Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

The Federal Council

27.1.2021

Switzerland's Long-Term Climate Strategy

Contents

Summary

On 28 August 2019, the Federal Council decided that Switzerland would aim to reduce its greenhouse gas emissions to net zero by 2050 and gave the Federal Department of the Environment, Transport, Energy and Communications (DETEC) the task of drawing up a long-term climate strategy, thus ensuring that Switzerland meets a requirement of the Paris Agreement. This document 'Switzerland's Long-Term Climate Strategy' is the result of this work.

The science is clear: to ensure sufficiently high probability of global warming remaining below 1.5° Celsius, global CO_2 emissions must be reduced to net zero by the middle of this century at the latest. Any CO_2 still emitted at this point must be fully and permanently removed from the atmosphere through sinks (negative emissions). The emission of other greenhouse gases, particularly methane and nitrous oxide, must also be significantly reduced. The Paris Agreement adopted by the international community at the end of 2015 and ratified by Switzerland on 6 October 2017 aims to limit global warming to well below 2° Celsius but, if possible, to 1.5° Celsius. By aiming to cut its greenhouse gas emissions to net zero by 2050, Switzerland is making a contribution to the Paris Agreement that is in line with its climate policy responsibility and capacities. It has a strong foundation for achieving the net-zero target thanks to its already largely CO_2-free domestic power supply, a strong clean-tech sector, its internationally renowned educational and research institutions, its high level of prosperity and prodigious capacity for innovation. By pursuing this goal, Switzerland is keeping pace with its most important trading partner, the European Union, which also announced its intention to become carbon-neutral by 2050, as well as China and Brazil which aim to achieve these goals by 2060. Various other states have already adopted legally binding net-zero targets or have pledged to do so, including France, Germany, Sweden, Denmark, New Zealand, Canada, Japan, South Korea, South Africa and the United Kingdom.

Switzerland's Long-Term Climate Strategy outlines the path to the net zero goal. It sets out ten key strategic principles that will guide and shape Switzerland's climate policy actions over the coming years:

1. Switzerland will take advantage of the opportunities presented by a systematic transition to net zero.
2. Switzerland will assume its climate policy responsibility.
3. Priority will be given to reducing domestic emissions.
4. Emissions will be reduced across entire value chains.
5. All energy sources will be used effectively taking account of their optimal usage potential.
6. The Swiss Confederation and the cantons will gear their planning activities to net zero in all climate-relevant areas.
7. The transition to net zero will be carried out in a socially acceptable way.
8. The transition to net zero will be achieved in an economically viable way.
9. The transition to net zero will also improve environmental quality.
10. The Long-Term Climate Strategy is based on openness to all types of technology.

The Long-Term Climate Strategy outlines possible developments up to 2050 for the buildings, industry, transport, food and agriculture, financial market, waste and synthetic gases and international aviation sectors and defines strategic goals for each sector. The strategy also determines the requirement for negative emissions that is likely to be needed to balance the remaining emissions. The following principle applies: greenhouse gas emissions must be reduced as far as possible in every sector – whether through a sufficiently high price for emission-intensive technologies, through technical measures or by promoting alternatives. The buildings and transport sectors can cut their fossil emissions to zero by 2050 and energy-related emissions can also be almost completely eliminated in industry too. The reduction potential in agriculture and the food industry will also be harnessed. Finally, international aviation will also have to contribute to the attainment of the target, particularly through the use of renewable sustainable fuels and alternative drive systems. Difficult-to-avoid emissions from some industrial processes, such as cement production or incineration, will be offset by the use of carbon capture and storage (CCS) technologies. These technologies can largely prevent emissions from entering the atmosphere.

The revision of the CO_2 Act adopted by Parliament in the 2020 autumn session requires greenhouse gas emissions to be halved by 2030. The set of measures approved puts Switzerland on course to

achieve the net-zero target by 2050 and is a key element in attaining this goal. Based on the scenarios available, a reduction in greenhouse gas emissions by just under 90 per cent overall by 2050 compared with 1990 is possible. The greenhouse gas emissions remaining after the use of CCS technologies – just under seven million tonnes of CO_2 equivalent in total – must be balanced with negative emissions. The respective shares to be achieved through measures in Switzerland or abroad by 2050 are not yet determined. The current level of compensation abroad, with projects that reduce emissions and therefore substitute reductions in Switzerland, is to be increasingly replaced long-term through international commitment in the field of negative emissions as domestic capacity for geological storage is limited. When using negative emissions technologies abroad, the same standards in terms of social acceptance and environmental sustainability shall apply as in Switzerland.

From a scientific perspective, the reduction of global greenhouse gas emissions to net zero is imperative to keep global warming below the critical threshold. A lack of or insufficient action would come at a very high price, even by 2050. This applies especially to Switzerland which is significantly affected by climate change. If global warming continues, existing studies indicate that the cost for Switzerland by 2050 would amount to up to 4 per cent of annual GDP. However, if global emissions are significantly reduced and global warming is restricted to a maximum of 1.5° Celsius, the cost by 2050 would only stand at a maximum of 1.5 per cent of GDP. According to these estimates, the benefits of a global reduction in emissions to net zero would amount to 2.5 per cent of GDP for Switzerland by 2050. This roughly equates to around 20 to 30 billion Swiss francs. These benefits increase sharply long-term as the cost of unchecked climate warming rises exponentially.

This means it is in Switzerland's interests to reduce greenhouse gas emissions to net zero and contribute to the global efforts to restrict global warming. Attaining the net-zero target requires a transformation of the current energy supply system which still relies heavily on fossil energies. Even without the net-zero goal, additional investment in the energy system of 1,400 billion francs is required by 2050, according to Energy Perspectives 2050+. The goal of achieving net zero by 2050 increases the need for investment by 109 billion francs in total which is only 8 per cent. The cost of operating the energy supply plants rises by around 14 billion francs. Reducing emissions to net zero will also enable savings to be made on energy costs of 50 billion francs, in particular by eliminating imports of fossil energies,.[1] Overall, additional annual expenditure of around 2.4 billion francs on average will be incurred over the period 2020–50.

This means the reduction of emissions to net zero is also likely to pay off financially by 2050. A key factor will be structuring the transition to the net zero goal over the coming years in a socially acceptable, economically viable and environmentally sustainable way and aligning the regulatory environment accordingly. The complete revision of the CO_2 Act lays the foundation in this respect.

[1] This figure does not include potential savings in international aviation. If they are also taken into account, the savings amount to around CHF 64 billion.

1 Introduction

Switzerland signed the Paris Agreement in 2015 and ratified it in 2017. The Paris Agreement obliges all states to reduce their greenhouse gas emissions for the first time. The main overarching objectives are limiting global warming to well below 2°C compared to the pre-industrial era, whereby a maximum increase in temperature of 1.5°C is being targeted, improving adaptability to climate change and making financial flows consistent with low-greenhouse-gas development. Switzerland wishes to make its contribution to achieving these goals. The Federal Council is endeavouring to cut greenhouse gas emissions to the target of net zero by 2050, as it announced in 2019.[2] This means Switzerland should no longer produce any greenhouse gas emissions overall by 2050. Switzerland will therefore reduce the use of fossil energies to a minimum, cut its greenhouse gas emissions as far as possible and balance remaining emissions through negative emissions. Negative emissions technologies (NET) use technical or natural processes that remove CO_2 from the atmosphere and permanently store it. Switzerland is also committed to making financial flows consistent with environmental sustainability at national and international level.

Switzerland is already being severely impacted by climate change. Without effective climate protection measures, these effects will continue to worsen. According to the CH-2018 Swiss Climate Change Scenarios, the summers will be drier in future, heavy rainfall will be more intense, the average and highest temperatures will rise and snowfall and snow cover will continue to decline, particularly in lower-lying areas. There is great need for action. To attain the net-zero target, greenhouse gas emissions in Switzerland must decrease sharply over the coming years and decades. The revision of the CO_2 Act, which was adopted by Parliament during the 2020 autumn session, establishes the climate policy framework until 2030. The new CO_2 Act is a key element in ensuring Switzerland meets its 2050 climate target. It will enable Switzerland to halve its emissions overall by 2030 and reduce them by at least 37.5 per cent domestically. With the newly created Climate Fund, the emissions limits for buildings and new vehicles and the strengthening of established market economy approaches, it contains instruments that will have an impact beyond 2030. The Act also obliges the Federal Council to submit proposals to Parliament on post-2030 reduction objectives in good time. It puts Switzerland on course to achieve balanced greenhouse gas performance which is what the Federal Council is striving to attain in Switzerland by 2050.

In this Long-Term Climate Strategy, the Federal Council sets out how greenhouse gas emissions should develop overall in the various sectors to 2050, how high the requirement for negative emissions could be and the strategic principles on which climate policy action should be based at federal, cantonal and communal level over the coming years.

2 Mandate for the development of a Long-Term Climate Strategy

The need to reduce greenhouse gas emissions to net zero is based on the scientific evidence presented by the Intergovernmental Panel on Climate Change IPCC (Section 2.1). The requirement to draw up long-term climate strategies is enshrined in the Paris Agreement (Section 2.2). The Federal Council therefore gave the departments responsible the task of drawing up a long-term climate strategy for Switzerland in August 2019. This strategy is the result of their work and enables Switzerland to assume its responsibility to limit the rise in the global temperature to 1.5° Celsius, to prevent mis-investment and to take advantage of emerging opportunities (Section 2.3).

2.1 Scientific basis

In autumn 2018, the IPCC published its special report on global warming of 1.5° Celsius (subsequently referred to as the '1.5° Report').[3] This summarises the current knowledge available on how global warming can be limited to a maximum of 1.5° Celsius and what impacts such warming will have compared with a rise in temperature of 2° Celsius. According to the '1.5° Report', the global temperature has already risen by around 1° Celsius since the beginning of industrialisation. The sharp rise in warming since 1950 by around 0.65° Celsius can no longer be attributed to natural fluctuations. This has been caused by greenhouse gas emissions, especially from the use of fossil fuels, such as oil, gas and coal, and extensive changes in land use, for example the destruction of rain forests.

[2] Federal Council press release of 28.8.2019, can be viewed at: https://www.bafu.admin.ch/bafu/en/home/topics/climate/news-releases.msg-id-76206.html.

[3] IPCC (2018).

The '1.5° Report' outlines emissions pathways which are compatible with global warming by a maximum of 1.5° Celsius. The most important finding is that the global CO_2 emissions in scenarios with no or limited overshoot will reach their peak by around 2020 and must then fall to around 45 per cent of the 2010 level by 2030 and to net zero by the middle of the century (2045–55). At the same time, the climate impacts of the other greenhouse gases (non-CO_2 emissions), in particular from methane, nitrous oxide and black carbon, must also decline sharply by 2050 and beyond. Figure 1 shows this in a graphic.

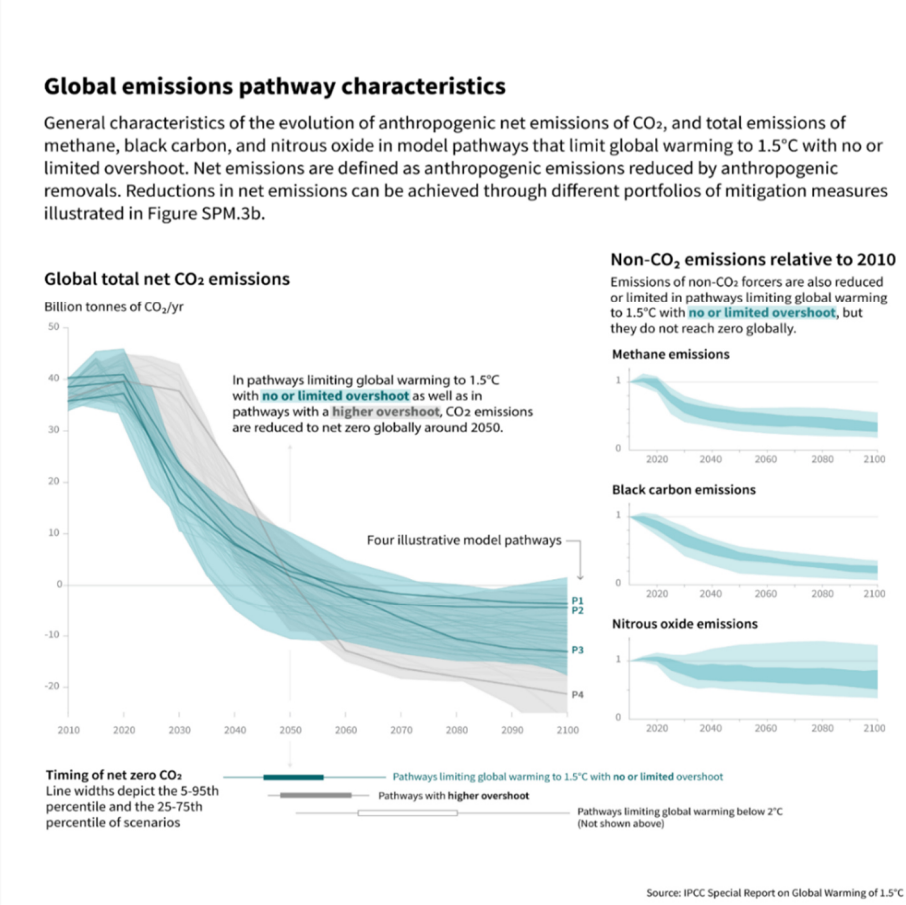

Figure 1: Global emissions pathways compatible with warming of 1.5°C. Source: IPCC (2018)

The '1.5° Report' also clearly shows that the effects of global warming by 2° Celsius and by 1.5° Celsius differ significantly. In Central and Southern Europe, a significant water shortage and – particularly in the Mediterranean region – a sharp increase in extreme droughts are anticipated in the event of warming by 2° Celsius. As a result, there is a much greater risk, for example, of more frequent and significantly hotter heatwaves, water and food shortages, but also a greater loss of alpine habitats. The effects of climate change will also result in an increase in migration of people from severely affected regions and countries.

Net zero refers to the balance between the emission of greenhouse gases, on one hand, and their removal and storage in sinks on the other. The emission of greenhouse gases cannot be completely eliminated in some sectors. From a current perspective, this includes agricultural food production, some industrial processes, such as cement manufacture, and waste incineration. To achieve the net-zero goal, these remaining emissions must be balanced by the use of technologies or processes that remove CO_2 from the atmosphere and store it permanently. Long-term, i.e. beyond 2050, the emission balance must be negative overall so that the concentration of greenhouse gas in the atmosphere falls further. Only then can global warming be limited to 1.5° Celsius with sufficiently high probability. If the emissions are not reduced on time and the temperature goal of 1.5° Celsius is then exceeded, the emissions balance must become negative at an earlier stage to reverse the overshooting of the temperature target. An early reduction in emissions also lessens dependency on technologies about the potential and costs of which there is still a great deal of uncertainty.

These scientific findings form the basis for Switzerland's long-term climate policy goals. Climate protection is a fundamental requirement if human wellbeing is to be ensured long-term. Achieving the net-zero target is imperative for the international community and so too for Switzerland. Only then will the probability of restricting climate warming to a tolerable level be sufficiently high. This requires global efforts to which Switzerland wishes to make its contribution in line with its responsibility and capabilities. This target should be attained while at the same time securing prosperity in an optimal way and ensuring social cohesion and the conservation of resources in all areas of the environment.

2.2 International provisions from the Paris Agreement

The Paris Agreement requires all contracting parties to draw up long-term climate strategies (Art. 4 para. 19):

> *"All Parties should strive to formulate and communicate long-term low greenhouse gas emission development strategies, mindful of Article 2 taking into account their common but differentiated responsibilities and respective capabilities, in the light of different national circumstances."*

The framework convention on climate change stipulates that the long-term climate strategies are to be submitted by the end of 2020 and should be based on a time horizon of the middle of the century (section 3 para. 35 of Decision 1/CP.21 of the UNFCCC Framework Convention on Climate Change).

Finally, the Paris Agreement stipulates that the global emissions must reach their peak as soon as possible and then fall sharply. A balance between emissions by sources and removal by sinks must be achieved by the second half of the century (Article 4 para. 1). These are the key points for the long-term climate strategies. This strategy is also based on these key points.

In addition to the Paris Agreement, the 2030 Agenda for Sustainable Development also underlines the importance of climate protection.[4] As one of 17 Sustainable Development Goals in total, Goal 13 calls on states to take immediate measures to combat climate change and its impacts. The Goal also provides for the incorporation of climate policy measures into national policies, strategies and planning (Target 13.2). Switzerland is primarily implementing the 2030 Agenda via its Sustainable Development Strategy (see Section 6.2).

2.3 National environment

The Paris Agreement states that the long-term climate strategies should be based on the principle of 'common but differentiated responsibilities' and should take account of 'respective capabilities, in light of different national circumstances'. Switzerland is a highly developed state with a strong economy and global trading relations. It therefore bears particular responsibility, together with other industrial states and emerging countries.

Switzerland is in a favourable position to assume its climate policy responsibility long-term. Resolutely embarking on the path towards a greenhouse-gas-neutral future also presents the opportunity to consolidate its leading role as a centre of innovation. Switzerland has internationally renowned universities and educational and research institutions. The two Swiss Federal Institutes of Technology in Zurich and Lausanne are amongst the world's best universities and are regularly included in the top 20 in international rankings. Overall, universities, the private sector, private organisations and the Swiss Confederation spend around 23 billion francs or 3.4 per cent of GDP on research and development, according to 2017 figures. OECD estimates indicate that this is the third highest figure worldwide, after South Korea and Israel. In total, the research and development sector employs 82,000 full-time equivalents.

Many innovative companies are operating in Switzerland and the cleantech sector is well represented. The cleantech sector has achieved strong growth over recent years. The environment sector has almost doubled its value creation since 2000 (from CHF 10.9 to CHF 21.2 billion).[5] It has developed much more dynamically than the overall economy. The provision of renewable energies as well as energy saving and energy management (energy-saving measures, insulation, the construction of new low-energy-consumption buildings etc.) have seen particularly strong growth. Employment in the environment sector

[4] See https://www.eda.admin.ch/agenda2030/en/home/agenda-2030/die-17-ziele-fuer-eine-nachhaltige-entwicklung.html for an overview of the Sustainable Development Goals.

[5] According to the definition of the Federal Statistical Office, the environment sector covers "Activities concerning the manufacture of goods or the provision of services that protect the environment against pollution and other adverse effects, on one hand, and foster the conservation of natural resources on the other." For further details see: https://www.bfs.admin.ch/bfs/de/home/statistiken/raumumwelt/umweltgesamtrechnung/umweltgueter-dienstleistungen.html.

has risen by 87 per cent since 2000 to around 150,000 full-time equivalents. Overall, the environment sector and other cleantech-relevant sectors (such as public transport) today employ 5.1 per cent of the workforce and contribute 4.2 per cent of GDP.

The reduction of greenhouse gas emissions presents growth opportunities that extend beyond the cleantech sector. Examples include the IT sector, which can contribute to emissions reduction with digital solutions in various areas, as well as the insurance and financial sectors. As a major global financial centre, Switzerland can also play a key role in making financial flows consistent with the climate-resilient development required by the Paris Agreement.

The situation in Switzerland is also favourable in other respects. The Swiss recycling system performs well and companies are increasingly taking on board the concept of a circular econmy. Switzerland's electricity production is largely CO_2-free, while emission-intensive industries only make up a relatively low share. Many developments required to achieve the net-zero target are already under way. New buildings do not produce CO_2 emissions in many cases today, the proportion of new registrations accounted for by electric vehicles is increasing rapidly, and the industry and services sectors are relying less and less on fossil fuels. These developments must be consistently driven forward. There are greater challenges in other areas, such as food and agriculture, international aviation and technologies for the capture and storage of CO_2 and negative emissions.

In terms of legislation, Switzerland has a broad-based foundation for assuming its climate policy responsibility. It has had national climate legislation since 2000 with the CO_2 Act. In the 2020 autumn session, Parliament concluded its consultation on the complete revision of the CO_2 Act. With the complete revision, Parliament sets out goals and measures to 2030. The new CO_2 Act nevertheless extends beyond 2030 and lays the foundation for Switzerland to achieve its climate goal for 2050 (see Section 6.1). This strategy outlines how greenhouse gas emissions could develop to 2050 and sets out the long-term objective. It reduces the risk of mis-investment in plants that will continue to emit high levels of greenhouse gases for decades. The Long-Term Climate Strategy creates planning stability and provides guidance for action in all sectors concerned. If the renewal cycles are applied consistently with immediate effect to replace infrastructure, plants, vehicles and heating systems with lower-CO_2-emiting alternatives, Switzerland will occupy an advantageous position over the medium to long-term.

3 Previous development of climate and emissions in Switzerland

3.1 Climate development in Switzerland

Systematic observations of the climate system over many years show that Switzerland is severely affected by climate change.[6] The near-ground air temperature has risen by around 2° Celsius between the pre-industrial reference period of 1871 to 1900 and the last 30 years between 1991 and 2020[7] – which is significantly higher than the global average of around 1° Celsius.[8] Warming in Switzerland has been particularly high since the 1980s. In some years, such as in 2019, 2018 and 2015, it was even more than 2.5° Celsius warmer than in the pre-industrial reference period of 1871 to 1900. Nine of the ten warmest years since measurements began were in the 21st century (see Figure 2). The consequences of this warming are already evident today: heatwaves are occurring at increasingly closer intervals and to a greater extent than in the past, and intensive heavy rainfall is more frequent. The retreat of the alpine glaciers, whose volume has declined by around 60 per cent since the mid-19th century, is clearly visible. The number of days of snowfall per year has also fallen. At 2,000 metres above sea level, this is 20 per cent lower today than in 1970, and at 800 metres above sea level it only snows half as often as it did at that time. The vegetation period today is two to four weeks longer on average than 50 years ago.[9] Climate change is also putting greater pressure on biodiversity and posing a threat to traditional habitats. The climate changes are also having an impact on health. For example, the heatwave summers in 2003, 2015 and 2019 resulted in significant excess mortality.[10]

[6] National Climate Observing System (GCOS Switzerland): http://www.gcos.ch/inventory

[7] MeteoSwiss (2019)

[8] At international level, the period 1850 to 1900 (early industrial period) is used as a reference and compared with a norm period (1981 to 2010). In this analysis, the temperature increase stands at 1.5°C in Switzerland and at 0.6°C globally.

[9] See https://www.meteoswiss.admin.ch/home/climate/climate-change-in-switzerland.html for a summary of the effects of climate change in Switzerland.

[10] Ragettli / Röösli (2020).

Climate change will have an even greater impact in future. MeteoSwiss and the Federal Institute of Technology Zurich showed how the climate could develop in Switzerland to the middle of the century and beyond in the CH2018 Swiss Climate Change Scenarios published in 2018.[11] These scenarios indicate that – without effective global climate protection measures – summers will become drier and heavy rainfall more intensive, the average and highest temperatures will increase and snowfall and snow cover will continue to decrease. A comprehensive reduction in global greenhouse gas emissions in line with the goals of the Paris Agreement would significantly mitigate climate change, also alleviating the effects in Switzerland. In this scenario, the developments already under way would still continue but the extent of the changes would be significantly less overall. Based on the current situation, around half of the potential climate changes could be avoided by the middle of the century with systematic global climate protection measures and two-thirds by the end of the century. Table 1 shows the main effects – each to the middle of the century – according to the CH2018 Swiss Climate Change Scenarios.

