10 of the Kyoto Protocol. The chapter on financial resources and transfer of technology in Switzerland's NC6 does not provide references to information about the activities and programmes undertaken in fulfilment of its commitments under Article 10. However, a table is included in annex 1, including references to the relevant chapters of the NC6. In order to enhance transparency, the ERT encourages Switzerland to clearly identify the activities, actions and programmes undertaken to fulfil its commitments under Article 10 in the section on financial resources and transfer of technology in its next NC.	The encouragement has been addressed: Switzerland now provides support for technology development and transfer through the activities and measures mentioned in section 7.2 of its seventh national communication in line with its commitment under Article 10 letter c of the Kyoto Protocol as well as Article 4, paragraphs 3 and 5, of the Convention. It would not be possible for Switzerland to distinguish the activities to fulfil its commitments under Article 10 of the Kyoto Protocol and Articles 4, paragraphs 3 and 5, of the Convention since they speak to the same issue and any distinction would not lead to increased impact in recipient countries.	7.2
110. However, the ERT noted that the NC6 contains limited information on training activities and no information on participation of public and non-governmental organisations in the preparation or domestic review of NCs. The ERT therefore encourages Switzerland to report and provide more information on these activities in its next NC.	Information on training activities: Substantive information on training activities at the domestic level as well as in the context of international cooperation is now provided. The restructuring of chapter 9, based on the revised reporting guidelines, further contributes to the better visibility of this information. Participation of public and non-governmental organisations in the preparation or domestic review of national communications: Information has been added stating the approach followed by Switzerland while preparing its national communications under the UNFCCC.	9.4 9.7 9.8
'Report of the technical review of the **second biennial report** of Switzerland' (FCCC/TRR.2/CHE)		
68. In addition, Switzerland stated that it attaches great importance to the mobilisation of private climate finance through public interventions, but there are still significant gaps in data availability for these activities, and methodological constraints still exist that hamper the Party's ability to fully estimate the volume of both directly and indirectly mobilised private climate finance. The ongoing development by a number of donor countries of a common methodology to track and report mobilised private climate finance will encourage and facilitate the accounting of such financial flows. Switzerland is determined to build on this framework to improve the coverage of its data on mobilised private climate finance in the coming years. This will facilitate a more complete and transparent reporting on this important matter. The ERT therefore encourages Switzerland to report in its next BR, to the extent possible, the information on private financial flows leveraged by bilateral climate finance towards mitigation and adaptation activities in non-Annex I Parties and on PaMs that promote the scaling up of private investment in mitigation and adaptation activities in developing country Parties.	This encouragement was taken into account: Switzerland now reports on private financial flows which were leveraged by its bilateral climate finance towards mitigation and adaptation activities in developing countries.	7.1.1 and 7.1.6 Annex B.6.1 BR CTF table 7(b)
81. In its BR2, Switzerland did not provide information on success and failure stories related to technology development and transfer. The ERT encourages Switzerland to report on success and failure stories related to technology development and transfer referred to in paragraph 21 of the UNFCCC reporting guidelines on BRs.	This encouragement was addressed and success stories were integrated in the project examples presented in Switzerland's seventh national communication.	7.2 Annex B.6.2