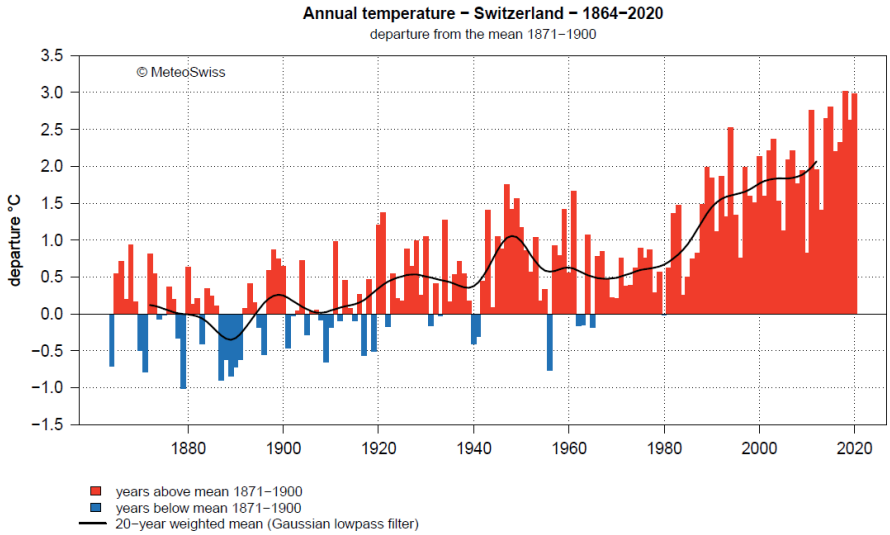

Figure 2: Deviation of the average annual temperature in Switzerland from the average in the period 1871 to 1900. Source: CH2018 (2018)

	Without effective global climate protection measures (RCP 8.5 scenario)	**With systematic global climate protection measures (RCP 2.6 scenario)**
Annual average temperature	+2.0 to +3.3°C	+0.7 to +1.9°C
Summer temperature	+2.3 to +4.4°C	+0.9 to +2.5°C
Winter temperature	+1.8 to +3.3°C	+0.6 to 1.9°C
Change in precipitation in summer	-25% to +9%	-16% to +7%
Change in precipitation in winter	-3% to +21%	-1% to +16%
Annual highest temperature	+2 to +5.7°C	+1 to +3.2°C

Table 1: Overview of climate-related effects compared to the current situation (1981 to 2010) by the middle of the century (2045–74) with and without effective climate protection measures. Source: CH2018 (2018)

The figures highlight that effective global climate protection measures in line with the goals of the Paris Agreement are in Switzerland's interests. While temperatures would also continue to go up in this scenario, they would climb much less rapidly than in the event of an unchanged rise in emissions. The differences will become even clearer long-term towards the end of the century. For example, without global climate protection measures, the average summer temperature would rise by 4.1° to 7.2° Celsius in Switzerland by this time. Effective climate protection measures would slow the increase and limit it to 0.7° to 2.4° Celsius compared with the reference period of today.

[11] CH2018 (2018).

3.2 Development of emissions in Switzerland

In 2018, Switzerland's greenhouse gas emissions amounted to 46.4 million tonnes of CO_2eq[12] in total, according to the greenhouse gas inventory. Compared with the base year of 1990, this equates to a decline of around 14 per cent. A downward emissions trend has been observed since around 2005 – despite continuous population growth (see Figure 3). During the prior period, emissions remained relatively constant except for some annual fluctuations. The orange line shows the development of greenhouse gas emissions per capita. They have declined significantly since 1990 and stood at 5.4 tonnes of CO_2eq in 2018. Even though the trend is generally moving in the right direction, Switzerland will not meet the target of reducing total emissions by 20 per cent in 2020 compared to 1990. Additional measures are required to put Switzerland back on course beyond 2020.

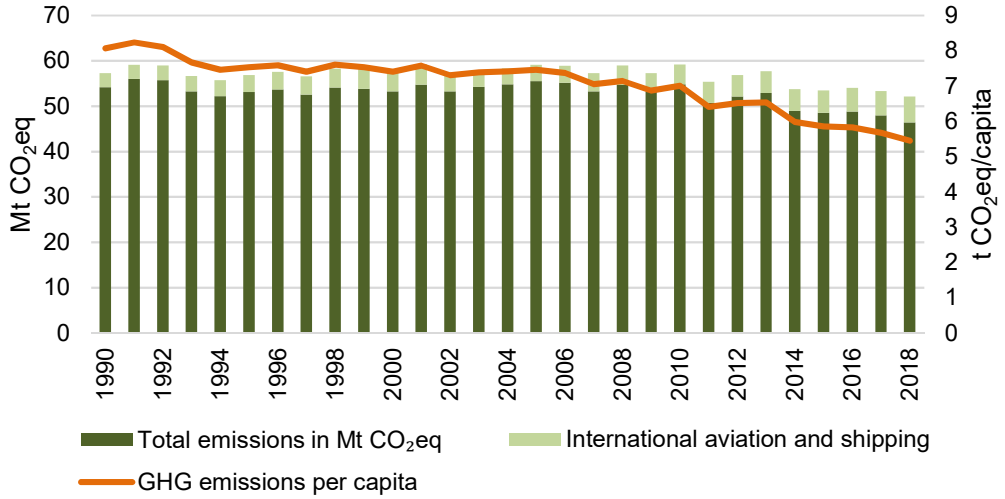

Figure 3: Switzerland's greenhouse gas emissions overall (left axis) and per capita (excluding international aviation and shipping, right axis). Source: Switzerland's greenhouse gas inventory (FOEN 2020)

If international aviation and shipping – which are not part of the international and national assessment parameters – are included, the emissions in 2018 would stand at 52.1 million tonnes of CO_2eq which is around 9 per cent below the 1990 figure. The percentage decrease compared with 1990 is lower in this scenario which is attributable to the increase in emissions from international aviation.

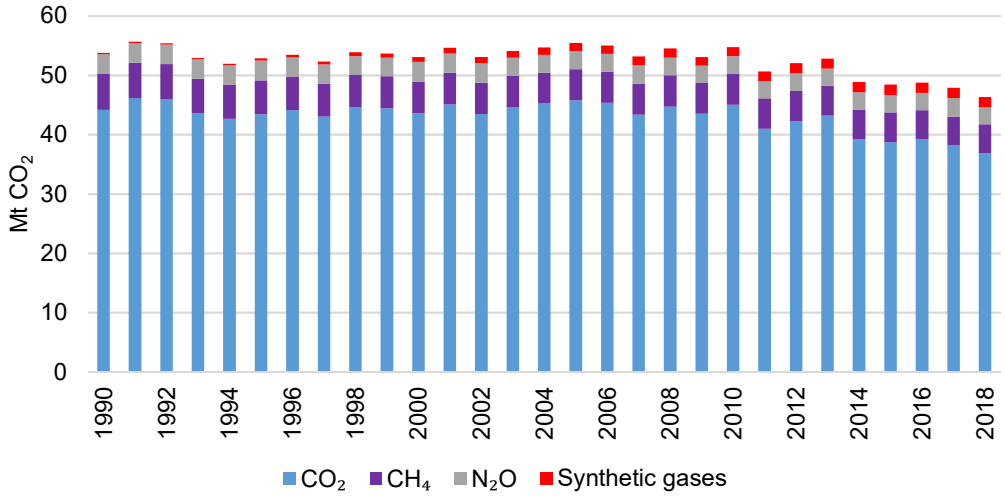

Figure 4: Switzerland's greenhouse gas emissions by gases (excluding international aviation and shipping). Source: Switzerland's greenhouse gas inventory (FOEN 2020)

[12] Switzerland's greenhouse gas inventory: https://www.bafu.admin.ch/greenhouse-gas-inventory; without international aviation and shipping.

The breakdown by gases in Figure 4 shows the dominant role of CO_2 emissions, which account for around 80 per cent of total emissions today. This means the fall in overall emissions since 1990 is primarily due to a decline in CO_2 emissions. Around 16 per cent of total greenhouse gas emissions are methane (CH_4) and nitrous oxide (N_2O), both of which are predominantly generated in agriculture. The remaining just under 4 per cent is accounted for by synthetic greenhouse gases where hydrofluorocarbons (HFC), which are used as refrigerants for example, are significant.

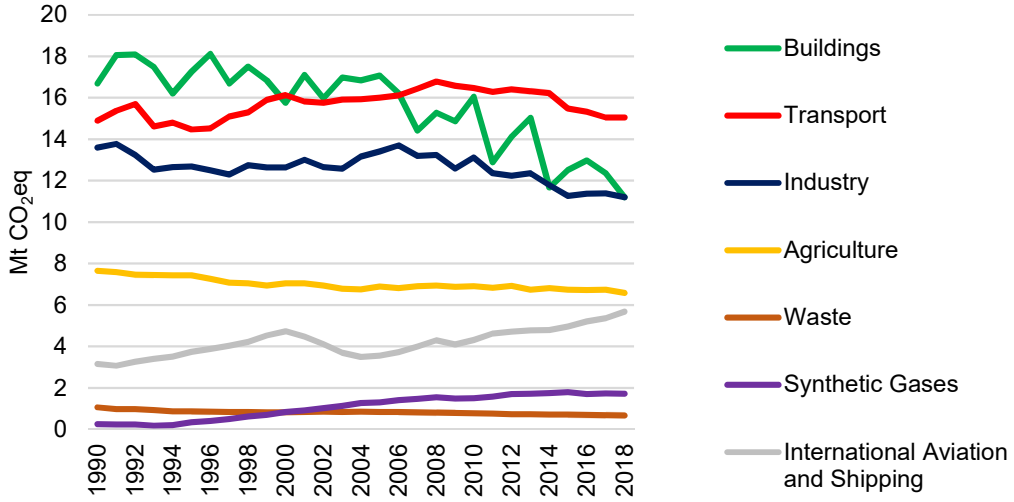

Figure 5: Switzerland's greenhouse gas emissions by sectors according to the CO_2 Ordinance, supplemented by figures on international aviation and shipping. Source: Switzerland's greenhouse gas inventory (FOEN 2020)

The breakdown by sectors in Figure 5 clearly shows that the emissions reductions are primarily attributable to the buildings sector. The annual fluctuations are weather-related and highlight the continued high level of dependence on fossil-fuel heating systems. Emissions in industry and – to a lesser extent – in agriculture have also fallen, while they have now stabilised in the waste sector[13]. The transport sector has accounted for the highest share of emissions for several years. While the trend has been on a slight downward trajectory for around ten years, emissions are still at the level of 1990. International aviation emissions show a clear upward trend to 2019 and would now make up around 10 per cent of Switzerland's total emissions if they were included in the assessment.[14] The short-term development over the coming years is still uncertain due to the COVID-19 pandemic.

Figure *3* to Figure 5 show the emissions generated in Switzerland according to the international guidelines (territorial or point of sale principle). Food and other goods imported into Switzerland and the associated emissions abroad are not included here. In contrast, the footprint perspective covers the entire supply chain and differentiates between emissions generated in Switzerland and those generated abroad. Figure 6 shows that the greenhouse gas emissions are more than twice as high as under the territorial principle if the share generated abroad is also considered. The share generated abroad has clearly risen over the course of time and almost completely offsets the reduction in domestic emissions.[15]

Figure 6 shows the importance of emissions for which Switzerland is responsible abroad. A comprehensive climate policy must assume responsibility for this too. Domestic measures to conserve resources in Switzerland, for example by means of sustainable consumption, resource-efficient production processes, sustainable supply chains and recycling management policies, can make a substantial contribution to reducing environmental pollution abroad. This will enable Switzerland to reduce its footprint abroad by 2050. This also reflects the will of Parliament.[16]

[13] The waste sector in this classification primarily includes the emissions from landfilling, biogas plants and wastewater treatment plants. Incineration plants are allocated to the industry sector.

[14] The emissions from international shipping only amount to just over 20,000 tonnes of CO_2eq and are therefore negligible.

[15] FSO Air Emissions Accounts (2020).

[16] Parliament added a provision to the CO_2 Act which states that emissions reductions abroad, which are not included in the reduction target but also contribute to emissions reduction, should be in line with emissions caused by Switzerland abroad as far as possible (Art. 3 para. 3 CO_2 Act).

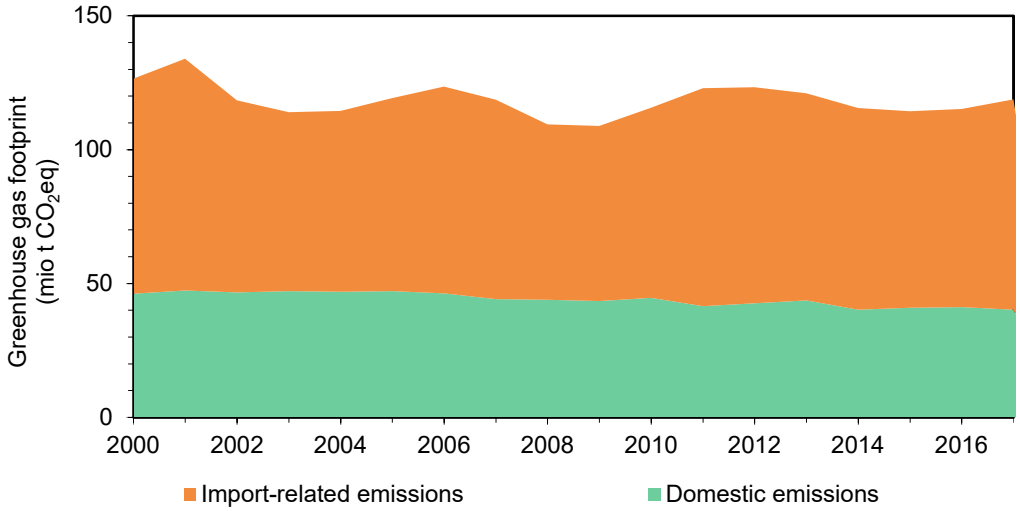

Figure 6: Development of the greenhouse gas footprint based on Swiss final demand from 2000 to 2017, broken down by domestic and import-related emissions (emissions related to exported goods and services are not included). Source: FSO Air emissions accounts (2020)

4 Long-term target for 2050

In line with the scientific evidence, based on the Paris Agreement, in accordance with its 'highest possible ambition'[17] and in view of specific economic and social requirements, Switzerland has set itself the following long-term target[18]:

Switzerland should achieve balanced greenhouse gas performance by 2050 at the latest (net zero).

Switzerland's greenhouse gas target for 2050 (net-zero target)…

… means achieving equilibrium between sources of emissions and removal and covers all internationally governed greenhouse gases (not just CO_2);

… includes all sectors in the greenhouse gas inventory (energy, industrial processes and product usage, agriculture, land use, land use changes and forestry (LULUCF), waste and others);

… covers the emissions within Swiss national borders (territorial or point of sale principle);

… also includes the emissions from international aviation and shipping attributable to Switzerland;

… does not determine specific domestic and international shares for emission reductions;

… represents an interim goal where future development after 2050 is still undecided.

4.1 Classification and meaning

The net-zero target means that greenhouse gas emissions must achieve a balance between sources and removal by 2050 at the latest. The target covers all internationally governed greenhouse gases. In addition to CO_2, it also includes methane (CH_4) and nitrous oxide (N_2O) as well as certain synthetic greenhouse gases. This is of particular significance because the methane and nitrous oxide emissions, especially in agriculture, are difficult to avoid or cannot be completely avoided as things currently stand.

The target covers all sectors in the greenhouse gas inventory: energy (1), industrial processes and product use (2), agriculture (3), land use, land use changes and forestry (LULUCF) (4), waste (5) and other (6).[19] In its counter-proposal to the 'Glacier Initiative' (see Section 6.3), the Federal Council proposed also including emissions from international aviation[20] and international shipping in the target in

[17] 'Highest possible ambition' according to the Paris Agreement (Art. 4 para. 3)

[18] Federal Council press release of 28.8.2019, can be viewed at: https://www.bafu.admin.ch/bafu/en/home/topics/climate/news-releases.msg-id-76206.html

[19] The figures in brackets refer to the corresponding categories in the greenhouse gas inventory in accordance with the provisions of the UNFCCC.

[20] In 2018 greenhouse gas emissions from international aviation stood at 5.7 million tonnes of CO_2eq according to the greenhouse gas inventory. The emissions are based on the aviation fuel used in Switzerland for international flights. This figure does not include the indirect climate effects of aviation, such as its impact on cloud formation (see Section 8.4).

future, provided this is feasible scientifically and technically in line with the data in the greenhouse gas inventory. These emissions sources are not included in Switzerland's current reduction target.

Net zero serves as a target value because Switzerland cannot reduce its emissions completely to zero in all sectors by 2050. The generation of greenhouse gases is technologically unavoidable as things stand in food production, in agriculture and in certain industrial processes, such as cement manufacture or waste incineration. These technically unavoidable emissions – assuming no alternatives are available or the emissions cannot be reduced in another way – must be balanced through the use of technical and natural removal or through emissions-reducing measures abroad.

The net-zero target for all greenhouse gas emissions can simply be referred to as 'greenhouse gas neutrality'. It refers, based on international reporting standards, to national greenhouse gas emissions, which means that the territorial or point of sale principle (for transport fuels) applies.[21] Emissions that Switzerland generates abroad are not included in the reporting parameters of Switzerland's net-zero target. However, the climate goals of the Paris Agreement can only be achieved if these emissions are also reduced. These emissions must therefore be covered by the reduction targets of other countries.

Achieving the net-zero target will require a comprehensive and rapid reduction in domestic greenhouse gas emissions. Buildings and road traffic must become almost or completely free of fossil emissions. Greenhouse gas emissions must also be reduced in industry and the waste sector as far as technically feasible. The emission of synthetic greenhouse gases, which are used in cooling systems for example, must also be restricted to a minimum. Agriculture must utilise its full capacities – for example in manure and soil management and livestock farming – to reduce the emissions of methane and nitrous oxide. Additional potential lies in the development of less greenhouse-gas-intensive foodstuffs in which Swiss companies are playing a leading role. The potential for reducing emissions in international aviation must also be exploited. The net-zero target requires the use of technologies to capture and store (CCS) or, in some cases, utilise CO_2 (CCU), particularly at large, fixed-location point sources, such as incineration facilities and cement factories. The net-zero target also requires the use of negative emissions technologies to balance the remaining emissions that are difficult to avoid technically (see Section 8.9).

The reduction of global CO_2 emissions to net zero by the middle of the century and the simultaneous comprehensive reduction of the other greenhouse gases is the only way of limiting global warming to below 1.5° Celsius, according to the scientific evidence. Switzerland's net-zero target is in line with the requirements of the Paris Agreement according to which developed countries should reduce their emissions to net zero more quickly than developing ones. Switzerland possesses the required capabilities and is well positioned by international comparison to systematically implement the transition to net zero. The completely revised CO_2 Act plays a key role in this respect.

An internationally coordinated climate policy that meets the goals of the Paris Agreement is essential for Switzerland. Switzerland is already being severely affected by the impacts of climate change today. It therefore has a strong interest in the international community taking joint action and the major emitters also setting and implementing ambitious reduction targets. Only by adopting this approach can the required technologies be developed, produced and applied to the extent required. Switzerland is reliant on this global technological progress and its application to attain its target. Switzerland can only credibly call for robust framework conditions and a reduction in emissions at international level if it is implementing the measures required itself. Measures at national level and efforts at international level must therefore go hand in hand.

4.2 Domestic and foreign shares of reductions

The Long-Term Climate Strategy leaves open the level of the domestic and foreign shares of the emissions reductions required by 2050. In the completely revised CO_2 Act, Parliament set the ratio between domestic and foreign reductions to at least three quarters versus a maximum of one quarter for 2030 (see Section 6.1). The principle of the highest possible ambition, to which the contracting parties to the Paris Agreement are committed, means that domestic greenhouse gas emissions should be reduced as far as possible. The inclusion of measures abroad is particularly beneficial during a transition period to obtain flexibility and time so that regular investment cycles for infrastructure renewal can be used.

[21] The point of sale principle applies to transport fuels. The emissions are attributed to the country where the fuel is used.

Reduction measures abroad are also an option long-term. The potential for measures abroad is nevertheless set to decrease as all countries must continuously reduce their greenhouse gas emissions toward net zero under the Paris Agreement. Their willingness to favourably assign allowable reduction options to other countries is likely to decrease, while the investment required to reduce the remaining emissions will increase. This means the prices for reductions abroad are set to rise long-term. Over the short and medium-term, reductions abroad can nevertheless provide support for partner countries and foster knowledge and technology transfer. The same quality requirements and environmental and social standards should apply to reduction efforts both domestically and abroad.

Climate change is a global phenomenon that does not recognise national borders. If Switzerland's responsibility for climate change is viewed from an international perspective, it is evident that around two-thirds of Switzerland's greenhouse gas footprint is generated abroad (see Section 3.2).[22] Switzerland, which is a technologically advanced and innovative country, can contribute towards establishing and expanding the use of low-emission technologies and processes in developing countries. Such commitment abroad therefore remains important. Internationally Switzerland advocates binding and effective rules on the allowability of reductions abroad (Article 6 of the Paris Agreement) and is already considering bilateral cooperation with various states. In this respect, the Federal Council approved an agreement with Peru[23] – the first of its kind in the world – on 14 October 2020 and an agreement with Ghana[24] on 18 November 2020.

Negative emissions technologies can generally be used both in Switzerland and abroad. Participation in relevant projects abroad can be worthwhile whereby the same requirements in terms of social acceptability and environmental sustainability as in Switzerland must be ensured. The framework conditions for allowability must be governed at international level. In view of uncertainty over the potential, costs and risks of negative emissions technologies, the comprehensive reduction of emissions in Switzerland is essential if the net-zero target is to be met.

5 Strategic principles of the Long-Term Climate Strategy

The Long-Term Climate Strategy outlines how the net-zero target can be achieved by 2050. Building on the progress achieved by the complete revision of the CO_2 Act, the climate strategy shows emissions developments, targets and the related challenges, going beyond the year 2030 and for the various sectors. The relevant future legal framework conditions can be defined on this basis.

The Long-Term Climate Strategy faces a major challenge: while the global target status is clearly defined scientifically and is bindingly laid down in the Paris Agreement, significant uncertainty exists over implementation. Forecasting technical developments is challenging. The effects of various instruments on the economy and society can only be predicted in general terms long-term. The scientific basis in all these areas must therefore be improved over the coming years. The course towards a low-greenhouse-gas future must nevertheless be set today despite the existing uncertainties. The greatest possible room for manoeuvre should also be maintained: there must be scope for new models of thinking and action in society, the economy and technology as well as their development. Options, structures and requirements may change over the next 30 years, for example with new forms of work, living and mobility.

The Long-Term Climate Strategy marks the beginning of this process. It outlines the Federal Council's views on the direction of Switzerland's long-term climate policy and, in an initial step, sets out ten overarching strategic principles which are crucial to attaining the net-zero target from a present-day perspective. These principles aim to provide guidance for climate policy but also other related policy areas. They are key elements on the path to net zero but provide the greatest possible room for manoeuvre.

[22] According to the Federal Statistical Office, just under two-thirds of Switzerland's total greenhouse gas footprint is generated abroad, see https://www.bfs.admin.ch/bfs/en/home/statistics/territory-environment/environmental-accounting/air-emissions.html. The FOEN uses a slightly different method in its estimations, but includes a similar Switzerland/abroad ratio.

[23] Federal Council press release of 20.10.2020 can be viewed at https://www.bafu.admin.ch/bafu/de/home/themen/klima/mitteilungen.msg-id-80791.html.

[24] Federal Council press release of 23.11.2020 can be viewed at https://www.bafu.admin.ch/bafu/de/home/themen/klima/mitteilungen.msg-id-81266.html.

Principle 1:
Switzerland will seize the opportunities presented by a systematic transition to net zero

Systematic alignment with the net-zero target presents major opportunities for Switzerland as a centre of research and innovation. These opportunities must be seized. Switzerland can play a leading role in the development of new, low-emissions technologies, processes and solutions and thus enhance its competitive position – both in the real economy sectors as well as in the financial sector. This will benefit not only climate protection, but also the export industry. The goal of cutting emissions to net zero by 2050 sends out a clear message on the alignment of this innovation capability. It also encourages Swiss research and innovation actors to contribute to attainment of the target. In addition to the development of new technologies to reduce emissions, research can also support the transition to net zero with findings from interdisciplinary and transdisciplinary projects.

Principle 2:
Switzerland will assume its climate policy responsibility

Switzerland is dependent on the commitment of other states in climate policy. It can only credibly call upon others to demonstrate this commitment if it is implementing the required measures itself. Switzerland therefore relies on the principle of common but differentiated responsibilities and different capacities (see Section 2.2) and will systematically pursue its path towards the net-zero target by 2050. In this way, it will also make its contribution to the global efforts on limiting global warming. It will also systematically pursue the two other goals of the Paris Agreement, i.e. improving adaptability to a changed climate and making financial flows consistent with climatic sustainability. Switzerland also supports the reduction of direct and indirect subsidies for fossil energies.

Principle 3:
Reducing emissions in Switzerland will take priority

Switzerland wishes to achieve some of its reduction by 2030 abroad. This share achieved abroad is to become increasingly less long-term. The contributions to the net-zero target to be achieved in Switzerland and abroad have been left open by the Federal Council. However, the key to attaining the net-zero target most probably lies in reducing emissions in Switzerland. Avoidable emissions must be completely eliminated as far as possible by 2050. This means that fossil heating and motor fuels can only be used in clearly defined exceptional cases. Remaining emissions will be balanced by negative emissions technologies. These technologies will supplement the comprehensive emissions reduction. Owing to their limited potential, negative emissions technologies should be reserved for emissions that are difficult to avoid technically. Switzerland will also endeavour not to relocate emissions abroad as far as possible (carbon leakage). To the extent that this is compatible with international trade obligations , no electricity produced with fossil energies is to be used for power-based applications.

Principle 4:
The emissions will be reduced across entire value chains

Goods and services imported into Switzerland cause greenhouse gas emissions elsewhere in the world. The aim is to structure the framework conditions in such a way that the production of and demand for goods and services across the entire value chain cause as little environmental pollution as possible and generate the lowest possible greenhouse gas emissions.

The Swiss Confederation, the cantons and the communes will conserve natural resources and step up their efforts to apply the principle of a circular economy within the scope of their responsibilities and capabilities. This will also contribute towards reducing environmental pollution abroad. If materials are used for longer, their quantities are reduced, they are replaced by lower-emissions alternatives and reused, emissions will be cut across the entire value chain.

Principle 5:
All energy sources will be used efficiently taking account of their optimal utilisation

In addition to completely avoiding fossil heating and motor fuels as far as possible and the rapid expansion of renewable energies, the efficient management of all energy sources is a further key element in target attainment. On one hand, this means that the potential available to improve energy efficiency and to reduce energy consumption is to be harnessed in all sectors. On the other, the energy sources available should be used as efficiently as possible. They should be used on a cross-sector basis where they

are optimal for the application. Energy sources that are scarce or expensive to produce (e.g. synthetic energies) should be used where alternatives are difficult to find and there are no other solutions.

Principle 6:
The Swiss Confederation and the cantons will gear their planning activities to the net-zero target in all climate-relevant areas

A key requirement for attaining the long-term climate goals is avoiding mis-investment: buildings and infrastructure have a long lifespan and are in use for many years. If such infrastructure is constructed and maintained with emissions-intensive building materials and operated with fossil energies or encourage the use of fossil energies, they will cause emissions over the long-term. The Swiss Confederation and the cantons are therefore required to ensure careful planning activities geared to the climate goals. This applies in particular to spatial and transport planning, urban development and energy planning. New legal provisions and investment projects should also be verified for compatibility with the net-zero target and climate protection should be incorporated into all relevant policy areas and strategies.

Principle 7:
The transition to net zero will be carried out in a socially acceptable way

The Swiss Confederation – together with the social partners, the cantons and the communes – will ensure that the transition to the net-zero target is carried out in a socially acceptable way. Additional financial burdens for low-income households or particular regions will be avoided or mitigated with appropriate measures. Infrastructure will be planned with a view to facilitating the transition to net zero for the population.

Principle 8:
The transition to net zero will be carried out in an economically viable way

The Swiss Confederation will ensure that the transition to the net-zero target is carried out in an economically viable way, cost-efficiently and in line with the polluter-pays principle as far as possible and contributes to the internalisation of external costs. It will establish clear framework conditions so that investment and renewal cycles can be systematically used to avoid mis-investment and to largely replace fossil energies. It will also ensure that sectors and companies facing international competition do not suffer any disadvantages vis-à-vis their competitors.

Principle 9:
The transition to net zero also improves environmental quality

In addition to the climate, there are also major challenges in other areas of the environment. Attaining the net-zero target should therefore go hand in hand with greater conservation of other environmental resources. Many synergies exist, for example in the areas of air quality and biodiversity. However, interests must also be weighed up. Climate protection should not come at the expense of other environmental areas but should be compatible with them and support measures aimed at improvements.

Principle 10:
The Long-Term Climate Strategy is based on the principle of openness to all types of technology

Long-term technological, economic and social developments can only be predicted with a large degree of uncertainty. As much political room for manoeuvre as possible should therefore be maintained. The Long-Term Climate Strategy is open to all types of technology. It is based on a broad understanding of technology. As well as digitalisation, material sciences and engineering, new farming methods in agriculture, operational and organisational improvements and social and cultural innovations also play an important role. In relation to negative emissions technologies, the strategy takes account of the limited availability of suitable CO_2 storage sites and the fact that suitable processes are not yet available to the extent required. Negative emissions technologies should therefore only be used on the condition that no greenhouse gases from fossil energies which could be avoided through technical measures will be emitted by 2050 at the latest.

6 Switzerland's climate legislation

The CO_2 Act and the related CO_2 Ordinance are the legal basis of Switzerland's climate policy. They set out the targets, instruments and responsibilities for implementation and enforcement. The CO_2 Act also

transposes the international climate policy obligations (Kyoto Protocol, Paris Agreement) into national law. In addition to the CO_2 Act, measures from other sector policies and legislation also contribute to emissions reduction, particularly in the areas of the environment, energy, agriculture, forestry and timber management and voluntary measures.

6.1 Complete revision of the CO_2 Act

In autumn 2020, a complete revision of the currently valid CO_2 Act was adopted which – subject to the outcome of the referendum – is set to enter into force in 2022 together with the applicable implementing provisions. The Act will make a contribution to the goals of the Paris Agreement, namely restricting global warming to well below 2° or 1.5° Celsius, to improving adaptability and making financial flows consistent with climatic sustainability. The Act's purpose article also explicitly stipulates the objective of balanced climate performance.[25]

The revision of the Act aims to halve Switzerland's greenhouse gas emissions by 2030 compared with 1990. At least three-quarters of the reduction should be achieved in Switzerland and a maximum of one quarter abroad. The CO_2 Act also requires further reductions to be achieved abroad which cannot be included in the reduction target, and namely in the level of emissions that imported goods and services generate elsewhere in the world. In this way, Switzerland will undertake additional efforts to limit global warming to 1.5° Celsius.

The revision of the Act builds on the exisiting set of measures in the buildings, transport and industry sectors and also incorporates the field of aviation. Long-term perspectives have already been adopted with various measures. They not only put Switzerland on course to halve emissions by 2030, but also have a long-term impact in relation to the net-zero target by 2050. The complete revision provides for the following measures:

- A Climate Fund will be set up to finance climate protection measures. They will include measures to cut CO_2 emissions from buildings and the funding of technologies and other measures to reduce greenhouse gas emissions. This covers the promotion of measures aimed at innovative and direct reduction of the climate impacts of aviation, climate-friendly cross-border passenger transport (such as night trains) and measures undertaken by the cantons and communes. The current technology fund, which guarantees loans to innovative companies, will also be incorporated into the Climate Fund. These guarantees enable banks to make more debt capital available for the rollout and marketing of new technologies. However, the Climate Fund can also provide support in earlier phases of the innovation process and, for example, support pilot, demonstration and flagship projects. The development of climate-friendly technologies is the key to the transition to net zero. The Climate Fund will receive a third of the revenues from the CO_2 levy on fossil-based heating fuels – up to a maximum of 450 million francs – and just under half of revenues on levies on air travel. The Climate Fund will also fund measures to prevent damage caused by climate change. Half of the compensation payments made by vehicle importers who fail to meet their CO_2 target, further penalty revenues and income from the auctioning of emissions rights will also be available.
- The CO_2 levy on fossil-based heating fuels intended as an incentive tax encourages the economical use of fossil energies and greater conversion to low-CO_2 and CO_2-free energies. Two-thirds of the revenues will be returned to the population and the economy which also makes them socially acceptable. As an impact analysis conducted on behalf of FOEN shows, the CO_2 levy has resulted in significant reductions in emissions since its introduction.[26] It should therefore be continued using the same mechanism as today. Depending on the development of emissions from fuels, the levy rate may be increased from 96 francs per tonne of CO_2 at present to a maximum of 210 francs per tonne of CO_2 by 2030. The maximum rate possible under the currently applicable law of 120 francs per tonne of CO_2 did not have to be applied. If emissions are reduced to a sufficient degree, the maximum rate will not have to be used in future either. The CO_2 levy contributes to the decarbonisation of the heating supply system by making the replacement of fossil-based heating systems with emissions-free alternatives more attractive. This gradual and potentially complete replacement over the long term is a key requirement for attaining the net-zero target.

[25] Federal Act on the Reduction of Greenhouse Gas Emissions (CO_2 Act) of 25 September 2020, Federal Gazette 2020 7847.
[26] Ecoplan (2017).

- The buildings programme will be continued indefinitely and will now be managed by the Climate Fund. Through overall contributions to the cantons, it supports energy-related renovation, the use of renewable energies, building technology and new replacement buildings. It will benefit, for example, homeowners wishing to improve their property's insulation. In addition to the buildings programme, the Swiss Confederation can now provide direct support for the replacement of fossil-based heating systems or guarantee investments in climate-friendly building improvements. To promote electric mobility, contributions for the installation of charging stations in apartment blocks and multi-family buildings and other multi-party developments are provided for. To drive forward the introduction of district heating networks, investments in the construction or expansion of heating networks and heat generation systems can be guaranteed. The Climate Fund can also make a contribution to communes for spatially coordinated energy-relating planning and support production plants for renewable gas. The buildings programme and the additional measures will contribute, on one hand, towards ensuring the energy consumption of buildings falls further towards the technically feasible and economically viable minimum. On the other, they will support renewable energies and the installation of local and district heating systems as a replacement for inefficient, decentralised solutions in the field of heating.
- Responsibility for the energy-related buildings measures lies primarily with the cantons. In accordance with the completely revised CO_2 Act, they should ensure that the CO_2 emissions of the building stock falls by half on average by 2026 and 2027 compared to 1990. The cantonal building regulations based on the model energy regulations for the cantons (MuKEn) should make the main contribution in this respect. The 'MuKEn' and their future development will also create incentives for replacing existing buildings that no longer meet the future requirements with new ones that comply with the current standards. This will also create opportunities for urban densification, the modernisation of the building stock and CO_2-free energy supply.
- With the complete revision of the CO_2 Act, new binding limits will apply for buildings Switzerland-wide from 2023. The Act differentiates between existing and new buildings. New buildings constructed from 2023 must no longer generate any CO_2 emissions. In contrast, existing buildings can continue to emit CO_2. The Act takes account of the transition being easier in new buildings. However, the Act defines limits where new heating systems are installed in existing buildings. From 2023, the target after the replacement of a heating system stands at a maximum of 20 kilograms of CO_2 a year per m^2 of energy reference area. This target value falls in five-year increments by five kilograms of CO_2 per m^2 a year and, as a result, will stand at zero in 2043. The limits lay the foundation for CO_2-neutral building stock long-term. In cantons, which had brought into effect Part F of the basic module of the 'MuKEn 2014' or a more stringent regulation in relation to the share of renewable energy in the replacement of heating systems by the entry into force of the CO_2 Act, these provisions will apply from 2026.
- The CO_2 levy on fossil fuels also covers industry. However, the CO_2 Act takes account of economic viability. Much of industry receives a full refund on the CO_2 levy and in return is subject to other instruments:
    - Companies in sectors of the economy whose competitiveness is adversely affected by the CO_2 levy can obtain exemptions from the duty. In return, they make a commitment to the Swiss Confederation to reduce their emissions. The new CO_2 Act is to make this option available to all companies. Only measures whose costs can be recouped within four years through savings will be required. The period is eight years for building measures. Operators of combined heat and power plants (CHP) can also obtain exemptions from the CO_2 levy on fossil fuels which they use for power generation provided they commit to investment in efficiency measures. The CO_2 duty and the reduction obligations will contribute to reducing avoidable emissions, particularly those from the generation of process heat, at the same pace as technical progress and the availability of renewable energies. Both instruments will pave the way for the gradual decarbonisation of industry.
    - Large emitters, such as the cement, glass, ceramics, paper and chemicals sectors, will participate in the emissions trading system (ETS) and are also exempt from the CO_2 levy. The ETS provides a market where emission rights can be traded. One emission right entitles the holder to the emission of one tonne of CO_2. The total amount of emission rights is limited.

The ETS participants are assigned some free emission rights. Emission rights can be purchased or sold on the trading system. This incentivises the major emitters to undertake measures to reduce their greenhouse gas emissions. In total, over 50 plants in Switzerland are included in the ETS. Switzerland's emissions trading has been linked with that of the EU since 2020. This gives Swiss companies access to the European market for emission rights. Flights within Europe are also covered by emissions trading in the same way as in the EU. The emission rights available will be reduced by 2.2 per cent each year. The instrument is therefore geared towards the net-zero target long-term. If greenhouse gases are captured at the point of origin using carbon capture and storage (CCS) or removed from the atmosphere by negative emissions technologies (NET), they can be included in the ETS as an emissions-reduction measure.

- Any new fossil-thermal power plants constructed in Switzerland will be subject to emissions trading. In line with EU regulations, they would not be assigned any free emission rights but would instead have to purchase them at auction or on the secondary market. Diverging from the EU, the CO_2 price, which they must pay at the minimum, should be in line with external costs.
- Incinerators of waste are currently excluded from emissions trading. In return, they entered into a sector agreement that is valid until the end of 2021. They undertook to make indirect emissions savings by increasing power and heat production and recycling more metal from slag. If a new sector agreement is concluded for the period from 2022, the incinerators will remain excluded from emissions trading. The sector is already focusing intensively on CCS and NET with a view to carbon-neutral operation and is driving forward the implementation of the first specific projects.
- If plants, which generate large volumes of greenhouse gas emissions, are newly constructed or upgraded, the operator will now ensure climate-friendly operation as far as possible. All possible technical and operational measures to reduce emissions must be taken into account as part of the environmental impact assessment. This counteracts the construction of additional new, potentially long-life infrastructure operated with fossil energies and emissions-intensive plants.
- A CO_2 emissions target value of 130 grams of CO_2 per kilometre on average applied to new cars from 2013 in line with EU regulations. A target value of 95 grams of CO_2 per kilometre on average has applied since 2020. Delivery vehicles and light articulated vehicles are also subject to emissions regulations for the first time (average target value of 147 grams of CO_2 per kilometre; target values according to the New European Driving Cycle (NEDC)). With the complete revision of the CO_2 Act, target values for cars and light commercial vehicles will fall in line with the EU from 2025 by a further 15 per cent, from 2030 by 37.5 per cent for cars and 31 per cent for light commercial vehicles. Emissions regulations for heavy commercial vehicles will also apply from 2025 also based on EU regulations. Vehicle importers who fail to meet the target values must make compensation payments. The emissions regulations incentivise importers to import more efficient vehicles and to increase the share of hybrid and electric vehicles. The emissions limits are a key instrument on the path to greenhouse-gas-free transport in view of the development beyond 2030 already defined. Compliance with the CO_2 targets requires an increasing share of low-emission drive systems. The effectiveness of this mechanism is already evident: newly registered electric cars (battery-powered electric vehicles and plug-in hybrids) reached a new record high in Switzerland in 2019 with a share of 5.6 per cent. The trend also continued in 2020. The share of electric vehicles stood at 12.1 per cent in the first ten months with the target of 10 per cent – which the industry association 'auto-schweiz' set itself for 2020 – already being surpassed.
- Manufacturers and importers of fossil fuels are obliged to compensate some of the CO_2 emissions from transport. In 2020, the share to be compensated for stood at 10 per cent. The fuel importers can pass on the costs of the compensation measures to consumers under the applicable law with a maximum surcharge of five centimes per litre of fuel. With the complete revision of the CO_2 Act, the compensation component can be set within a range of 15 to 90 per cent after consultation with the sector. As a result, the CO_2 emissions from transport will be largely offset by compensation measures. Compensation abroad is now also allowable whereby the minimum reduction in Switzerland must initially amount to 15 per cent, rising to 20 per cent from 2025. These requirements will result in an increase in investment in climate-protection measures. To take account of fuel importers passing on the costs to consumers, the completely revised CO_2 Act sets a ceiling for the surcharge.

This cannot exceed 10 centimes per litre up to 2024 and 12 centimes per litre from 2025. The compensation obligation also applies to around 4 per cent of aviation fuels, which are used in Switzerland for national and international flights and that are subject to mineral oil tax.

- Biogenic fuels can replace gasoline and diesel, thus reducing CO_2 emissions from transport. Mineral oil tax relief will continue to be granted on biogenic fuels until the end of 2023 provided environmental and social requirements are met. Their use will subsequently be supported by fuel importers subject to compensation obligations. The CO_2 compensation obligation has resulted in a sharp increase in the share of biogenic fuels over recent years. The complete revision allows vehicle importers to now include synthetic fuels in the calculation of the CO_2 emissions of the new vehicle fleet.
- In public transport, disincentives to switch from diesel-fuelled buses to buses with lower greenhouse gas emissions will be eliminated as the partial mineral oil tax rebate for licensed transport companies gradually expires: initially in local transport from 2026, and also in regional passenger transport from 2030 unless topographical conditions prevent climate-friendly alternatives. The additional revenues from the mineral oil tax are earmarked for promoting CO_2-neutral, renewable drive technologies.
- Two new steering levies are provided for in aviation. At least half of the revenues will be redistributed to the population and economy. Up to 90 per cent of the population could benefit depending on the structure.[27] A ticket levy will be introduced on scheduled and charter flights where the level can be varied within a range of 30 to 120 Swiss francs depending on distance and class of travel. A levy of 500 to 3,000 francs will be levied for business and private flights. The levy amount depends on the flight distance, take-off weight and competitiveness of the airports. Airlines which achieve significant emissions reductions can benefit from a lower rate for both levies. This provides them with an incentive to use more renewable fuel, for example. Support with innovative measures to reduce climate impact in aviation can also be provided by the Climate Fund which will receive less than half of the revenues from the flight levies.
- In relation to financial flows, the completely revised CO_2 Act ensures greater transparency over supervision. The Swiss National Bank and the Swiss Financial Market Supervisory Authority will have to report regularly on climate-related risks.

The measures adopted will reduce greenhouse gas emissions in Switzerland by just under 38 per cent by 2030 compared with 1990 if implemented systematically. As this Long-Term Strategy outlines in Section 9, a reduction in emissions in Switzerland of around 88 per cent can be achieved by 2050 compared with 1990. The completely revised CO_2 Act puts Switzerland on this reduction pathway. The revised Act is set to enter into force in 2022.

6.2 Further measures in other sector policies

In addition to the CO_2 Act, further pieces of legislation and sector policies also contribute to reducing greenhouse gas emissions.

For the agricultural sector, which caused 14.2 per cent of greenhouse gas emissions in Switzerland in 2018, the Federal Council adopted its message on the future development of agricultural policy from 2022[28] on 12 February 2020 and introduced steps to reduce methane and nitrous oxide emissions. Specific reduction pathways and interim targets are also to be set in the implementing provisions for the complete revision of the CO_2 Act. In the related message, the Federal Council proposed a domestic reduction contribution for the agricultural sector of 20 to 25 per cent by 2030 compared with 1990. This target is derived from the Climate Strategy for Agriculture in which the Federal Office for Agriculture assessed the potential for reducing emissions in the food and agriculture sectors in 2011. According to this climate strategy, emissions in agriculture can be cut by a third by 2050 compared with 1990. If the potential of the agricultural and food sectors is fully harnessed, a reduction of up to two-thirds can be achieved according to the Climate Strategy for Agriculture.[29]

[27] Sotomo Research Institute (2020).

[28] Message on the future development of agricultural policy from 2022 (AP22+), Federal Gazette **2020** 3955

[29] FOAG (2011).

In addition to the technical measures and financial incentives that the Federal Council proposed in its Message on Agricultural Policy 2022+, greater emphasis is also being placed on the production and consumption of food. The Federal Council is also currently focusing on information, individual responsibility and improving the framework conditions. Closely related to this is the avoidance of food waste. The Federal Council is currently drawing up an action plan in fulfilment of a postulate.[30]

The Energy Strategy 2050, which aims to transform energy supply, makes a major contribution to attaining the climate policy goals. A significant expansion of renewable energies – such as hydropower, photovoltaic systems, biomass, geothermal energy and wind energy – is planned in the field of power generation. In addition to efficiency measures, more domestic renewable energies are to replace fossil energies in the area of heating. To consolidate the expansion of renewable energies, the Federal Council wishes – based on the results of a consultation procedure on an amendment to the Energy Act – to partially extend the support to 2035, on one hand, and to give it a more competitive structure on the other. It also wishes to turn the statutory limits for electricity generation from hydropower and other renewable energies of at least 54.4 TWh for 2035 into binding targets and to also define targets for 2050. By opening up the electricity market to all customers, the Federal Council also intends to better integrate renewable energies into the market and to strengthen the position of decentralised electricity production to enable innovative services, such as district system solutions and electric mobility packages, to be created.

To drive forward the electrification of transport, the Swiss Confederation, together with the cantons, communes and various industry representatives, signed a joint roadmap to promote electric mobility on 18 December 2018. This aims to increase the share of electric vehicles amongst newly registered cars to 15 per cent by 2022. Electric vehicles also enjoy various benefits. They are exempt from automobile duty, do not fall under mineral oil tax and in some cantons enjoy preferential treatment with regard to cantonal tax on vehicles. Federal government supports the expansion of the network of charging stations to improve the infrastructure. The Federal Council approved the report "Voraussetzungen für ein Schnellladenetz für Elektroautos auf Nationalstrassen" (Requirements for a fast-charging network for electric vehicles on national highways) on 28 June 2017. The report outlines how the set-up of a fast-charging network can be driven forward.

In addition to future drive systems, traffic avoidance and the modal shift also play a key role in the decarbonisation of transport. This also includes improved harmonisation of urban development and transport. Spatial planning coordinated with public transport infrastructure and the intelligent networking of all individual systems will enable the further promotion of lower-CO_2 mobility. This also contributes to optimal efficiency of the overall transport system which DETEC has set itself as a target for 2040.[31] The approval of the counterproposal to the 'Bike Initiative' by the Swiss people on 23 September 2018 also gave the Federal Council a mandate to lay down the key principles for cycle path networks. Responsibility for planning, construction and maintenance remains with the cantons while the Swiss Confederation can provide support through subsidiary measures.

Various federal government strategies are also closely related to climate and support climate policy objectives. The 2030 Sustainable Development Strategy (SDS 2030) by the Federal Council will set out the medium to long-term priorities for sustainable development. It also outlines Switzerland's contribution to the Sustainable Development Goals (SDGs). Great importance is attached to climate policy. The SDS 2030 includes the thematic area of climate, energy and biodiversity as one of three priorities and refers to climate policy goals for 2030 and 2050. A further priority is 'consumption and production' which underlines the need for transformation towards a sustainable food system.[32]

International cooperation also aims to cut emissions in value chains abroad despite these emissions not counting towards the Swiss climate target. The new CO_2 Act nevertheless states that Switzerland should also contribute towards reducing emissions abroad and to the extent that it offsets the emissions it causes. According to the International Cooperation Strategy 2021–24, international cooperation resources in the field of climate change will be gradually increased from 300 million francs a year (2017–20) to around 400 million francs per year by the end of 2024. To encourage the private sector to make

[30] 18.3829 Chevalley postulate. Action plan to combat food waste.

[31] DETEC (2017).

[32] The SDS 2030 was still in the consultation procedure when the Long-Term Climate Strategy was adopted. See https://www.are.admin.ch/sne.

climate-friendly investments in developing countries, Switzerland will promote partnerships, including at multilateral level, which will aim to mobilise private funds. In addition to the specific programmes, the issue of climate change is also covered by most international cooperation programmes.[33]

The Forestry Policy 2020, the New Growth Policy 2016–19, the Foreign Policy Strategy 2020–23 and the Digital Switzerland Strategy are also of importance. The Federal Council also duly noted the report entitled "Massnahmen des Bundes für eine ressourcenschonende, zukunftsfähige Schweiz" (Swiss Confederation measures for a resource-saving, future-oriented Switzerland) in June 2020 and will propose measures to improve the conservation of resources and recycling on the basis of it.[34]

6.3 Popular initiative 'For a healthy climate (Glacier Initiative)'

The 'For a healthy climate (Glacier Initiative)', submitted at the end of November 2019, seeks to enshrine the objectives of the Paris Agreement in the constitution. It calls for Switzerland to reduce its greenhouse gas emissions to net zero by 2050 at the latest. According to the initiative, no fossil heating and motor fuels can be sold from 2050 whereby exemptions are permitted if no technical alternatives are available. The remaining emissions are to be balanced by safe greenhouse gas reductions in Switzerland. This also applies to the climate impacts of international aviation. The initiative also calls for the definition of a reduction pathway, including interim goals, at legislative level which will, at the minimum, ensure a linear reduction of greenhouse gas emissions by 2050.

The Federal Council decided to submit a direct counterproposal to the initiative,[35] in which it supports the main requirements of the initiative, namely enshrining the net-zero target in the constitution and the withdrawal from fossil energies. In contrast to the popular initiative, the Federal Council does not wish to ban fossil energies. Their use should continue to be permitted provided this is necessary for reasons of national security, the protection of the population or economic viability. Under this proposal, exemptions would also be possible if alternative energies are too expensive and would have an adverse impact on competitiveness. This may be the case in aviation, for example. According to the Federal Council – in agreement with the popular initiative – its emissions should also be included in the net-zero target, but only if this is scientifically and technically possible in line with the data in the greenhouse gas inventory.

In contrast to the initiative, the Federal Council does not wish to restrict this offsetting of the remaining emissions through safe reduction of greenhouse gases to domestic reduction, but also wishes to permit reductions abroad. Such flexibility is far-sighted in view of the limited potential in Switzerland.

7 Emissions reductions by 2050 according to Energy Perspectives 2050+

This and the following sections on the various sectors indicate how greenhouse gas emissions in Switzerland could develop so that the targeted net-zero goal can be attained. The emissions pathways are largely based on the 'Energy Perspectives' of the Swiss Federal Office of Energy. They are supplemented by the estimates for sectors not covered by the Perspectives. In specific terms, this concerns methane and nitrous oxide emissions in the agriculture (category 3 in the greenhouse gas inventory), waste (category 5 in the greenhouse gas inventory), land use, land use changes and forestry (LULUCF or category 4 in the greenhouse gas inventory) and other (category 6 in the greenhouse gas inventory) sectors.

7.1 The basis of the Energy Perspectives 2050+

The Energy Perspectives help to estimate the long-term development of energy supply and demand in Switzerland based on various assumptions and scenarios. The latest version from 2012 (Energy Perspectives 2050) formed the basis for reviewing and updating Swiss energy policy after the reactor accident in Fukushima. This revision resulted in the Energy Strategy 2050 and the new Energy Act which entered into force on 1 January 2018. The possible long-term alignment of energy policy was set out in the 'new energy policy' scenario which provided for the reduction of energy-related CO_2 emissions to

[33] The International Cooperation Strategy 2021–24 was still being drawn up when the Long-Term Climate Strategy was adopted. See https://www.eda.admin.ch/IZA2021-2024.
[34] FOEN (2020).
[35] Federal Council (2020).

around 1.5 tonnes per capita a year by 2050 as an overarching strategic goal. If the population increased to around 10 million, around 15 million tonnes of CO_2 would still be emitted by 2050.

The Energy Perspectives 2050 were comprehensively revised, not least taking account of this Long-Term Climate Strategy. The framework data was updated and the new climate policy requirements were set as objectives. The time horizon of the Perspectives was also extended by ten years to 2060 ('Energy Perspectives' 2050+ and subsequently referred to as 'EP2050+').[36] The EP2050+ and its scenarios provide a comprehensive model basis for the first time that sets out the objectives of energy and climate policy in an integral way, shows their implications and outlines the possible technological developments and measures to attain them. It focuses on measures in Switzerland.

7.2 Scenarios of the EP2050+

The EP2050+ scenarios are based on a set of assumptions and are not a forecast strictly speaking. They show possible emissions pathways for the individual sectors and contain two basic scenarios. The **'net-zero' scenario (ZERO basis)** describes a possible development of the Swiss energy system and the resulting emissions on the path to the net-zero target by 2050. It is based on the trends of technological progress currently being observed, projects them in the future and shows the technological developments required for a reduction of emissions to net zero. It assumes a high increase in energy efficiency at the earliest possible stage, the sustainably useable biomass potential being exhausted and the energy system having a significantly higher degree of electrification, for example, as a result of the increasing importance of electric mobility and electrical heat pumps. Synthetic heating and motor fuels and hydrogen (electricity-based energy sources, power-to-gas/liquid/H_2) play a slightly less significant role but make major contributions in some sectors. These assumptions form the basis for what is called the basis variant of the net-zero scenario which is focused on below.[37]

Further reduction pathways are conceivable depending on the development of technology. The EP2050+ therefore contains three additional variants of the ZERO scenario, each with different technological priorities and measures in Switzerland.[38] All variants are compatible with the net-zero target. This means the energy-related greenhouse gas emissions will be reduced as far as technically possible. Remaining emissions are generally only found in a few industrial sectors (e.g. geogenic emissions from cement production), in recycling, agriculture and from the use of synthetic greenhouse gases. They must be balanced with CCS or negative emissions technologies.

The **'Business as usual' (BAU) scenario** serves as a comparative basis. This scenario reflects the measures and instruments of energy and climate policy in force up to the end of 2018 and the current market conditions and projects them in the future without any further tightening of measures. It also carries forward current or presently foreseeable trends in efficiency increases of plants, installations, vehicles and systems into the future. The measures of the complete revision of the CO_2 Act completed in 2020, which were still undergoing parliamentary consultation when the scenarios were being drawn up, are not included in the scenarios. The comparison of this scenario with the net-zero scenario reveals the need for additional action required for target attainment by 2050 under the assumptions made. Additional investment requirements and cost increases or decreases can also be determined in the same way. The integration of the measures of the completely revised CO_2 Act into the 'Business as usual' scenario would result in a sharper decline in emissions in the 'Business as usual' scenario. This narrows the gap to the ZERO basis scenario in terms of both emissions and additional investment requirements.

[36] Prognos/TEP Energy/Infras/Ecoplan (2020).

[37] The measures implemented in the models are selected on the basis of existing potential restrictions (spatial and temporal) and technical feasibility. Additional criteria are cost efficiency, acceptance, security of supply and robustness of target achievement. For a more detailed discussion, see Prognos/TEP Energy/Infras/Ecoplan (2020).

[38] Variant A is based on extensive electrification of the entire energy system. Biogas and synthetic gases (e.g. hydrogen) play a more important role in variant B in addition to electricity. Variant C attaches more importance to heating networks and fluid biogenic and synthetic heating and motor fuels. The results of the basis variant of the ZERO scenario are shown in the following sections under the assumption of electricity requirements being met by Switzerland's own production in the annual performance assessment by 2050 ('balanced annual performance' strategy variant, nuclear power station duration: 50 years).

7.3 Framework data and developments of the EP2050+

The framework for the long-term forecasts is based on economic and demographic developments. These framework developments can be estimated based on Swiss Confederation forecasts or on national and international studies.

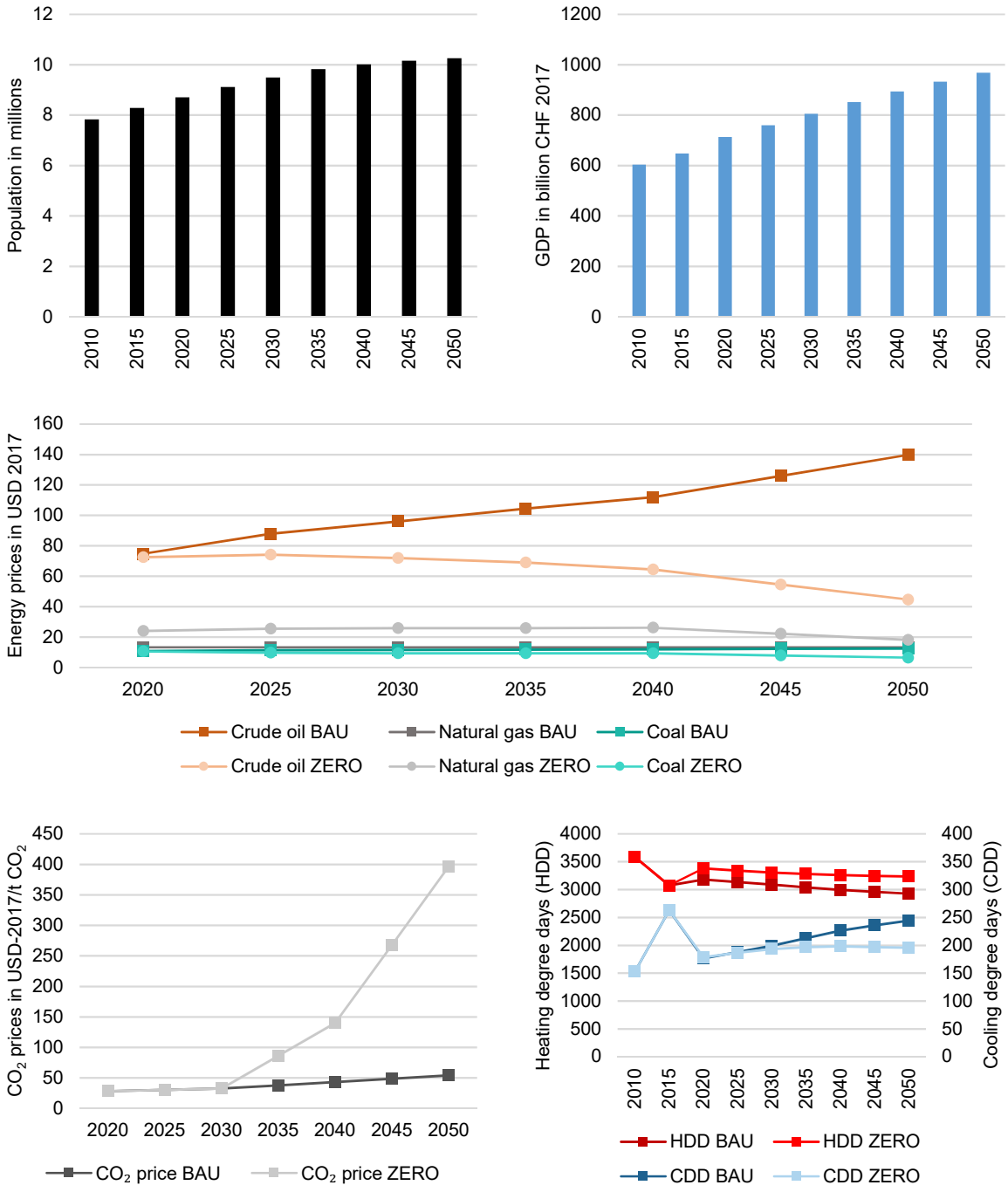

Figure 7: population developments, GDP, energy prices (in USD/bbl or USD/MWh), CO_2 prices, heating and cooling degree days according to EP2050+. Source: Prognos/TEP Energy/Infras/Ecoplan (2020), partly unpublished detailed data.

- The **population** will grow at an average rate of 0.9 per cent a year until 2030 and at an average of 0.4 per cent a year until 2050. Switzerland's permanent resident population will reach around 10.3 million people by 2050.[39]

[39] FSO (2015), reference scenario A-00-2015.

- **Economic output**, measured in terms of gross domestic product (GDP), will rise at an average rate of 1.3 per cent a year until 2030 and then at an average of 0.9 per cent a year. This means GDP will increase by around 38 per cent by 2050 compared to today.[40]
- The **energy price** assumptions are based on the World Energy Outlook 2018 of the International Energy Agency and differ depending on the scenario. In the 'Business as usual' scenario, the prices of the fossil energies increase until 2060. In contrast, they fall in the ZERO basis scenario due to lower demand.[41]
- The international **CO_2 prices** in the European emissions trading system also develop differently long-term based on the assumptions. In the ZERO basis scenario, a relatively sharp increase is required compared to today, whereas there is only a moderate rise in the 'Business as usual' scenario. [42]

The development of the **heating and cooling degree days** is based on the Swiss Climate Scenarios CH2018 (see Section 6). In the 'Business as usual' scenario, the development is based on scenario RCP4.5 where the average annual temperature in Switzerland rises by around 1.8° Celsius by 2060 compared to the reference period of 1984 to 2002. The heating degree days fall by around 14 per cent up to 2050 compared to this reference period, while the cooling degree days increase significantly. The ZERO basis scenario is based on the RCP2.6 scenario. In this scenario the average annual temperature climbs by 0.8° Celsius by 2060. The heating degree days decline by 11 per cent by 2050 compared with the reference period and there is only a slight rise in the cooling degree days (all compared to the reference period 1984 to 2002).

The framework developments, in particular the international energy prices, must reflect a consistent 'world' in the scenarios. This means Switzerland must pursue an internationally coordinated energy and climate policy and not act independently to avoid providing any inventive to relocate emissions abroad. The ZERO basis scenario applies the assumption that Switzerland's main trading partners, for example the EU, are pursuing equally ambitious targets. In relation to climate policy, this means that all contracting parties are pursuing the goals of the Paris Agreement just as systematically as Switzerland and are implementing appropriate measures. This requires international technological progress from which Switzerland also benefits.

7.4 Development of power supply according to the EP2050+

The EP2050+ shows the development of power supply in the context of the net-zero target (ZERO basis scenario). The second key framework condition – in addition to the net-zero target – is ensuring secure power supply at all times in future. The long-term development of demand for power is influenced by two opposing effects. On one hand, the technical progress and the measures taken result in tangible efficiency improvements, reducing demand for electricity. On the other, there are developments resulting in greater demand for power, in particular the market penetration of electric vehicles and heat pumps as well as the production of electricity-based energies, such as hydrogen, and the deployment of CCS.

Total gross power consumption (including the consumption of storage pumps and grid losses) rises to around 84 TWh by 2050 in the ZERO basis scenario. This represents an increase of around 30 per cent compared to today. The EP2050+ shows how Switzerland can meet this demand on an annual average with its own production by 2050. Long term, Switzerland's power supply will be provided by hydropower plants and other renewable energies. Generation by hydropower plants and other renewable energies (primarily photovoltaic systems) rises continually over the course of time. Electricity imports will be required in the annual balance during the transition period. The integration into the European power system via imports and exports always remains fundamentally important in order to meet power requirements seasonally and at all times. Figure 8 shows the development of power generation by technologies based on the ZERO basis scenario of the EP2050+.

The significant renewable electricity production – particularly through photovoltaic systems – can be integrated into the power system if the national grids have the required capacities. The anticipated high

[40] SECO (2018).
[41] IEA (2018).
[42] IEA (2018).

degree of flexibility in the Swiss power system helps in this respect: existing and new hydropower plants and additional flexibility in power consumption can make significant contributions in future.

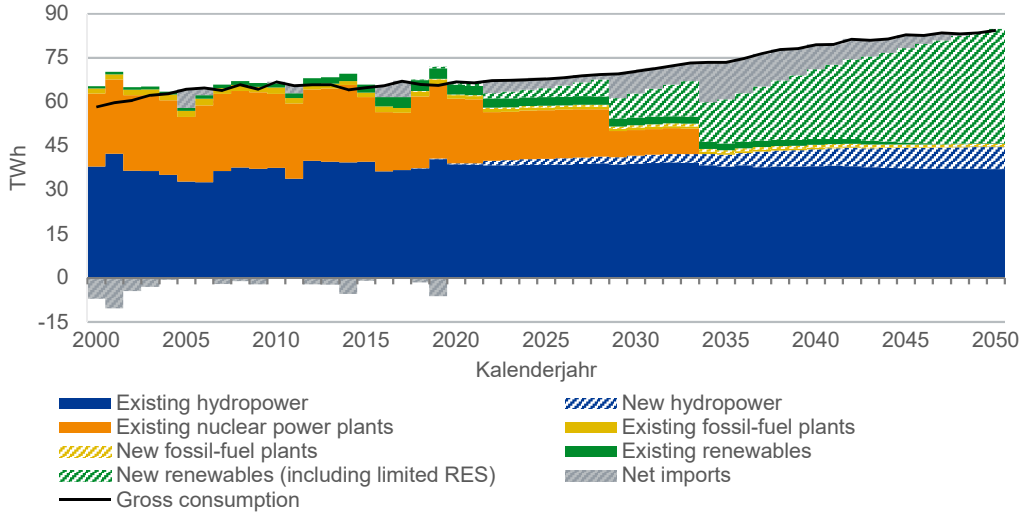

Figure 8: Development of power generation by technology according to the ZERO basis scenario of the EP2050+ (strategy variant 'balanced annual performance 2050', nuclear power plant term: 50 years). Source: Prognos/TEP Energy/Infras/Ecoplan (2020)

8 Strategic goals and challenges in the individual sectors

8.1 Buildings sector

For the 2050 time horizon, Switzerland is pursuing the following objective in the buildings sector to attain the overall net-zero target for greenhouse gas emissions:

2050 target: the building stock no longer generates any greenhouse gas emissions by 2050.

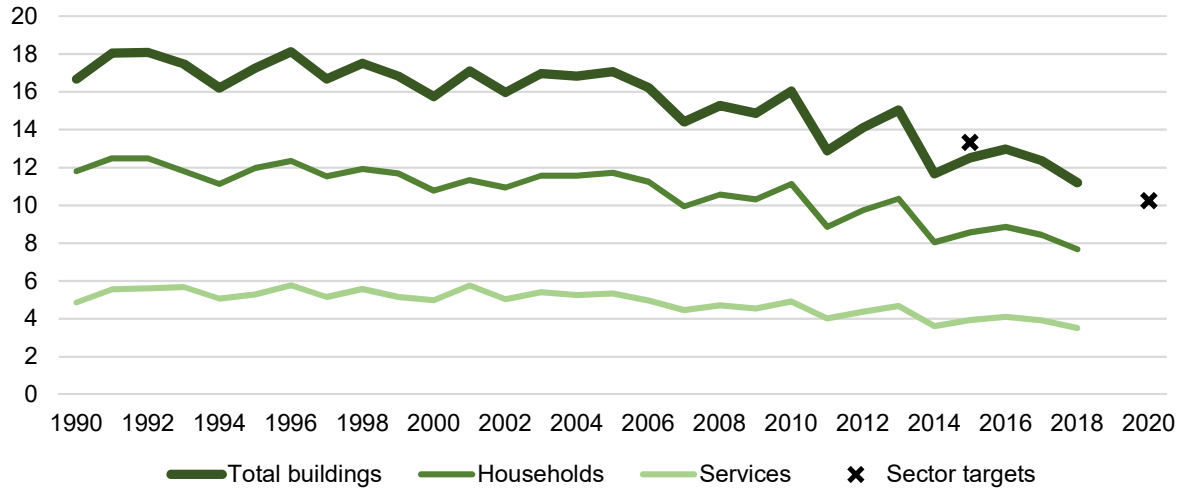

Figure 9: Emissions from the buildings sector in million tonnes of CO_2eq. Source: Switzerland's greenhouse gas inventory (FOEN 2020)

The buildings sector covers emissions from private households (category 1A4b of the greenhouse gas inventory) and the services sector (category 1A4a). In 2018, greenhouse gas emissions stood at 11.2 million tonnes of CO_2eq which is over 34 per cent below the level in 1990. The buildings sector has met its sectoral goal for 2015 in accordance with the CO_2 Ordinance (minus 22 per cent compared with 1990). Under the revised CO_2 Act, the cantons must ensure that emissions from buildings are 50 per cent lower by 2026/27 than in 1990. These efforts and the measures set out in the revised CO_2 Act can reduce emissions by 65 per cent by 2030 compared with 1990.

The annual fluctuations in the historic emissions are attributable to weather conditions. Demand for heating – which still primarily comes from fossil-based sources – rises in years with colder winter temperatures. The emissions are higher in these years. The trend is reversed in years with relatively warm winters.

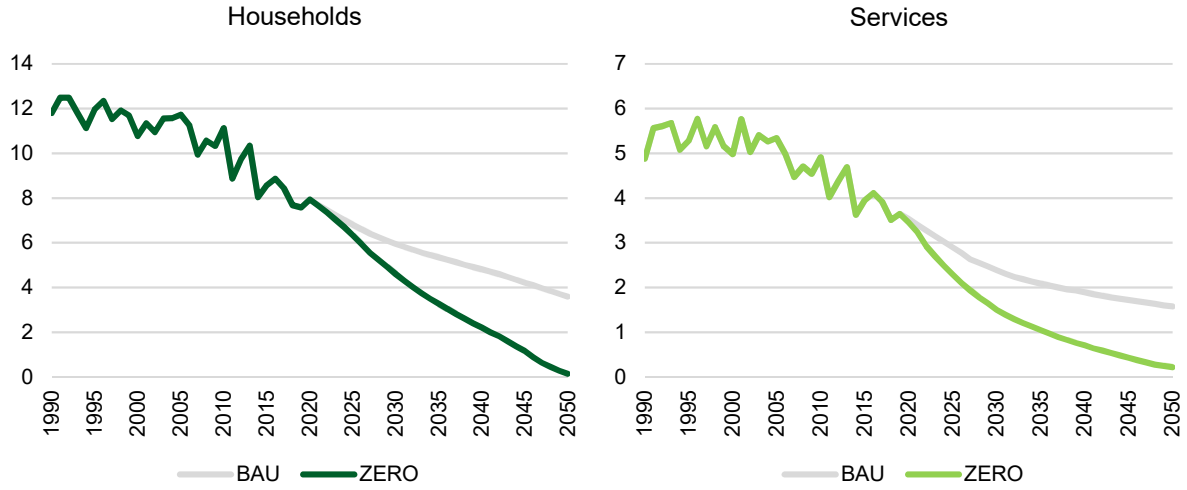

Figure 10: Emission developments of households (left) and the services sector (right) in Mt CO_2eq based on the 'Business as usual' and ZERO basis scenarios of the EP2050+. Source: Prognos/TEP Energy/Infras/Ecoplan 2020.

Figure 10 shows the possible development of emissions from households and in the services sector according to EP2050+ to 2050. A reduction to zero for households is possible by 2050, but there are low levels of remaining emissions from older infrastructure in the services sector. The comparison with the 'Business as usual' scenario clearly shows that much greater efforts are needed to maintain the reduction pathway towards net-zero emissions.

According to the EP2050+, the decarbonisation of the heating supply system is the first main lever for reducing the greenhouse gas emissions of households. Heating supply will continue to make up the biggest part of energy requirements long-term. It is mainly met today by heating oil and natural gas. These fossil energies must be replaced by emission-free alternatives by 2050. Figure 11 shows the development of energy consumption in the ZERO basis scenario according to EP2050+.

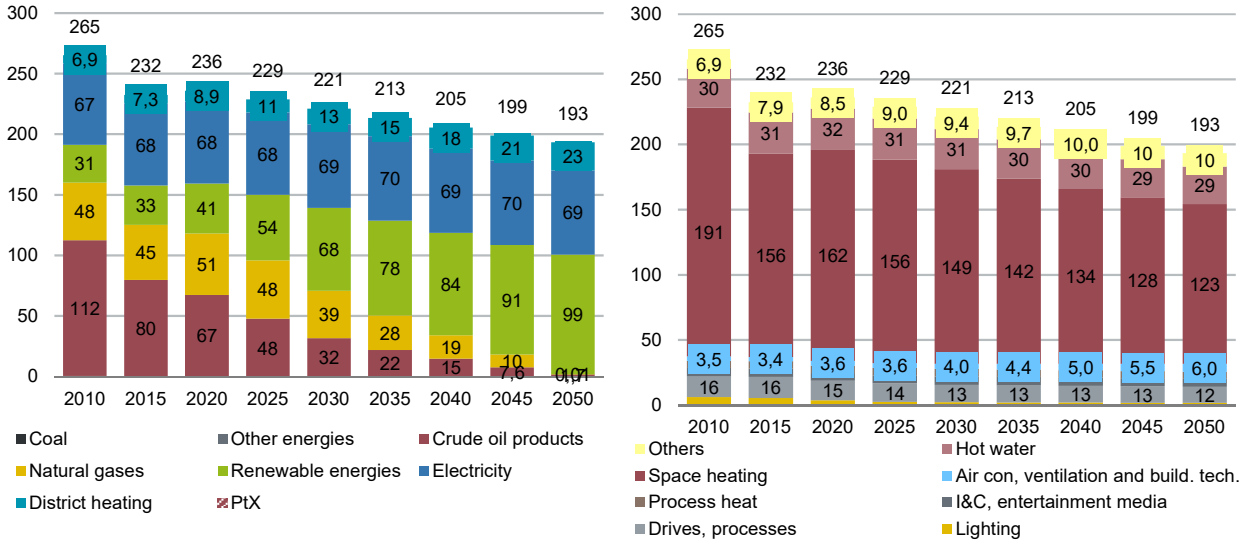

Figure 11: Development of the energy consumption of households by energy source (left) and by use (right) in PJ according to the ZERO basis scenario of the EP2050+. Source: Prognos/TEP Energy/Infras/Ecoplan 2020, unpublished detailed data.

The fossil energies are almost completely eliminated in the buildings sector by 2050. By contrast, the importance of new renewable energies and district heating increases significantly. They meet – together with electricity – almost all energy demand by 2050 despite the simultaneous increase in heated living space (driven by population growth). This depends on future renovations and new buildings being much

more efficient than today. These efficiency improvements are the second main lever. Heating demand per m^2 is set to fall by around 35 per cent in new single and multi-family homes in comparison with 2020–50, according to the EP2050+. Progress on a similar scale is required for renovations. Figure 11 (right) also shows the proportionally dominant role of heating supply long-term and also its decline (in absolute terms) compared to today. There is increasing energy demand mainly in the areas of air-conditioning, ventilation and building technology owing to the rising demand for air-conditioned living space. Compared to space heating, this area nevertheless still accounts for a small share of energy demand of residential buildings. Electricity is also primarily used.

Renovation work must significantly increase over the coming years in order to replace fossil energies quickly and fully. The frequency for energy-related renovations of building components (windows, façade, roof and flooring) then also increases significantly in the ZERO basis scenario. The renovation rates in old building stock are 30 to 50 per cent higher than in the 'Business as usual' scenario. The renovation rate for single-family homes rises to around 1.4 per cent a year by 2040 in old housing stock. The rate then stands at 1.2 per cent a year for the entire housing stock. For multi-family homes, the rate in old housing stock stands at 1.6 per cent a year (1.2 per cent a year for the entire housing stock). The level of renovation also changes in parallel with renovation frequency. The consumption of extensively renovated buildings falls to 50 kWh/m^2 per year (for space heating) long-term for single-family homes and to around 35 to 40 kWh/m^2 a year for multi-family homes. Restrictions on insulation (e.g. heritage protection, planning restrictions) in some of the buildings holds back the reduction. From 2040, new buildings reach around 30 to 35 kWh per m^2 of energy reference area per year for single-family homes and 25 kWh per m^2 of energy reference area per year for multiple-family homes.

According to the EP2050+, heat generation is also the main driver behind the development of emissions for services. The generation of process heat and air conditioning also play a role. The demand for heating and cooling is based on the development of gross value creation and full-time equivalents (FTE) in the individual sectors. Sector scenarios are available which estimate the developments of these parameters. These scenarios indicate that FTEs increase by 2040 and then remain stable (see Figure 12 left). Gross value creation rises relatively consistently overall (see Figure 12 right). The importance of the retail sector increases by 2050. Further major contributions come from the financial sector and other services, including real estate and housing.

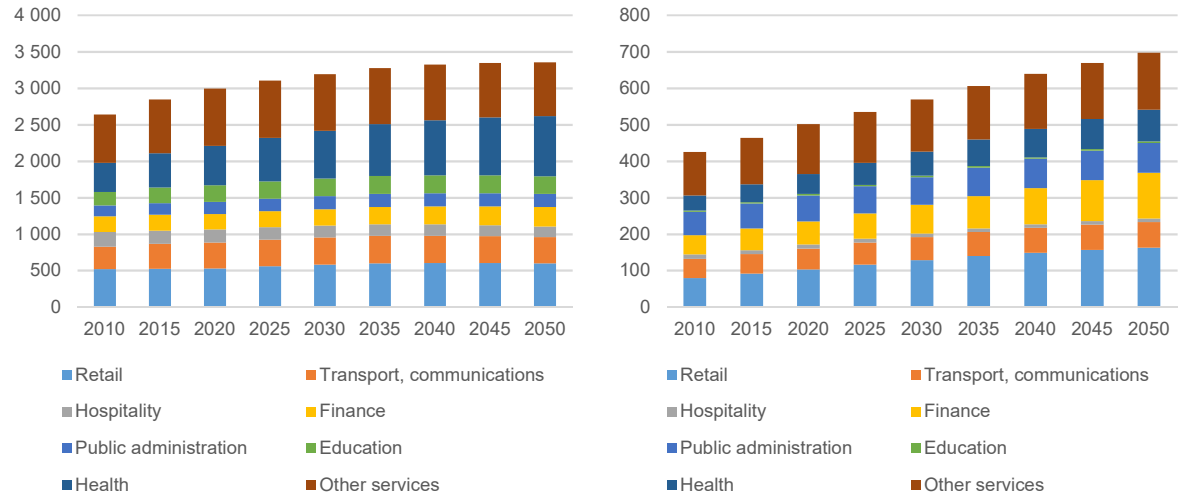

Figure 12: Development of full-time equivalents (left) and gross value creation (right, in billion CHF) in services by sector according to the EP2050+. Source: Ecoplan, 2018. Sector scenarios 2014 to 2030–60 – update 2018. On behalf of the Swiss Federal Office of Energy, Bern. Modifications by Prognos/TEP Energy/Infras/Ecoplan 2020, unpublished detailed data.

To reduce the emissions, the decarbonisation of energy supply, particularly heat generation, is also imperative in the services sector. The fossil energies widely used today (heating oil and natural gas) are to be replaced by lower-emission or emission-free alternatives. In a similar way to households, heat pumps and heating networks also play a key role in the services sector. In addition, the increased use of biomass-based heating systems (incl. biomethane) and district heating will enable the almost complete replacement of fossil-based energies by 2050 (see Figure 13 left).

In addition to the extensive decarbonisation of energy supply, the improvement of energy efficiency is the second main pillar. The potential available must be fully exploited as far as possible as with households. If this is achieved, significant savings can be made on applications that are relevant to the development of greenhouse gas emissions (process heat and space heating, hot water). Figure 13 (right) shows the development of energy consumption by types of use and outlines the efficiency improvements, particularly in space heating.

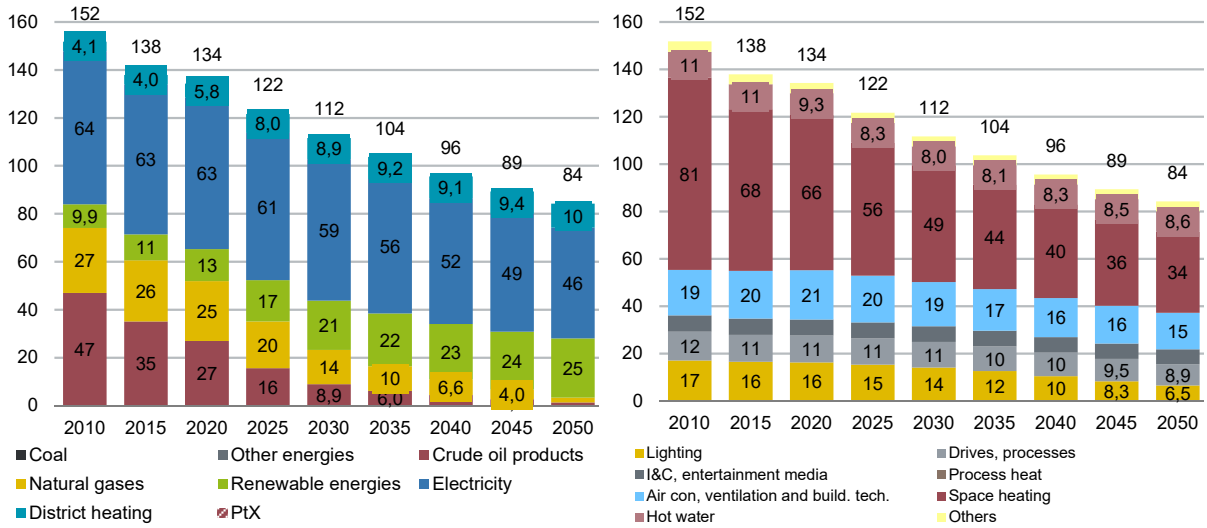

Figure 13: Development of energy consumption of services by energy source (left) and type of use (right) in PJ according to the ZERO basis scenario of EP2050+. Source: Prognos/TEP Energy/Infras/Ecoplan 2020, unpublished detailed data.

Investment cycles in the buildings sector tend to be medium to long-term. The fact that lots of old oil and gas heating systems are still being replaced with new fossil-based systems is therefore an issue. A rapid change of approach is required in this respect. The current low-interest rate environment and the existing incentive mechanisms of the Swiss Confederation and the cantons (buildings programme, tax allowances, CO_2 levy on fossil fuels) actually provide good incentives for full or partial energy-related renovations, particularly in larger services buildings. However, a study conducted as part of the city of Zurich's research programme shows that over half of people who have opted for a fossil-based system did not even consider a non-fossil alternative.[43] This illustrates that a reduction in emissions in the buildings sector can only be achieved to the required extent if suitable framework conditions or regulations exist.

At institutional level, the allocation of responsibilities between the Swiss Confederation and the cantons is a key factor. The cantons have extensive powers in the field of buildings which means they are also responsible for reducing emissions in line with the target. Under the new CO_2 Act, the cantons will receive targeted support from the Swiss Confederation in this area (specification of CO_2 limits for replacement of fossil-based heating systems, overall contributions to cantonal funding programmes, supplementary Confederation programmes, CO_2 duty). The effects of these new measures must be closely monitored to develop further regulations or measures if required to ensure the long-term targets are met.

Various structural obstacles also exist which often obstruct the use of renewable energies and energy-related building shell renovations. These include, for example, different ownership relationships, landlord-tenant issues, expensive planning permission processes or stringent requirements in relation to creditworthiness. These obstacles cannot be overcome with a simple solution. A combination of various approaches geared to the individual target groups is needed that takes account of the different challenges in the best possible way.

8.2 Industry sector

For the 2050 time horizon, Switzerland is pursuing the following objective in the industry sector to achieve the overarching net-zero target on greenhouse gas emissions:

[43] Lehmann / Meyer / Kaiser / Ott (2017).

2050 target: Greenhouse gas emissions in the industry sector are reduced by at least 90 per cent compared with 1990.

The industry sector is made up of various sub-sectors. According to the greenhouse gas inventory, it comprises energy conversion (category 1A1), industry (1A2), evaporative emissions (1B) and emissions from industrial processes (2 without synthetic gases). Category 1A1 also includes incineration. In 2018, greenhouse gas emissions in the industry sector stood at 11.2 million tonnes of CO_2eq which was around 18 per cent below the 1990 level. The industry sector met the interim target for 2015 according to the CO_2 Ordinance (minus 7 per cent compared with 1990). According to the explanatory report on the CO_2 Ordinance, the expected target contribution for 2020 (minus 15 per cent compared with 1990) was also already reached by 2017. However, the target attainment for 2020 has not yet been confirmed owing to additional emissions of nitrous oxide emissions discovered in the chemical industry in 2018. With the complete revision of the CO_2 Act, emissions can be reduced by around 35 per cent by 2030 compared with 1990.

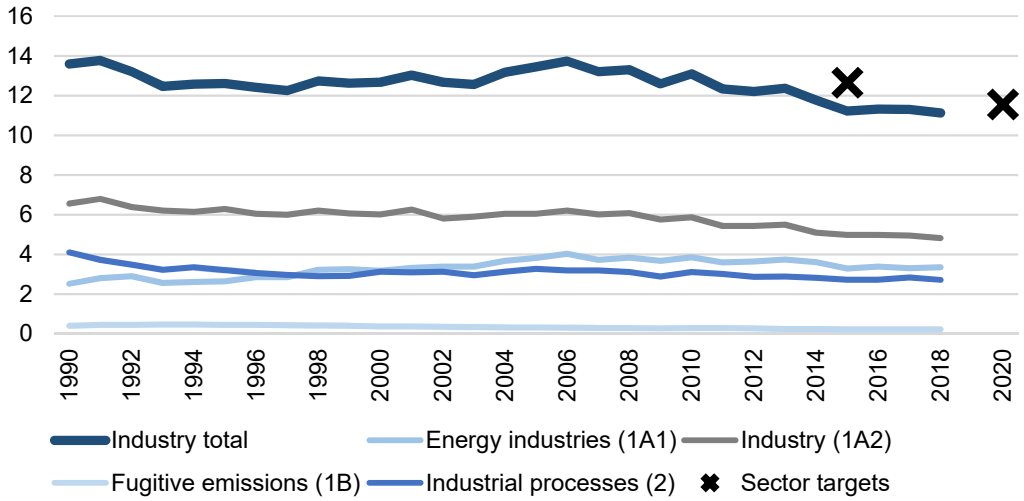

Figure 14: Emissions in the industry sector in million tonnes of CO_2eq. Source: Switzerland's greenhouse gas inventory (FOEN 2020)

Figure 14 shows the development of emissions in the industry sector since 1990, broken down by individual sub-sectors. Industry (1A2) today accounts for just under half of the emissions. Energy conversion (1A1) makes up around 30 per cent. Its share has risen since 1990 which is mainly attributable to the increasing emissions from waste incineration. Conversely, emissions from industrial processes have fallen (2). Their share has gone down since 1990 and today accounts for around a fifth. The evaporative emissions are relatively low. Overall, emissions have fallen significantly since 1990.

The sector scenarios also form the basis for assessing the development of emissions in the industrial sector.[44] The development of employment and gross value creation are taken into account. In general, these scenarios indicate that employment is set to fall slightly by 2050, except in the construction sector and the chemicals and pharmaceutical sector. Value creation in the industry sector will go up by 2050, primarily driven by a significant rise in the chemicals and pharmaceutical sector.

[44] The industry sector in the EP2050+ is not exactly the same as the definition used in the CO_2 Ordinance. Energy conversion, which includes incinerators for example, is assessed separately in the EP2050+.

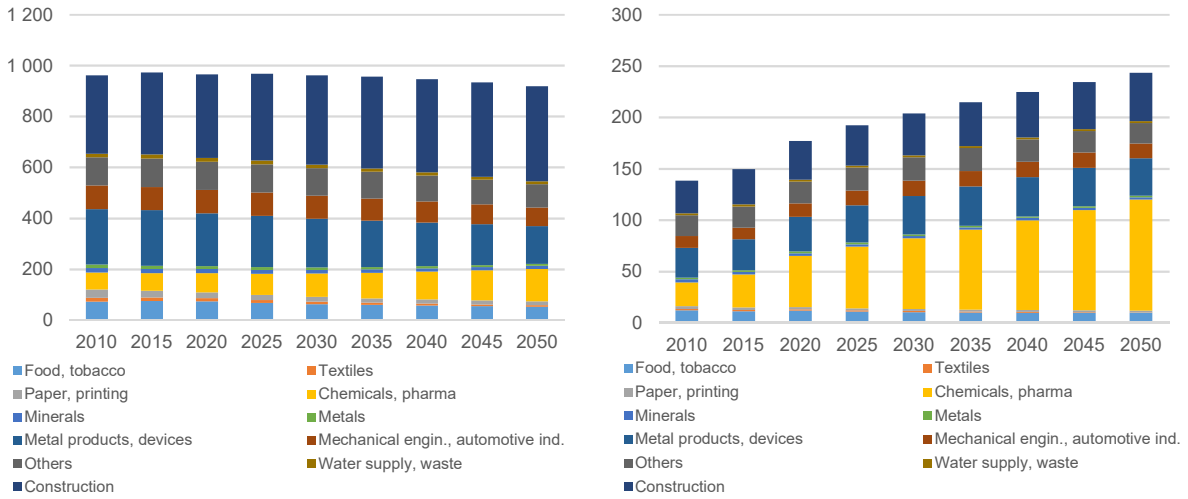

Figure 15: Development of full-time equivalents (left) and gross value creation (right in billion CHF) in the industry sector (without energy conversion) by sector according to EP2050+. Source: ECOPLAN, 2018. Sector scenarios 2014 to 2030–60 – Update 2018. On behalf of the Federal Office of Energy, Bern. Modifications by Prognos/TEP Energy/Infras/Ecoplan 2020, unpublished detailed data.

Figure 16 shows the possible development of greenhouse gas emissions, according to the EP2050+, in the industrial sector by 2050 compared with the 'Business as usual' scenario (left) and broken down by the categories of the greenhouse gas inventory (right). Overall, there will still be around six million tonnes of CO_2eq in 2050 which cannot be avoided. The remaining emissions mainly come from the cement production process (included in 2), the incinerators (included in 1A1) and the chemicals and pharmaceutical sector (included in 1A2). In contrast, the combustion-related emissions can be almost completely avoided by 2050.

EP2050+ indicates there will still be around 2.4 million tonnes of CO_2 in the cement industry in 2050 which cannot be prevented with measures to increase efficiency or through the replacement of fossil fuels. Most of them are geogenic emissions generated during manufacturing processes, i.e. during the burning of raw materials (limestone). CCS technologies are required to prevent these emissions. Only minimal residual emissions will remain in 2050 if CCS with a CO_2 capture rate of 90 per cent is deployed.

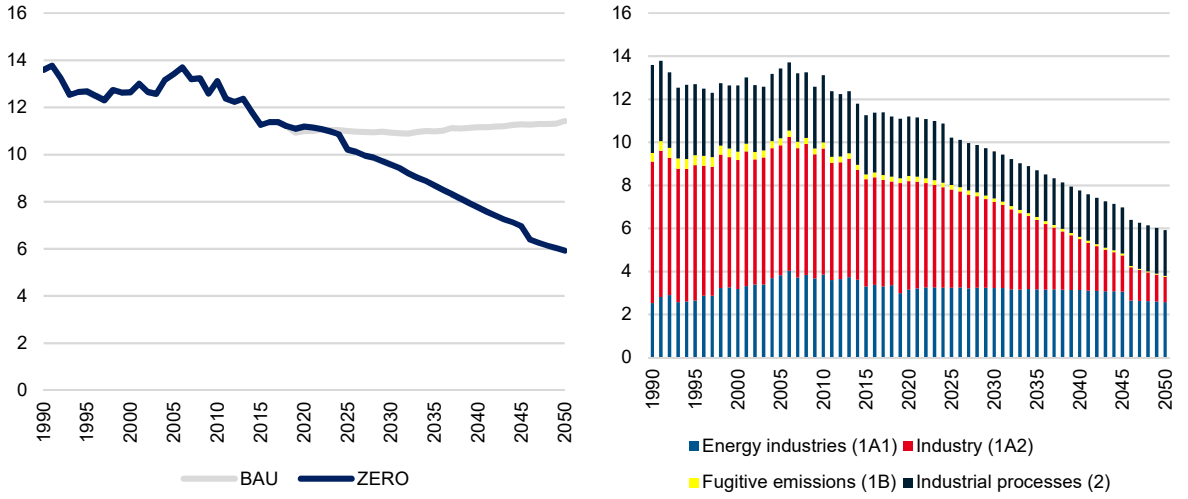

Figure 16: Development of greenhouse gas emissions in the industry sector overall (left) and by categories (right, only ZERO basis scenario) in Mt CO_2eq according to EP2050+ both without CCS and NET. Source: Prognos/TEP Energy/Infras/Ecoplan 2020.

The waste incineration situation is similar. The systematic recycling of reusable materials, more intensive separation in collection and digitalisation will enable emissions from waste incineration to be stabilised by 2050 compared to today despite the growth in the population and economy. This means there will be a remaining four million tonnes of CO_2 by 2050 of which around 1.5 million tonnes are of biogenic origin. Incineration plants are suitable as point sources for the use of technologies for the capture and

storage of CO_2. The extensive application of such technologies will enable emissions from waste incineration to be almost completely eliminated and could even result in negative emissions from the biogenic share.

Residual emissions are likely to remain in certain other sectors, particularly chemicals and pharmaceuticals. Less emphasis is placed on CCS as large point sources are not generally found in these sectors. The remaining emissions would therefore be balanced with negative emission technologies (NET). According to the EP2050+, a reduction of just under 60 per cent is feasible in the industry sector overall by 2050 compared with 1990 under the assumptions made and without contributions from CCS and NET. If the potential contributions of CCS are included (also see Section 8.9), there will still be around 1.2 million tonnes of CO_2eq in remaining emissions by 2050.

In a similar way to the buildings sector, increased energy efficiency and the substitution of fossil fuels with renewable energies and greater electrification are also the main levers for reducing emissions in industry, according to the EP2050+. On one hand, the efficiency potential available must be utilised and implemented as systematically and comprehensively as possible in all sectors. This concerns both technologies for heat generation (burners, ovens, steam generators) as well as electricity-based interdisciplinary technologies (e.g. pumps, presses and mills). Industrial processes also need to be optimised to achieve maximum efficiency. On the other hand, the replacement of fossil energies must be as comprehensively as possible. EP2050+ indicates that more biomass can be used to generate process heat in the medium temperature range. Renewable gases can be used instead of natural gas for the generation of process heat in the high temperature range. There is still moderate potential in the electrification of heat generation in the food industry, the papermaking sector and chemicals industry. Heat pumps and district heating can replace fossil energies as sources of building heating.

Figure 17 shows the development of energy consumption by energy sources (left) and type of use (right) in the industry sector (without energy conversion). The consumption of fossil energies falls sharply, whereas renewable energies play an increasingly important role. The generation of process heat remains predominant in terms of type of use.

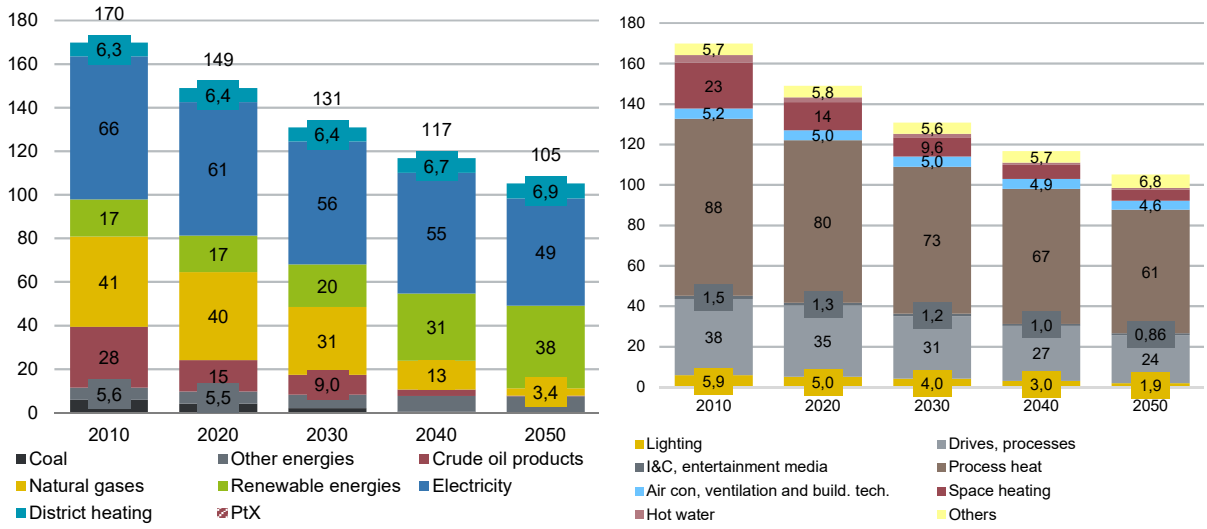

Figure 17: Development of final energy consumption in the industry sector (without energy conversion) by energy sources (left) and by type of use (right) in PJ according to the ZERO basis scenario of EP2050+ Source: Prognos/TEP Energy/Infras/Ecoplan (2020), unpublished detailed data.

The industry sector is extremely heterogeneous. The opportunities and approaches to emission reduction sometimes differ greatly between the individual sectors. Situation-oriented incentives are required to put the sector on course to meet the target. The reduction obligations in their current form only provide for the implementation of economic measures and do not therefore achieve any significant additional reductions. Systematic orientation to the net-zero target is required over the medium term. Orientation to net zero at the earliest possible stage also presents an opportunity for Switzerland as a centre of innovation and provides many sectors with new growth potential. It must be ensured that there is no relocation of emission-intensive activities abroad.

A second challenge is presented by reducing emissions that are technically difficult to avoid, particularly in the cement industry and waste incineration. The CO_2 capture technologies required have barely been tested in practice at this stage and must therefore be brought to market over the coming years.

8.3 Transport sector

For the time horizon 2050, Switzerland is aiming to achieve the following objective for transport (excluding international aviation) to attain the overarching net-zero target on greenhouse gas emissions:

2050 target: Land transport does not generate any more greenhouse gas emissions in 2050 with few exceptions.

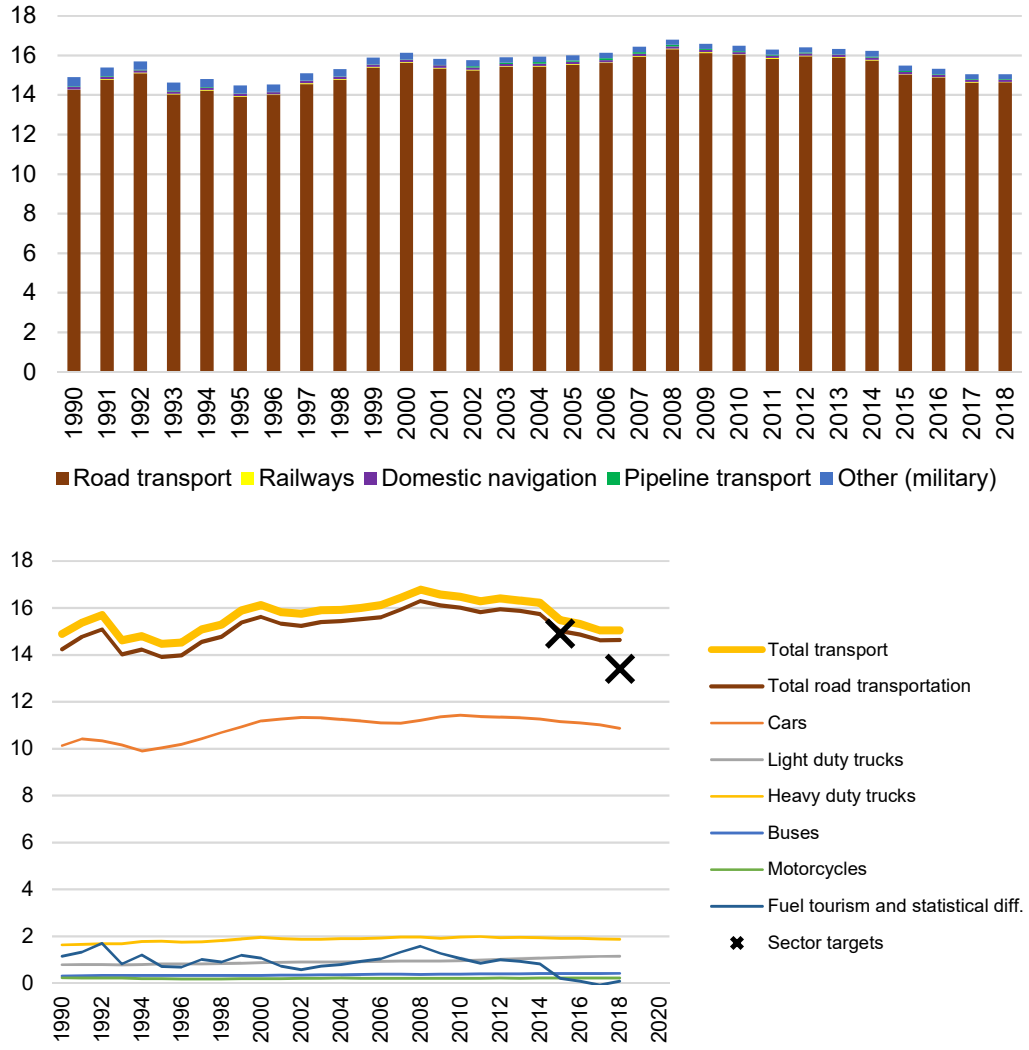

Figure 18: Emissions from the transport sector in million tonnes of CO_2eq (graphic above: transport emissions by sub-category; graphic below: emissions from road transport by sub-category). Source: Switzerland's greenhouse gas inventory (FOEN 2020)

The transport sector is made up of the transport (1A3) and military (1A5) emissions categories. In the greenhouse gas inventory, the category 1A3 is broken down into road transport, domestic aviation (excluding military), rail, domestic shipping and pipeline transport. The transport emissions stood at 15 million tonnes of CO_2eq in 2018 which is slightly above the 1990 level (14.9 million tonnes of CO_2eq). Over 97 per cent of transport emissions come from road transport which is why it is covered by this section. International aviation is not part of the transport sector and is indicated separately in the greenhouse gas inventory.

The CO_2 Ordinance stipulated that transport emissions had to be reduced to the level of 1990 by 2015. The sector clearly failed to meet this interim target (2015 emissions: 15.48 million tonnes of CO_2eq). According to the explanatory report on the CO_2 Ordinance, transport emissions should be 10 per cent

lower by 2020 than the 1990 level. The transport sector also looks likely to fall short of this expected target. One reason for this is that the compensation obligation on fuel importers has only resulted in negligible emissions reductions in the transport sector – most compensation projects are being carried out in other sectors. With the revision of the CO_2 Act, emissions can be reduced by 25 per cent by 2030 compared with 1990.

Figure 19 shows technologically feasible development of emissions under the ZERO basis target scenario compared with the 'Business as usual' scenario for the sub-sectors of road transport. From a technological perspective, the transport sector can operate on a greenhouse-gas-neutral basis by 2050 according to EP2050+. Compared with the 'Business as usual' scenario, this nevertheless requires much greater reductions.

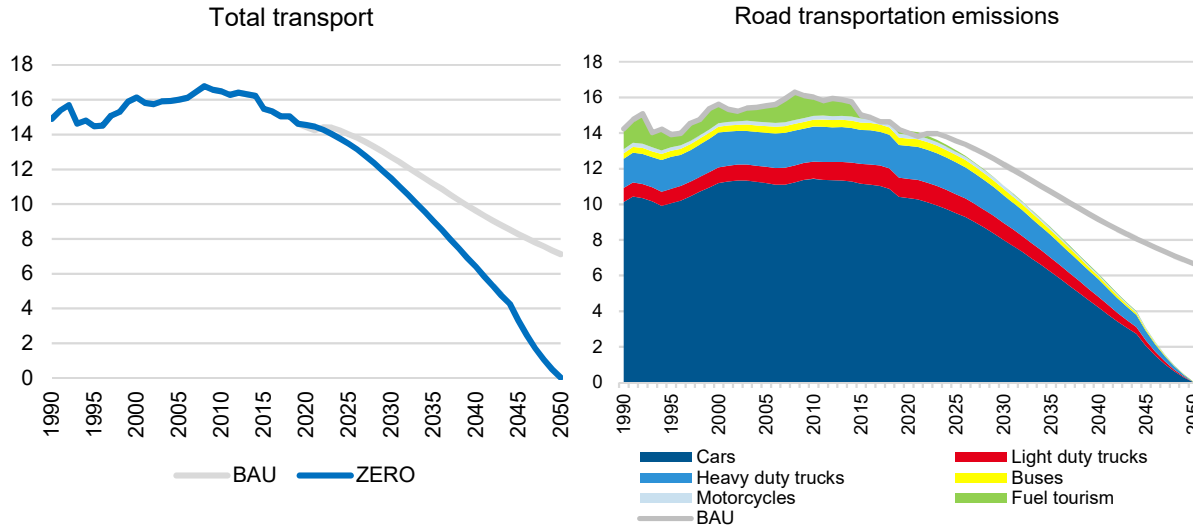

Figure 19: Emissions development in the transport sector by 2050 (in million tonnes of CO_2eq) according to EP2050+. Source: Prognos/TEP Energy/Infras/Ecoplan 2020, unpublished detailed data.

The number of kilometres travelled and the road-rail modal split in the EP2050+ are based on the forecasts in the Transport Outlook 2040[45] reference scenario. The number of kilometres travelled and the modal split are identical for all scenarios of the EP2050+. The number of kilometres travelled rises sharply by 2060. The reduction in emissions according to EP2050+ compared with the 'Business as usual' scenario is therefore due to a change in the fleet composition, extensive electrification, the use of greenhouse-gas-neutral fuels and greater efficiency across all vehicle categories (cars, light commercial vehicles, heavy goods vehicles). The emissions per kilometre travelled should fall much more quickly than in the past.

According to the EP2050+, the emissions reductions for cars and light commercial vehicles are achieved long-term through extensive electrification of the vehicle fleets: Figure 20 shows that the share of cars with combustion engines declines after 2020 and new vehicles with electric drives increase rapidly, particularly after 2030. From 2025–30, the EP2050+ assumes cost equivalence between electric and conventional vehicles for many applications. The range of an average battery-powered electric car of over 400 kilometres will be enough for most users. This means battery-powered vehicles play the most important role by far long-term (2050: 90 per cent of all new vehicles in the car and light commercial vehicle categories). The remaining ten per cent of new vehicles in 2050 are fuel cell vehicles (included in 'electric car' or 'electric light commercial vehicle' in the graphic above). They will be used where greater ranges or short refuelling times are required. Hybrid drives are relevant in all scenarios during the transitional phase but will be replaced by purely electric vehicles long-term. Almost half of the drive energy required is provided by renewable electricity-based and biogenic fuels which are used in combustion engines. Overall cars and light commercial vehicles with combustion engines which are still in circulation in 2050 can be operated on a greenhouse-gas-neutral basis, according to EP2050+.

[45] Federal Office for Spatial Planning (2016).

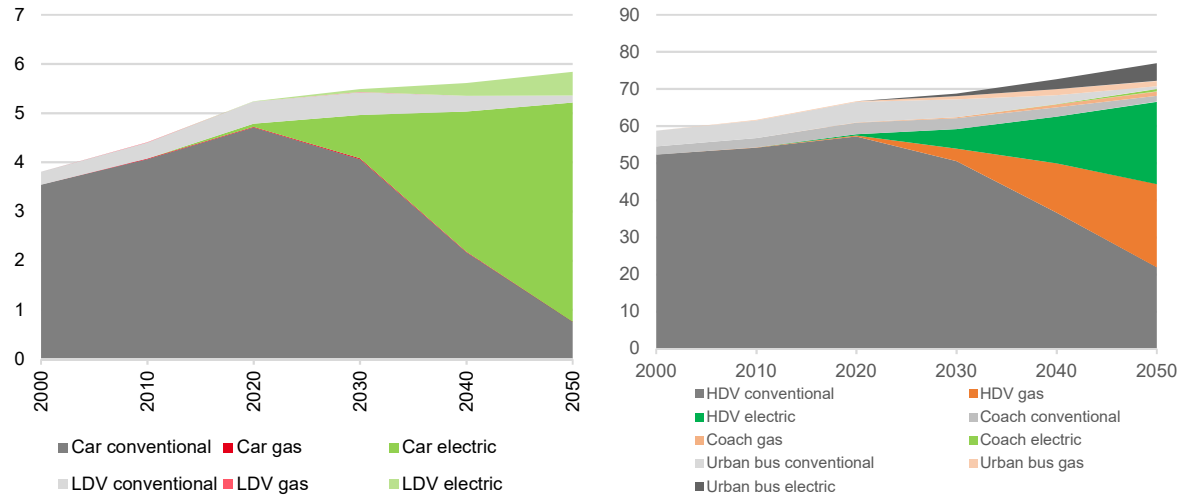

Figure 20: Fleet development of cars (C) and light commercial vehicles (LCV) (left, in millions) and heavy goods vehicles (HGV) (right, in thousands) by vehicle categories by 2050 according to the ZERO basis scenario of EP2050+. Source: Prognos/TEP Energy/Infras/Ecoplan 2020, unpublished detailed data.

According to EP2050+, new heavy goods vehicles will account for most fuel cell vehicles. Electricity-based or biogenic renewable fuels are only used for road transport if they are not required for other purposes for which fewer alternatives exist. Biogas could play a relevant role for heavy goods vehicles in a transition period. Electric vehicles are mainly used in public urban transport. It is nevertheless anticipated that vehicles with diesel engines, but which could be run on renewable fuels, will still be used long-term on longer routes in heavy goods transport (electricity-based or biogenic). Their share of the new vehicle fleet will still stand at around 20 per cent in 2050, according to EP2050+.

Transport modelling forecasts a further rise in passenger and freight transport driven by the expected growth in the economy and population. Owing to an increase in the number of kilometres travelled, there is a rise in energy demand, putting greater pressure on infrastructure and the environment. The technologies for largely greenhouse-gas-neutral transport already exist but are still not widely used enough. A widely accepted, effective operating framework is required here to accelerate the penetration of these technologies.

Further challenges facing greenhouse-gas-neutral transport are the conservation of resources in all areas of the environment (e.g. during raw material production for the batteries of electric vehicles and their recycling) and energy efficiency (for example, the use of synthetic fuels). Analyses of transport often only take account of the climate effects during the operational phase. This is in line with the applicable international requirements. However, the climate effects of the entire life cycle of the vehicles, transport chains and mobility infrastructure must be taken into account long-term (this takes place to some extent through emissions reductions in industry). At European level, the inclusion of lifecycle emissions in the regulation on fleet emissions is currently being assessed. A proposal on the recording of these emissions is to be presented by the European Commission by the end of 2023.

Digitalisation can make a positive contribution to the reduction of greenhouse gas emissions in various ways. Working from home and digital forms of collaboration can result in a reduction in the number of kilometres travelled and therefore lower energy consumption. Multimodal mobility services enable various energy-efficient and climate-friendly modes of transport to be linked. In online retail, fewer CO_2 emissions are generated per order on average if consignments are efficiently combined. Self-driving vehicles may result in a reduction in the number of journeys if vehicles are shared in future. Appropriate framework conditions must be established in order to harness this potential.

A greater shift of transport from road to rail also offers great reduction potential. A shift of transport to rail makes a major contribution to reducing greenhouse gas emissions and ensuring climate-compatible spatial development if the (additional) power used is produced in a renewable and sustainable way. The strengths of rail transport – particularly the high transportation capacity on a small area and relatively low energy consumption with good capacity utilisation – and technological innovations must be used in

an optimal way. This also applies to freight transport in particular. Innovative changes are required to transport goods competitively and in an eco-friendly way by rail.

8.4 Aviation sector

For the 2050 time horizon, Switzerland is pursuing the following objective in international aviation to achieve the overarching net-zero target on greenhouse gas emissions:

2050 target: International aviation from Switzerland should no longer generate climate-impacting emissions in net terms by 2050 as far as possible. This means:

- Fossil CO_2 emissions amount to net zero.
- The other climate impacts decline or are offset with other measures.

Greenhouse gas emissions from international aviation from Switzerland are currently excluded from the reduction target in exactly the same way as those from international shipping traffic. While these emissions are indicated separately in Switzerland's greenhouse gas inventory, they are not included in the assessment of target attainment in accordance with the CO_2 Act. While greenhouse gas emissions from international shipping are negligible for Switzerland, those created by international aviation are increasingly significant. In 2018, these emissions stood at around 5.7 million tonnes of CO_2eq (of which 5.6 million tonnes was CO_2). This means international aviation accounted for around 11 per cent of Switzerland's total greenhouse gas emissions and for around 13 per cent of total CO_2 emissions.[46]

International aviation, which has seen steady growth to date, is increasingly responsible for emissions from a climate policy perspective. As a result, the 193 member states of the International Civil Aviation Organization (ICAO), including Switzerland, agreed a global CO_2 compensation system in 2016 (Carbon Offsetting and Reduction Scheme for International Aviation CORSIA) in which Switzerland is also participating. CORSIA aims to achieve CO_2-neutral growth in international aviation. The commitment of member states to the compensation obligations is voluntary until 2026.[47] The system initially applies until 2035 and will then – depending on the impact – be continued or replaced by a new system.

In its direct counterproposal to the Glacier Initiative, the Federal Council proposes including the emissions of international aviation in the net-zero target for 2050 provided this is scientifically and technically feasible in line with the data in the greenhouse gas inventory. This is currently possible for the greenhouse gases CO_2, methane (CH_4) and nitrous oxide (N_2O). The reduction of CO_2 emissions is therefore a priority in the near future as they remain in the atmosphere for a long period. In addition to these gases covered by the greenhouse gas inventory, international aviation also generates other emissions that have an impact on the climate. These include water vapour (H_2O), nitrogen oxide (NO_x), sulphur dioxide (SO_2) and black carbon. In particular, the vapour trails and the high thin clouds that form as a result of them (cirri) are relevant. The impact of the latter on the climate is at least the same as that of CO_2. Both for the current climate impact of previous emissions from aviation and also with a focus on the remaining emissions budget that is compatible with the warming limit of 1.5°, the CO_2 emissions of aviation must be multiplied by a factor of around 2.5 according to the information currently available to reflect the total impact on the climate.[48] This figure is a global average. The factor can fluctuate significantly depending on weather conditions and altitude for an individual flight which means there is an element of uncertainty. These emissions are not currently included in the greenhouse gas inventory on account of this element of uncertainty. These emissions have a limited impact temporally in view of their short lifespan. They should also decrease long-term. However, the cutting of these emissions should not come at the expense of reducing fossil-based CO_2 emissions which remain in the atmosphere for significantly longer.

[46] To ensure a global assessment that is as complete as possible, emissions are calculated according to the point of sales principle. In the case of international aviation this means the emissions of a flight are attributed to the country where the fuel for this flight was provided. If the principle of national treatment – based on the data on the kilometres flown annually according to the transport micro-census – is applied instead of the point of sales principle, the emissions caused by the inhabitants of Switzerland would stand at around 7.7 million t CO_2.

[47] To date (as at November 2020) 88 states have committed to voluntary participation in the compensation obligations from 1.1.2021. With the participation of these states, around 77 percent of total emissions from international aviation are covered.

[48] Neu (2020). Comparing the climate impact of CO_2, which remains in the atmosphere for a long period, and short-life non-CO_2 emissions is generally complex and involves an element of uncertainty. The factor of 2.5 is based on the best estimate according to the information currently available.

A further challenge is the fact that the technical options for reducing emissions in international aviation are limited. The aviation sector should increasingly focus on renewable, sustainable fuels and on alternative drive systems. Options include synthetic fuels from renewable energies and advanced biofuels, hybrid drives and electric or hydrogen drives. However, it should be noted that – in contrast with other modes of transport – alternative drive technologies in aviation are unlikely to be suitable, as things stand, for large aircraft or long distances even long-term on account of the high energy density required for the energy sources as well as other technical requirements. The use of CO_2-neutral synthetic fuels may represent the only genuine alternative in the period under consideration to 2050. This potential – together with that of organisational measures (e.g. optimising flight routes) – must be harnessed. Remaining emissions must be balanced with negative emissions.

8.5 Food and agriculture sector

Agriculture is part of the food system that covers the entire value chain encompassing the production, processing, sale and consumption of food. For the 2050 time horizon, Switzerland is pursuing the following objectives to achieve the overarching net-zero goal on greenhouse gas emissions:

2050 targets:

Thanks to favourable framework conditions for sustainable food systems, the greenhouse-gas footprint of food is falling in line with the net-zero target and further relocation of greenhouse gas emissions abroad will be avoided.

- The greenhouse gas emissions from agricultural production in Switzerland have been cut by at least 40 per cent compared to 1990.
- Swiss agriculture will contribute a significant share of Switzerland's food supply of at least 50 per cent by 2050.

The emissions of agricultural production are distributed across several sectors and categories of the greenhouse gas inventory. They include:

- The methane and nitrous oxide emissions from livestock farming as well as nitrous oxide and CO_2 emissions from the use of fertilisers on agricultural soils (category 3 of the inventory);
- The greenhouse gases from the combustion of fossil heating and motor fuels in grass-drying operations and greenhouses as well as agricultural machinery and vehicles (parts of 1A4c);
- The carbon footprint of mineral and organic soils used in agriculture and the biomass grown on it (4B and parts of 4C).

Greenhouse gases from the production of imported fertilisers and fodder lie outside the system limits of national climate reporting. They are attributed according to the international guidelines on countries of origin.

In total, the greenhouse gas emissions from agriculture stood at 7.3 million tonnes of CO_2eq in 2018 which is around 1.1 million tonnes of CO_2eq or just under 13 per cent below the level in 1990. The development of emissions reflects the changes in the cattle population and the use of nitrogen-based fertilisers. Emissions have stagnated since the 2000s. Since 2007, they have not been on the pathway defined in the Climate Strategy for Agriculture which provides for a linear reduction from one to two-thirds by 2050 compared with 1990.[49] The indicative minimum target – according to the Climate Strategy for Agriculture – for 2020 (around 7 million tonnes of CO_2eq or a reduction by a sixth compared with 1990) is likely to be missed.

Figure *21* shows the development of emissions in agriculture since 1990, broken down by individual sub-categories. The methane emissions from the digestive process in livestock account for the greatest share at around 45 per cent. The nitrous oxide emissions from soil management makes up 20 per cent and the methane and nitrous oxide emissions from manure storage around 16 per cent.

Livestock farming is very significant in Switzerland. Around 70 per cent of land used for agricultural purposes is managed as pastureland and converted into food through ruminant animals. Animal fodder is grown on around 60 per cent of arable land and the imported animal fodder requires another approximately 250,000 hectares of arable land abroad. Finally, around half of the food produced in Switzerland

[49] FOAG (2011).

comes from animal production. Animal production accounts for over 85 per cent of agricultural greenhouse gas emissions.[50]

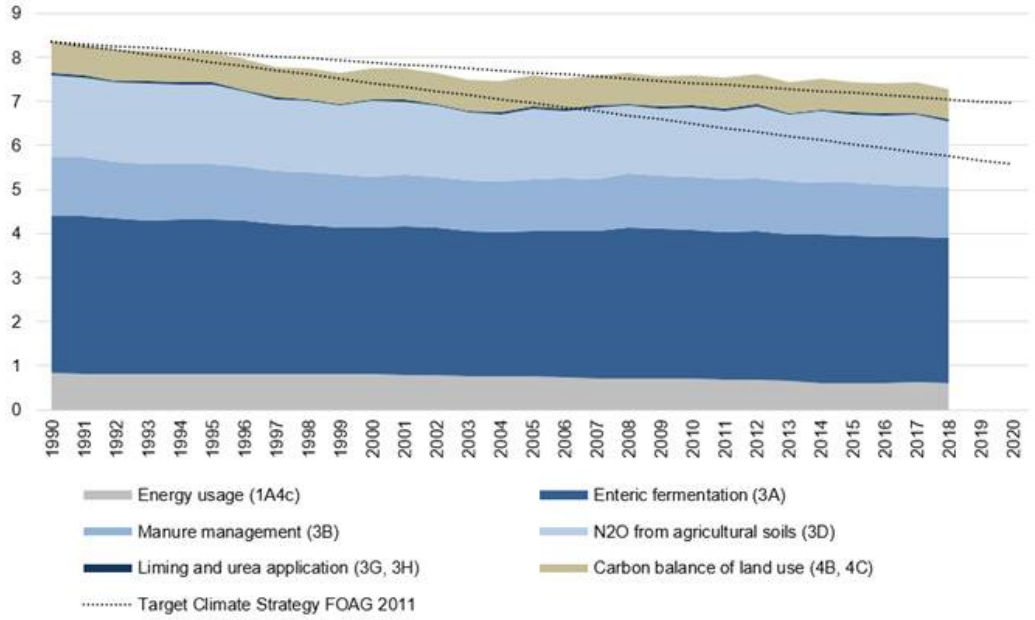

Figure 21: Development of emissions from agriculture in millions of tonnes of CO_2eq by sub-categories according to the national greenhouse gas inventory and the target pathways of the Climate Strategy for Agriculture (dotted lines). Source: Switzerland's greenhouse gas inventory (FOEN 2020)

The greenhouse gas inventory covers the emissions generated by agricultural production in Switzerland to the point of leaving the farm. However, emissions are then also generated downstream in the processing, sales and consumption of food. These emissions are attributed to the industry or services sector. A large proportion of food is also imported. The greenhouse gas footprint provides a more comprehensive evaluation of the domestic consumption of food as this also includes the downstream and import-related emissions. In 2018, the footprint of households for the emission item food – according to the overall environmental analysis of the Federal Statistical Office – stood at 15.6 million tonnes of CO_2eq[51]. This equates to around two tonnes of CO_2eq per person. This also includes food waste. The import-related emissions account for a share of 68 per cent.

Key elements of agricultural policy are border controls, direct payments and the evidence of ecological performance requirements (ÖLN). In the agriculture and food sector, the following climate-relevant instruments are in force or being planned:

- The funding of research and advisory projects enables the decision-making basis for agricultural policy to be established and support to be provided for agricultural businesses with implementation of scientific findings in practice. In addition to various research projects, the Swiss Confederation has also supported the 'AgroCleanTech' association with setting up a platform to provide information and exchange knowledge on energy and climate protection.
- The co-funding of projects as part of the resources programme enables new paths to be forged to improve resource efficiency in agriculture. Two resources projects have been running in the field of climate protection since 2016: a measures-based points system for greater climate protection on farming businesses is being created and applied as part of the IP-Suisse project. The Flaachtal project of the 'AgroCO2ncept' association aims to harness the specific optimisation potential on individual farms through operational greenhouse gas assessments and targeted advisory services.
- By promoting quality, innovative projects can foster the improvement of the quality and sustainability of Swiss agricultural products. Opportunities for contributing to the reduction of greenhouse gas emissions also exist in sales promotion, the water protection programme, rural development, structural improvements, livestock farming and crop cultivation. Larger farms can obtain an exemption

[50] Bretscher / Ammann / Wüst / Nyfeler / Felder (2018)

[51] Federal Statistical Office, overall environmental analysis, https://www.bfs.admin.ch/bfs/en/home/statistics/territory-environment/environmental-accounting/air-emissions.html.

from the CO_2 duty on fossil fuels if they in return commit to a reduction obligation with the Swiss Confederation. Some farms using greenhouse production and processing companies are already taking advantage of this option.

- Manufacturers and importers of fossil fuels are obliged to offset some of the CO_2 emissions from transport by supporting Swiss projects aimed at emissions reduction. Several biogas plants and the use of a specific fertiliser have been registered as compensatory projects in agriculture so far.

The message on the complete revision of the CO_2 Act for the post-2020 period indicated that a sectoral target on emissions reduction is also provided for in agriculture.[52] The Federal Council used the target of the Climate Strategy for Agriculture and proposed a reduction contribution of 20 to 25 per cent by 2030 compared to the base year of 1990. The target is primarily to be achieved through measures based on agricultural legislation. According to the message on the development of agricultural policy after 2022 (AP22+), agriculture should reduce its greenhouse gas emissions by 10 per cent by 2025 compared with 2015 in an interim stage. This represents a reduction by 19 per cent compared with 1990 and is also in line with the minimum target of the Climate Strategy for Agriculture. The interim target is to be achieved through additional requirements and incentives relating to evidence of environmental performance, direct payments and structural improvements as well as through pilot projects and networks.

- With regard to evidence of environmental performance, the tolerance limit of 10 per cent and any other allowance options in the nutrient balance are to be abolished. Distributors of nutrients in the form of fertilisers and fodder also undertake to disclose their deliveries to agricultural businesses.
- In relation to direct payments, production system contributions are planned to limit the input of raw protein into ruminant fodder, to ensure a longer period of use for cows, to reduce ammonia in livestock farming, to improve the efficiency of the use of nitrogen in crop cultivation and in special crops, to promote humus formation and soil fertility and to establish agroforestry systems. A reduction in the use of fossil energies is also provided for. The replacement of fossil-fuel-operated machinery should be facilitated through (optional) investment loans and the use of alternative machinery should (for a limited period) also be supported with production system contributions. Contributions should also be paid to promote locally adapted agriculture based on regional agricultural strategies. The Swiss Confederation should also provide investment support for innovative technologies to reduce negative environmental impacts.
- Pilot and demonstration projects, which contribute towards forming networks between research, education and advisory services, on one hand, and practical application in the agriculture and food sectors, on the other, will receive financial support. The same applies to networks of excellence and innovation for crop cultivation, livestock farming, livestock/animal health and animal welfare. Livestock farming legislation should also be amended so that environmental impacts are included in the assessment of state support.

Swiss agriculture should also make a major contribution to the food supply of the Swiss population in 2050. Food production results in emissions which cannot be completely avoided. According to the scientific information currently available, a halving of emissions in Swiss agriculture is possible by 2050 compared with 1990 while also achieving a higher level of self-sufficiency – provided the reduction potential in the food industry is also systematically harnessed. The food-related emissions could even be reduced overall by three-quarters per person a year compared to the current level, i.e. from 2 to 0.5 tonnes of CO_2eq.

Figure 22 shows the possible contributions from sets of measures in an ideal scenario from a current perspective based on their reduction potential by 2050. The graphic shows greenhouse gas emissions of agriculture in absolute terms (production perspective based on the territorial principle according to the greenhouse gas inventory; left) and the greenhouse gas footprint of food per person (consumption perspective including emissions abroad from imports and excluding domestic emissions of exports according to the overall environmental analysis; right).

[52] Message on the complete revision of the CO_2 Act post-2020, Federal Gazette 2018 247.

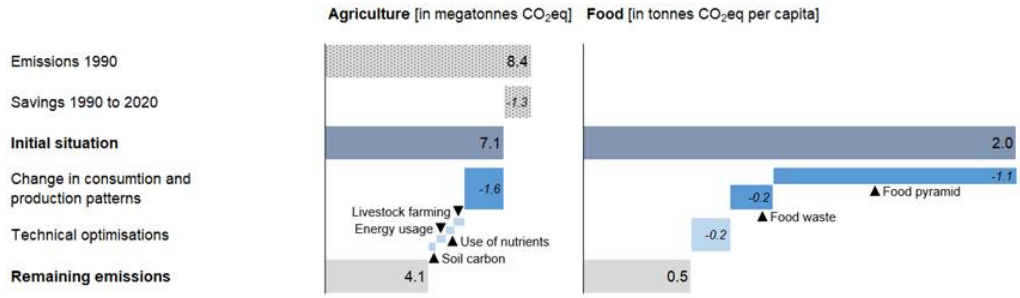

Figure 22: Greenhouse gas emissions and reduction potential by 2050 in agriculture and food from production and consumption perspectives according to the greenhouse gas inventory and the overall environmental analysis.

The greatest reduction contribution results from a change to consumption and production patterns. Establishing suitable framework conditions could more than halve this sector's greenhouse gas footprint as well as other negative environmental impacts. Combined with the complete avoidance of food waste in households, a reduction of 66 per cent in total could actually be achieved.[53]

On the production side, the use of space changes: whereas pastureland can still largely be used for dairy cattle farming, arable farmland is used for food production where possible and feasible. This could cut Switzerland's agricultural greenhouse gas emissions by a fifth compared to the current level.[54]

The emissions in agriculture and food production could also be further reduced through technical optimisations. In agricultural production this involves efficiency improvements in herd management and fodder (livestock farming), low-loss fertiliser management (nutrient management), maintaining the carbon stocks in moor soils (soil carbon) and the complete replacement of fossil heating and motor fuels with renewable energy sources (energy use). The latter also concerns the downstream sectors of processing and retail.

Around 4.1 million tonnes of CO_2eq from domestic agricultural production will remain by 2050 which cannot be avoided under the assumptions made based on the information currently available. This remaining amount must be balanced with negative emissions. It is unclear to what extent a further reduction or compensation of these emissions through a permanent increase in the carbon stocks in agricultural soil and biomass (for example, through humus formation, biochar and agroforestry) would be possible.

The greenhouse gas emissions generated by agricultural production are predominantly related to biological and biophysical processes and come from diffuse sources or sources that fluctuate significantly in terms of time and space. The various business operations also differ greatly. This makes it difficult to develop generally applicable and simple measures and to assess greenhouse gas emissions accurately at the level of the individual agricultural businesses. On one hand, there is substantial need for research and data evaluation. On the other, the major emissions drivers have long been identified and are undisputed. Research and digitalisation must be stepped up without holding back or preventing the simultaneous realisation of the identified and undisputed reduction potential.

Conflicting priorities can arise between a strategy focused on climate protection and a comprehensive sustainability strategy. In Switzerland 'the land of pasture', grass-fed ruminants play a major role, while the greenhouse-gas footprint of this form of production and the products made in this way should not be overlooked. Similar conflicting priorities are also apparent between soil cultivation and the use of herbicides. In a first step, the existing conflicting priorities should be made transparent and then resolved as far as possible. Balanced solutions should be aimed at.

8.6 Financial market sector

For the time horizon 2050, Switzerland is pursuing the following objective in the financial sector to achieve the overarching net-zero target on greenhouse gas emissions:

[53] Zimmermann / Nemecek / Waldvogel (2017).

[54] Bretscher / Ammann / Wüst / Nyfeler / Felder (2018).

2050 target: Switzerland's financial flows are to be made consistent with a pathway towards low greenhouse gas emissions and climate-resilient development by 2050 in accordance with the target of the Paris Agreement.

Article 2.1c of the Paris Agreement provides for the goal of: "Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development." In theory, establishing a climate-compatible real economy for the financial markets would be the most efficient way of achieving the net-zero target. This would mean investment and finance being automatically geared towards this objective. However, in view of this issue becoming much more urgent and the difficulty of achieving global internalisation in pragmatic political terms, the international community has agreed that the financial market should also play a proactive role in the transition to a climate-compatible global economy. By ratifying the Paris Agreement, Switzerland undertook to make financial flows compatible with climate goals. The objective has now also been enshrined in the revised CO_2 Act's purpose article. The financial sector plays a key role in achieving the climate goals and the fundamental and rapid changes to the global economy required to attain the net-zero target by 2050.

Accounting for over 9 per cent of GDP, the financial sector is a key part of the Swiss economy. It covers insurance companies, pension institutions and foundations on one hand. These are institutional investors which possess or manage significant assets (asset owners). The Swiss National Bank (SNB) also has assets of a similar volume to the pension institutions which it manages as part of its monetary policy mandate. Other key players on the Swiss financial market are intermediaries which advise institutional and private clients and manage their assets (asset managers). These include banks, fund management companies and investment firms. Other actors, which can have a climate-relevant impact on the financial market players previously mentioned, are consultancy firms, (foreign) credit rating agencies and stock exchanges.

The various financial market actors are closely interlinked with one another, but also with sectors in the real economy, such as buildings, industry and transport – in particular via the domestic mortgage and lending market and investments in Swiss and foreign companies. On one hand, the general global conditions for the real economy and the inherent price signals influence the activities and risk assessments of financial market actors. On the other, the various financial market actors create incentives – through advisory services, products/services or conditions – for companies and households which have a range of impacts from a climate perspective. Through their investment and financing decisions, dialogue with companies and political activities, they also influence climate-relevant developments in the real economy. The more aware financial market actors are about the climate impact of investment and financing activities and the more transparent and comparable their reporting on the relevant decisions and products/services is, the better the decision-making basis for customers, insured parties, politicians and supervisory authorities.

Thus far investors have not primarily focused on the impact they could have on containing climate change, but instead on the impact that climate change or its containment could have on their assets (climate risks for investors). This is also confirmed by an expert opinion by FOEN. It shows that financial market actors already take account of material risks – including climate risks – today in accordance with the legal provisions and are obliged to report on them. However, in contrast to risk analyses, reporting on the short and long-term climate impacts of investment and financing decisions are currently not explicitly required in any part of the applicable financial market legislation.[55]

Supervisory authorities and central banks are increasingly focusing on the various risks. This is helping to raise awareness amongst financial market actors about the importance of the issue. However, it cannot be assumed that financial market actors will take climate-relevant measures based on risk analyses, i.e. measures that contribute to containing climate change and the transition to a low-emissions age.

The existing findings indicate that investments on the Swiss financial market do not support the climate goals sufficiently.[56] This reflects the fact that the global economy is not on course to meet the obligations of the Paris Agreement. This means the financial market actors are still currently investing too heavily in companies that plan or promote an expansion of the production of CO_2-intensive technologies (gas-fired plants, the transportation of oil and gas, petrol and diesel vehicles etc.). Global investments in low-

[55] Eggen / Stengel (2019).

[56] 2°Investing Initiative / Wüest Partner (2020).

CO_2 alternatives, such as renewable energies or vehicles using alternative drive systems, have not yet increased sufficiently either. A similar picture emerges amongst the lenders on the Swiss financial market at global level.[57] In this area too, the climate impacts are comparable with those of listed companies on the global market which is not in line with the goal of the Paris Agreement.

Institutional investors have large portions of their assets invested in the Swiss real estate market. Through energy-efficient renovations and the replacement of fossil-fuel heating systems with alternatives using renewable energy supply, institutional investors can have a direct impact on the development of emissions in the buildings sector. Examples from Switzerland and abroad show that returns for investors can be improved with low expenditure, depending on the circumstances, through renovation measures in the case of existing buildings with an average to low energy standard.[58] In the 2020 climate compatibility test, pension funds indicated that they are carrying out conversion from fossil energy to renewable heating systems for 30 per cent of their buildings. Overall, 70 per cent of the buildings tested were still heated with oil and gas, while the figure was as high as around 80 per cent for mortgaged properties.[59]

Financial consultants and asset managers have the opportunity to systematically survey the climate and environmental goals of their institutional and private customers and to incorporate them into investment advice and portfolio management. Studies from the EU nevertheless indicate that most asset managers barely take account of climate criteria and risks during financial consultancy, but instead focus on financial criteria.[60] A third of the institutions surveyed in the 2020 climate alignment test indicated that they take account of their customers' climate and sustainability objectives. However, only five per cent regularly address the issue of their own accord. Most only survey their customers when they request it.

Investment trends are undergoing change. The financial markets can actively support this process. The results of the 2020 climate alignment test show that there are significant differences both between asset classes and between the portfolios of the individual financial institutions. The number of actors that see opportunities in actively supporting the transition towards net zero is also continually increasing. Two-thirds of participants in the 2020 climate alignment test said that they were pursuing a climate strategy. Improvements are nevertheless required to ensure these strategies make an impact and that customers are sufficiently well informed about the climate risks and effects of their investments. For example, more than half of the institutions – which indicate that they exclude coal from their investments – still hold equities and bonds of companies that mine coal or produce coal-based electricity.[61]

In the financial sector, the following climate policy instruments are in force or are being planned:

- *Increasing individual responsibility:* the revised CO_2 Act is relying on the individual responsibility of the sector for the time being for the period 2021–30. The financial market actors should work to make financial flows compatible with climate-resilient development through voluntary measures. The Swiss Confederation lays the foundations and provides support, regularly measures progress (the next climate compatibility test is scheduled for 2022) and assesses further options and incentives if insufficient impact is being achieved.
- *Transparency and dialogue*: The broad-based and representative participation in the voluntary climate compatibility tests in 2017 and 2020 shows that more attention is being paid to the issue of climate impact. The Federal Council has given the administration the task of assessing whether there is need for regulatory action in the areas of transparency, fiduciary obligations and risk.[62] It also discussed these matters in the report "Sustainability in Switzerland's financial sector – Situation analysis and positioning with a focus on environmental aspects".[63] As a result, the State Secretariat for International Financial Matters (SIF) has stepped up – in close cooperation the FOEN as well as

[57] Banktrack (2018).

[58] See for example https://www.copenhageneconomics.com/publications/publication/do-homes-with-better-energy-efficiency-ratings-have-higher-house-prices-econometric-approach;

[59] 2°Investing Initiative / Wüest Partner (2020).

[60] European Commission (2016) and 2° Investing Initiative (2017).

[61] 2°Investing Initiative / Wüest Partner (2020).

[62] Federal Council press release of 6.12.2019, can be viewed at https://www.admin.ch/gov/en/start/documentation/media-releases.msg-id-77424.html

[63] Federal Council (2020).

SECO and the FDFA – discussions with the sector as well as international activities related to this issue.

- *Development of approaches:* The Federal Council wishes to increasingly work towards industry agreements with the financial market actors in future.[64] A postulate submitted by the Council of States in autumn 2019 calls upon the Federal Council to outline – based on the results of the climate compatibility tests – how Switzerland can make its financial flows compatible with climate-compatible goals and to propose suitable measures.[65] In its responses to various parliamentary procedural requests, the Federal Council has underlined in the past that it regularly assesses the climate impact of the efforts made as part of individual responsibility and, on this basis, evaluates whether further steps are advisable.

The European Union launched a comprehensive action plan to fund sustainable growth in 2018 and has adopted various regulations in this regard.[66] A renewed 2020 Strategy aims to strengthen the aspects of both risks and impact and to mobilise more private funds for the 'European Green Deal'.[67] As many Swiss financial market actors also sell financial products in the EU, EU regulations are also highly relevant for Switzerland.

The investments and financial assets, loans, mortgages, consultations and products of the Swiss financial market actors should support the transition to a climate-compatible national and global economy and contribute to the net-zero target of the real economy sectors overall and their adaptation to climate change by 2050. This means avoiding new investments in fossil energies and their financing medium-term. The financial market can also play a key role in the penetration of alternative technologies and renewable energies and achieving a reduction in the emissions of its real estate portfolios in line with targets as quickly as possible.

The more transparently, consistently and comparably financial market actors explain the climate impacts of their products and corporate strategies to their customers and insured parties, the better they will be able to manage them according to their sustainability preferences. To ensure financial consultants and asset managers disclose comparable information on climate impacts proactively and comprehensively, in-depth and broad-based training and education and the development of the existing information on the climate impacts of financial flows are required. Efforts to create an eco-friendly image without legitimate grounds, which is known as greenwashing, can be counteracted through reliable indicators and standards. Today there is still no standard definition of when a financial product is classified as climate compatible or not. The Swiss Confederation nevertheless provides free, comparable and targeted climate compatibility tests on a regular basis. This tool is being continually improved and is coordinated internationally.[68] Participation in these tests, which is as representative as possible, enables progress or shortfalls to be highlighted. Such monitoring but also minimum requirements, provisions and standards can support market transparency and help to avoid greenwashing. Switzerland's approach is based on international standards and developments.

A challenge for climate-compatible investment is the various time horizons. Whereas investment and supervisory decisions and financial incentive systems are geared to the short term today (months to a few years), a long-term horizon is required to take account of climate risks and effects. Some European supervisory authorities are therefore discussing to what extent this can be corrected and climate risks can be tackled more effectively by means of taxation or equity or solvency requirements. One option would be financial incentives for more climate-compatible investment and financing decisions. Accordingly aligned, climate-optimised price signals from the global real economy – in other words CO_2 prices which internalise the external costs of climate change – would simplify the efforts of the financial market.

The EU is also increasingly assessing, as mentioned above, regulatory approaches that go beyond purely voluntary measures. It wishes to put the entire financial market on course to meet the target. The

[64] Federal Council press release of 26.6.2019, can be viewed at https://www.admin.ch/gov/en/start/documentation/media-releases.msg-id-75599.html.

[65] 19.3966 ESPEC-S postulate: Klimaverträgliche Ausrichtung und Verstärkung der Transparenz der Finanzmittelflüsse in Umsetzung des Übereinkommens von Paris (Climate-compatible alignment and strengthening of the transparency of financial flows as part of the implementation of the Paris Agreement).

[66] European Commission (2018).

[67] See https://ec.europa.eu/info/consultations/finance-2020-sustainable-finance-strategy_en

[68] See https://www.transitionmonitor.com

Swiss Confederation welcomes the current initiatives based on individual responsibility of various industry associations and continues to regularly monitor progress. It will continue the preliminary work already started, especially the climate compatibility tests, and will monitor the impact of the new provisions of the completely revised CO_2 Act on assessing climate-related financial risks. Depending on the progress made by 2030, new, significantly more effective approaches may also be required in Switzerland, for example in the regulatory environment and in training and education. This may be based on research results on the effectiveness of measures and the experiences of particularly advanced representatives at institutional and sectoral level.

8.7 Waste sector

The waste sector (category 5 of the greenhouse gas inventory) covers non-energy waste treatment in landfill sites and wastewater purification plants as well as through biological recycling. The thermal recycling of waste in incinerators and special-waste incineration plants falls under energy conversion and therefore the industry sector (see Section 8.2). As Figure *23* shows, the emissions from landfill sites and wastewater purification are most relevant. The former have declined steeply since 1990 which has in turn led to a fall in emissions in the sector as a whole. Emissions from wastewater treatment have risen slightly since 1990, partly due to population growth. However, there is an element of uncertainty about the level of these emissions. A research project conducted by the Swiss Federal Institute of Aquatic Science and Technology (EAWAG) provides grounds to assume that emissions from wastewater treatment plants may be three times higher than previously assumed.[69] The contributions from the other categories are negligible. In total, emissions from the waste sector amounted to over 670,000 tonnes of CO_2eq in 2018, which is around 37 per cent below the level of 1990.

The depositing of combustible waste in landfill sites has been banned in Switzerland since 1 January 2000. No such waste has been deposited in landfill sites since this date. The future development of landfill emissions can be projected relatively easily using models. These projections indicate that emissions will fall to around 60,000 tonnes of CO_2eq by 2050. The scope for technical reduction is limited and is largely already being implemented, in particular through a programme as part of the compensation obligation for fuel importers.

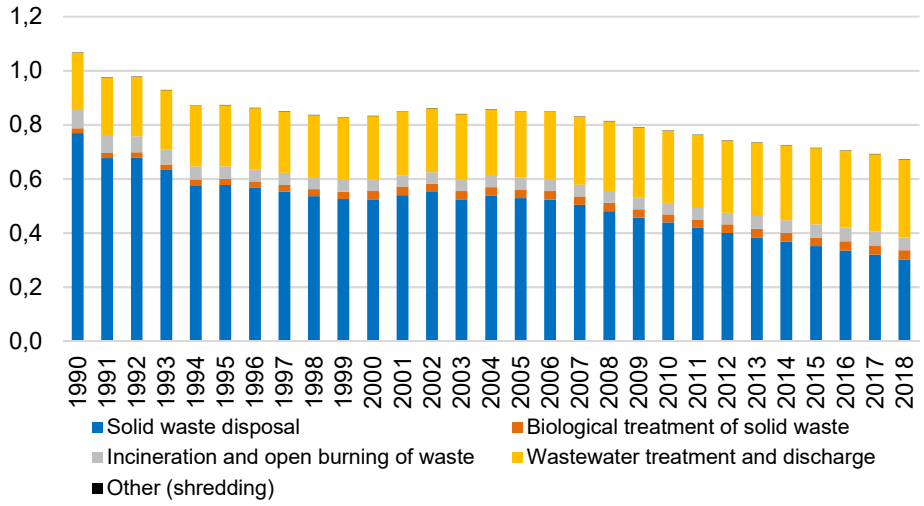

Figure 23: Emissions from the waste sector from 1990 to 2018 in million tonnes of CO_2eq. Source: Switzerland's greenhouse gas inventory (FOEN 2020)

The forecast shows emissions from wastewater treatment plants develops in line with population growth. This estimate is quite conservative and reflects the fact that the level of understanding of the impact of potential reduction measures (e.g. reduction of methane emissions by covering sludge tanks, reducing nitrous oxide emissions from biological purification through increased nitrogen elimination) is currently still quite low. The time series may also need to be corrected upwards based on the new findings indicated. The other components may also remain at around the current level long-term. Total emissions from the waste sector may still stand at around 500,000 tonnes of CO_2eq by 2050.

[69] EAWAG (2018)

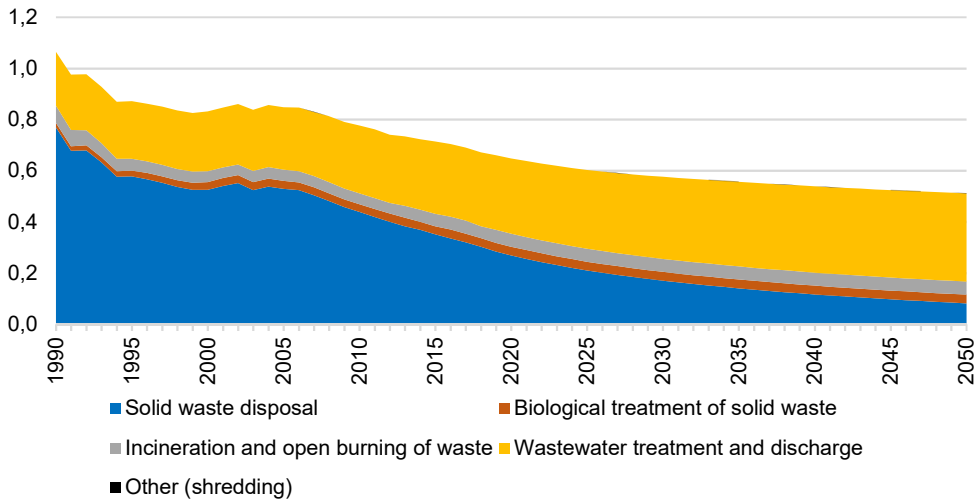

Figure 24: Possible emissions development in the waste sector by 2050 in million tonnes of CO_2eq

8.8 Synthetic gases

The synthetic gases (known as 'F gases', category 2 of the greenhouse gas inventory, excluding CO_2, CH_4, N_2O) include the emissions from hydrofluorocarbons (HFC), perfluorocarbons (PFC), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). HFC and PFC are mainly found in refrigerants and in foam materials for heat insulation. SF_6 is used, for example, as an insulation gas in electrical switching systems and NF_3 in the manufacture of flatscreen TVs and solar cells.

The F gases are classified as substances stable in the atmosphere in the Chemical Risk Reduction Ordinance. Here their use is restricted to applications for which there is currently no alternative and is set to be restricted further in future. The HFCs are covered by an international agreement signed by the international community at the 28th Meeting of the Parties to the Montreal Protocol held in Kigali in 2016. It provides for the gradual, comprehensive avoidance of use of this substance (Kigali Amendment). Switzerland ratified the Kigali Amendment in November 2018 and is implementing its provisions. Switzerland can also provide for further measures if alternative technologies are available.

In addition to the legal requirements, the compensation programmes also contribute towards reducing refrigerant-based emissions. In industrial and commercial applications, these programmes reduce the number of stationary cooling systems which are operated with refrigerants that are particularly harmful to the climate. Depending on the situation, this reduction is achieved through one of three measures. Firstly, these programmes promote the replacement of still functional systems operated with HFCKW or HFKW refrigerants with systems operated with natural refrigerants (early replacement).[70] Secondly, they aim to replace HFKW refrigerants that are particularly harmful to the climate with less harmful synthetic ones (drop-in). Thirdly, they support the new development of small commercial cooling systems which can be operated with natural refrigerants instead of HFKW.

For SF_6 an industry agreement exists in Switzerland between the FOEN and the operators of electrical switching devices and systems as well as particle accelerators which defines the reduction targets for SF_6 emissions. The scenarios therefore assume that the emissions of F gases will decline long-term. No more than around 0.3 million tonnes of CO_2eq should remain by 2050.

[70] HCFC: hydrochlorofluorocarbons; HFC: hydrofluorocarbons.

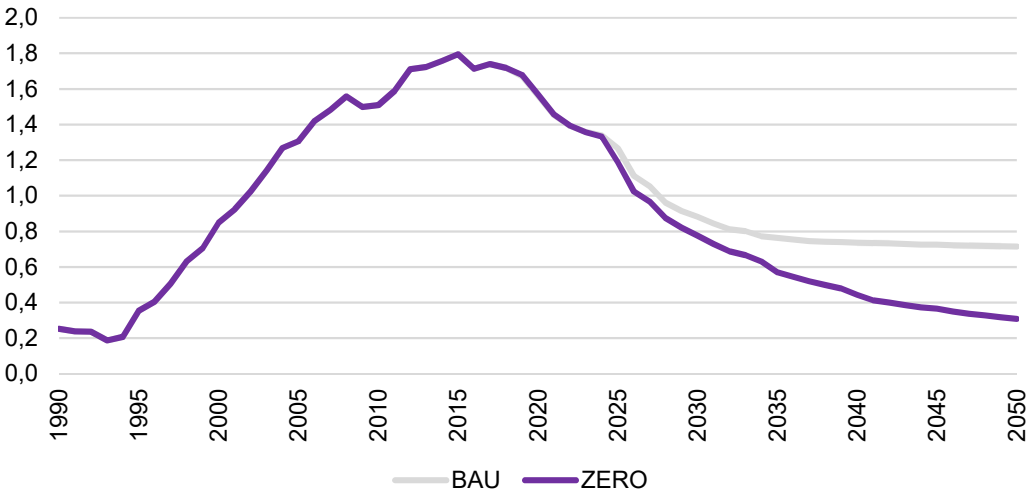

Figure 25: Possible development of emissions from the use of F gases in million tonnes of CO_2eq

8.9 Negative emissions technologies

For the 2050 time horizon, Switzerland is pursuing the following objective in relation to negative emissions technologies (NET) as a contribution to the attainment of the overarching net-zero target for greenhouse gas emissions:

2050 target: Switzerland's greenhouse gas emissions that are technically difficult to prevent and which are still occurring in 2050 will be completely balanced by means of biological and technical sinks by removing CO_2 from the atmosphere and storing it permanently, securely and sustainably (negative emissions).

Reducing greenhouse gas emissions to net zero requires the use of negative emissions technologies (NET).[71] NET remove CO_2 from the atmosphere using biological and technical methods and store it permanently. NET must remove the emissions remaining in 2050 which cannot be eliminated through measures to prevent or reduce them. This means they must remove at least as many tonnes of CO_2eq from the atmosphere as the remaining emissions still being generated. Only then will the emissions actually reach the net-zero target.

The Federal Council outlined its view in its report of 2 September 2020 in response to a postulate on the possible role of NET in Swiss climate policy.[72] It relies heavily on a report by the 'Risiko-Dialog' foundation and underlines that NETs are not a substitute for the priority and comprehensive reduction of greenhouse gas emissions.[73] Emissions-free alternatives are already available today in the buildings, transport and industry sectors. The potential for reducing emissions must therefore be fully harnessed in these sectors by 2050 so that they do not generate any greenhouse gas emissions as far as possible. The other, non-energy-related greenhouse gas emissions in agriculture, in the waste sector, from cement production and from the use of solvents and refrigerants should be reduced as far as possible.

NET should be regarded as a complementary element to emissions reduction. However, they should only be used for emissions that are difficult to avoid owing to limited domestic storage potential, the required transport of removed CO_2 over sometimes long distances, the current high costs involved, the potential risks, the concerns over acceptance by the public and the uncertainty over further technological development. In order for them to perform this role over the medium to long-term, suitable framework conditions must be established in good time both at national and international level. The research, development and implementation of all possible methods should be rapidly driven forward.

NET is a collective term for various approaches which aim to remove CO_2 from the atmosphere and store it permanently. In general terms, it can be divided into natural and technical methods. The natural methods remove CO_2 through photosynthesis. It is stored either directly in biomass or in the ground, in the sea or – in the case of combination with CCS – in geological underground disposal sites (bioenergy

[71] In international climate policy the term carbon dioxide removal (CDR) is increasingly being used to indicate negative emissions technologies (NET). The two terms are equally valid.
[72] Federal Council (2020).
[73] 'Risiko-Dialog' Foundation (2019).

carbon capture and storage BECCS). The technical approaches are based on chemical processes. CO_2 can be removed from ambient air by means of air filtration and the removed CO_2 can then also be stored underground (DACCS). Minerals can also remove CO_2 from the air and permanently store it chemically (enhanced weathering). Figure 26 provides an overview of the methods.

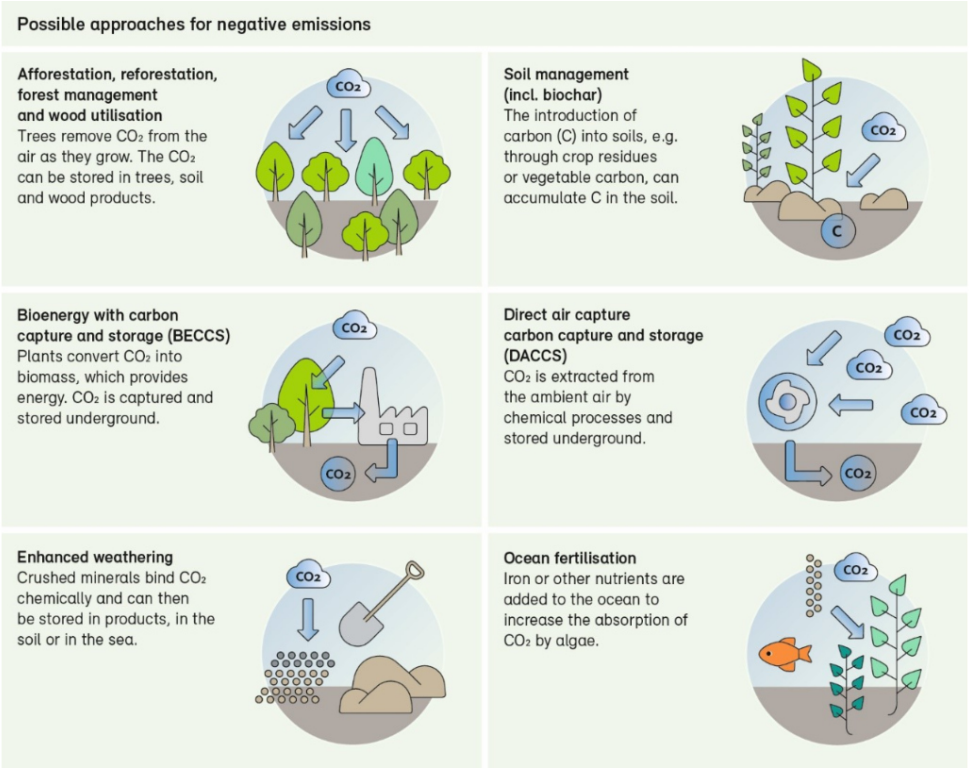

Figure 26: Negative emissions approaches. Source: FOEN graphic based on Mercator Research Institute on Global Commons and Climate Change MCC.

A key requirement for all NET is the permanent storage of the removed CO_2 as far as possible for several decades, or ideally centuries. This requirement is met in the case of storage in geological underground disposal sites. Secure storage of at least several thousand years can be assumed here. For permanent storage, the natural approaches require continuous, targeted management. Even then there is the risk, particularly with storage in biomass, that the CO_2 captured will be released again. This could happen, for example, in the event of extensive forest fires. The potential of natural approaches – depending on the method – could be exhausted within a few decades if the natural sinks reach saturation point.

The potential of the individual approaches for application in Switzerland and the costs and risks involved have only partially been established to date and are being explored as part of current research. Initial findings indicate that (re)forestation is likely to play a subordinate role in view of the limited space available. The Swiss forests can continue to act as a CO_2 sink if targeted forestry management measures are implemented. The long-lasting use of wood, for example in buildings, with subsequent energy usage could store CO_2 for a period and also replace CO_2-intensive materials (such as cement) and energy sources. Approaches in the field of soil management and the storage of biochar offer potential – depending on the method – which could be used sustainably. The same applies to bioenergy usage with CO_2 removal and storage (BECCS). Incinerators could play a role here as a significant share (currently around 50 per cent) of the CO_2 emitted during the burning of waste is of biogenic origin. This approach as well as machine-based CO_2 air filtration and storage (DACCS) are limited due to Switzerland's geological storage potential. Only rough estimates currently exist as the geological substructure has not been explored for this purpose. It can be assumed that there is capacity available at least for several decades provided such geological CO_2 storage sites can be successfully developed. Switzerland is likely to also be dependent on access to storage sites abroad.

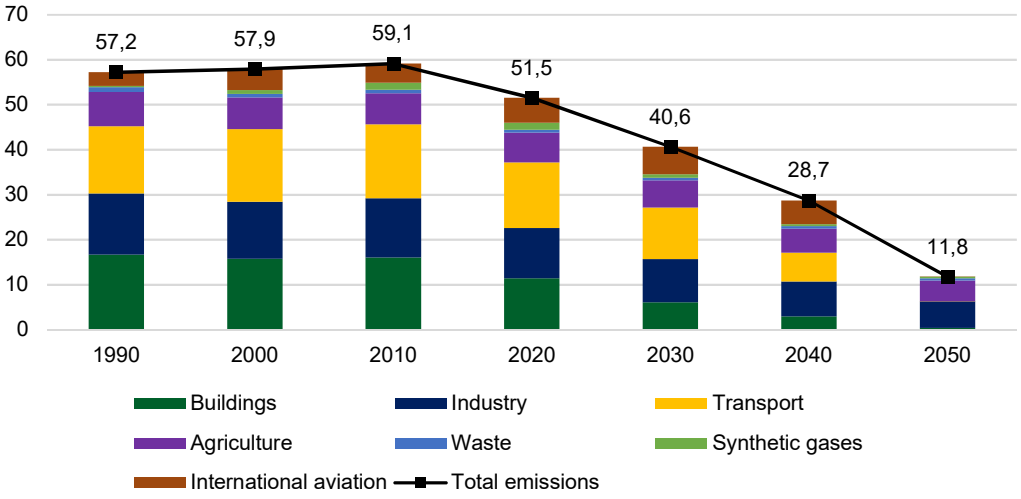

Figure 27: Development of emissions by 2050 by sectors in million tonnes of CO_2eq according to ZERO basis scenario of EP 2050+, including international aviation. Source: Own graphic based on Prognos/TEP Energy/Infras/Ecoplan 2020.

The use of NETs has an impact on other environmental and policy areas, for example land use, spatial planning and energy consumption. This means they must be deployed in agreement with these areas. Their use should also be based on recognised sustainability criteria and take account of the environmental, economic and social dimensions in an appropriate way.

The section on the individual sectors has shown the extent to which greenhouse gas emissions can be reduced by 2050. Technically difficult or unavoidable remaining emissions will continue to exist mainly in industry (cement production, incineration and the chemical industry), in agriculture and, to a lesser extent, in the households, services, transport, waste, synthetic gases and other sectors. Figure 27 shows the development of greenhouse gas emissions to 2050 by sectors. Around 11.8 million tonnes of CO_2eq will remain by 2050.

To eliminate the remaining emissions and to create negative emissions long-term, the use of CCS and negative emissions technology is required. The following scenarios are conceivable:

- The remaining emissions from cement production (around 2.4 million tonnes of CO_2eq in 2050) can largely be reduced with CCS.[74] CCS can also make a contribution in some other industrial sectors, particularly the chemicals and pharmaceutical sector.
- Around four million tonnes of CO_2eq of residual emissions may remain from incineration in 2050. CCS can also be used in incinerators. As some of the burned waste is of biogenic origin, negative emissions can be generated with the biogenic share. The biogenic share currently stands at around 50 per cent. This may decline long-term as biomass is also increasingly attractive for other applications. The EP2050+ assumes that around 1.5 million tonnes of CO_2eq (or over 37 per cent) will be of biogenic origin by 2050. The remaining 2.5 million tonnes of CO_2eq is fossil-based. Storage capacity is in turn required for the total emissions removed of around 3.6 million tonnes of CO_2eq (at a capture rate of 90 per cent).
- The emissions from international aviation are difficult to forecast. The EP2050+ assumes that a complete conversion to synthetic fuels is technically and economically possible by 2050. This means CO_2 emissions in 2050 would stand at almost zero. In view of the limited potential and uncertain economic viability of synthetic fuels, this forecast is deemed optimistic from a current perspective, but is nevertheless used as a basis below. If there are still emissions remaining in 2050, the need for NET would increase accordingly. The same would also apply for other climate effects if they were included in the net-zero target.
- The remaining emissions of 6.9 million tonnes of CO_2, most of which are accounted for by agriculture, must be balanced to achieve the net-zero target. Various options could be considered. Around 1.5 million tonnes of CO_2eq could be covered by the biogenic share of the incinerated waste. Further

[74] A capture rate of around 90 per cent is assumed. This means around 0.2 million tonnes remain from cement production.

potential exists in land management, the use of wood and the application of biochar as well as in the areas of DACCS, BECCS and in the enhanced weathering of minerals (cement). These estimates should be viewed with caution. The potential for DACCS and BECCS in Switzerland is still unclear. Restrictive factors are the high energy usage, possible conflicting priorities over the use of biomass, the currently still high costs and the limited storage capacity.

- It is uncertain whether the domestic potential will be sufficient to fully meet the requirement for negative emissions. Switzerland is also likely to have to rely on negative emissions abroad.

Table 2 shows the remaining emissions in 2050 and possible approaches to avoid or remove them using NET. Geological storage capacity is required for CO_2 emissions that are captured directly at an emissions source (cement factory, incinerator) or directly from the atmosphere. The carbon-neutral recycling of CO_2 represents a good approach on the path towards the net-zero target, depending on the application scenario, if the CO_2 comes from biogenic sources or directly from the atmosphere. However, only the permanent removal from the atmosphere is compatible with the net-zero target long-term. The extent of the potential in Switzerland for geological CO_2 sinks has not yet been conclusively established. A study carried out in 2010 estimated the theoretical geological storage potential at around 2.7 billion tonnes of CO_2[75] in total. This equates to just under 60 times Switzerland's current annual greenhouse gas emissions. Annual storage capacities of at least five million tonnes of CO_2 would be required by 2050; and even more if CCS is used in the production of biochar and/or DACCS. The current major uncertainty over the level and location of geological storage potential can only be reduced through prospection and exploration strategies. Heating supply based on geothermal technology would also benefit from such strategies. Better knowledge about the geological substructure is also urgently required for geothermal technology.[76]

Emissions source	**Emissions in 2050**	**Avoidance through CCS**	**NET requirement**
Cement production	2.4	2.2	0.2
Waste incineration (fossil-based share)	2.6	2.3	0.3
Further industrial sectors	1.2	0.6	0.6
Agriculture	4.6 (4.1-5.0)		4.6
Synthetic gases	0.3		0.3
Waste (landfill sites)	0.5		0.5
Transport	0.0		0.0
Buildings	0.4		0.4
Other	0.01		0.01
Total	**11.8**	**5.1**	**6.8**
Negative emissions – incineration plants			-1.3
Other NET (e.g. biochar, capture of pyrolysis emissions, BECCS, DACCS, abroad)			-5.5
2050 target			**0.0**

Table 2: Possible remaining emissions in 2050 and approaches to avoid or offset them according to the ZERO basis scenario of EP 2050+ (figures in million tonnes of CO_2eq). Source: Prognos/TEP Energy/Infras/Ecoplan 2020, unpublished detailed data.

If Switzerland is dependent on capacity abroad for depositing CO_2, there is a good chance that it will also one day be available. The North Sea, where projects concerning the geological storage of CO_2 are already under way, is a possibility. The transport of the captured CO_2 is one challenge. This must be

[75] Chevalier / Diamond / Leu (2010).

[76] The motion 20.4063 calls on the Federal Council to present a programme for the nationwide exploration of the geological substructure. The Federal Council recommends the motion for approval.

cost-effective and not generate any additional emissions. Transport via rail would be conceivable or, as a much more efficient option, the construction of a Europe-wide transport network to the deposition sites, for example via CO_2 pipelines. This would require pan-European cooperation. Initial, albeit not very specific, considerations are already being given to this, including by the relevant actors in Switzerland.[77] For Switzerland, DACCS could be implemented partly or exclusively directly at geologically suitable locations abroad. This would eliminate transport costs and the storage capacity available in Switzerland would be available to domestic point sources (cement factories, incinerators or other large plants).

It is important that CCS and NET capacities are developed over the coming years and then increased. The EP2050+ anticipates that the first capture of CO_2 in incinerators will be possible from 2035 (see Figure *28*). These volumes increase rapidly after 2040.

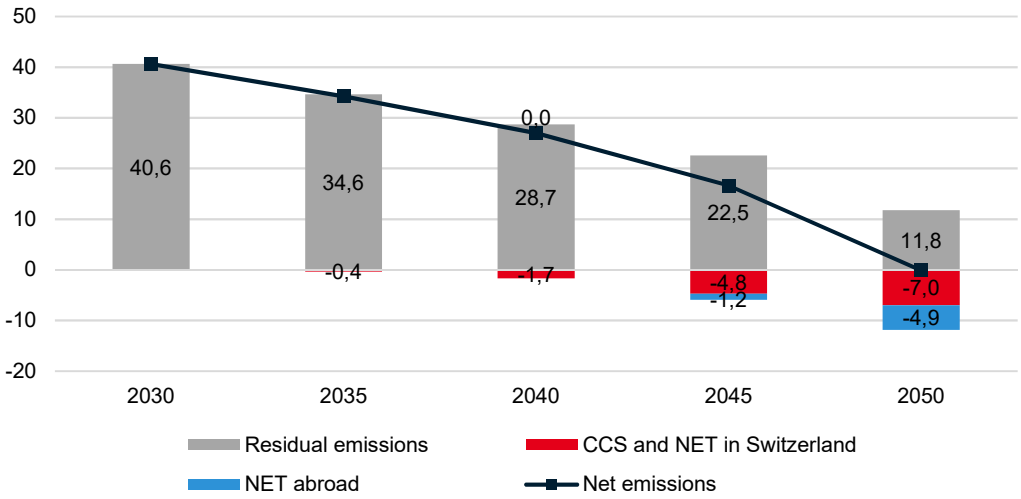

Figure 28: Development of the remaining emissions and contributions of NET and CCS in Switzerland and abroad (figures in million tonnes of CO_2eq) according to the ZERO basis scenario of EP2050+, including international aviation. Source: Own graphic based on Prognos/TEP Energy/Infras/Ecoplan 2020.

9 Development of total greenhouse gas emissions by 2050

Switzerland wishes to reduce its greenhouse gas emissions to net zero by 2050. It has the technical potential to achieve this objective. However, all actors are required to make their contribution as quickly and fully as possible. The key requirement for attaining the target is reducing all avoidable emissions in Switzerland. In addition to the approaches to replace fossil energies and to improve energy efficiency, CCS methods are also required. The remaining emissions which cannot be avoided with technical measures must be balanced with negative emissions technologies (NET).

The reduction of avoidable greenhouse gas emissions as completely as possible, on one hand, and the development and provision of the technical and natural sinks, on the other, represent two different challenges. This requires the involvement of various actors and the use of targeted regulatory incentives. It is therefore advisable to aim to achieve the development required to meet the net-zero objective using two targets: with a reduction pathway for the greenhouse gas emissions and a target (or a development pathway) for the negative emissions (including CCS contributions where applicable). This separate approach is required to ensure both challenges are given the appropriate status. It also enables specific objectives to be determined for the long-term reduction of greenhouse gas emissions in Switzerland and for the required sink performance.

[77] The association of Swiss waste recycling facility operators has developed the 'Carbon Hub' project which also focuses on the concept of a pan-European pipeline network.

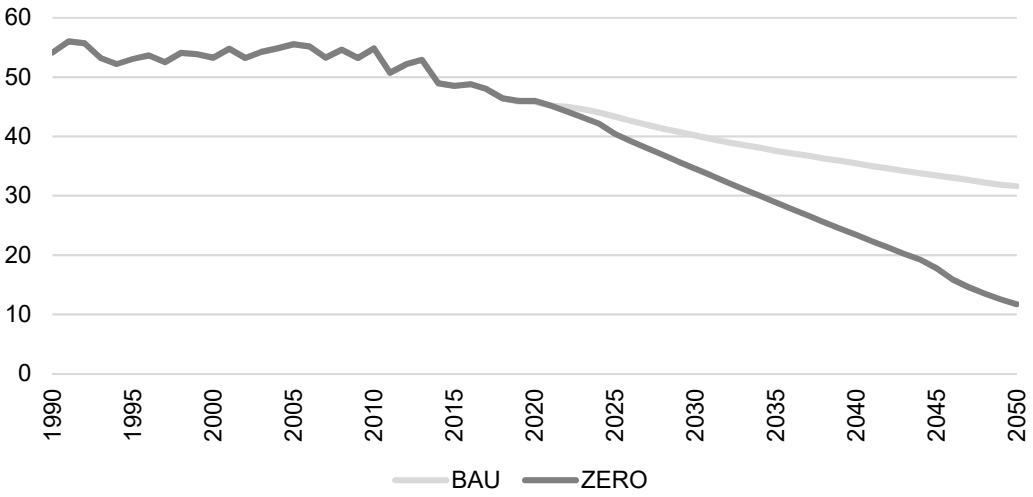

Figure 29: Reduction pathways of greenhouse gas emissions by 2050 in the 'Business as usual' and ZERO basis scenarios (in Mt CO_2eq) of EP2050+, both excluding CCS, NET and international aviation. Source: THGI FOEN & own graphic based on Prognos/TEP Energy/Infras 2020.

The completely revised CO_2 Act covers the period up to 2030. Domestic greenhouse gas emissions should decrease by at least 37.5 per cent by this point in time. A reduction to around 11.8 million tonnes of CO_2eq is possible by 2050, excluding contributions from CCS. Figure 29 shows the resulting reduction pathway. An average annual reduction of over one million tonnes of CO_2eq is required by 2030 in order to achieve the target of minus 37.5 per cent compared with 1990. Emissions should subsequently fall at a greater rate of around 1.2 million tonnes of CO_2eq. Figure 29 shows the difference to the 'Business as usual' scenario. Without further efforts, greenhouse gas emissions would still stand at well over 30 million tonnes of CO_2eq in 2050 according to this scenario.

Compared to the reduction pathway anticipated to 2030, ambitions should be further increased after 2030 so that emissions continue to fall. The measures planned to 2030 put the emissions on course to meet the target if they are systematically implemented. The capacities required for CCS and NET must be developed so that they can balance the remaining emissions long-term.[78] The following figures have been produced for the years 2040 and 2050 based on the above information. These figures could provide a basis for the definition of binding targets at a later stage.

	1990	**2018**	**2040**	**2050**
Greenhouse gas emissions excluding CCS contribution (in brackets: reduction compared with 1990)	57.2	51.8 (-10%)	28.7 (-50%)	11.8 (-79%)
Greenhouse gas emissions including CCS contribution (in brackets: reduction compared with 1990)	57.2	51.8 (-10%)	27.3 (-52%)	6.7 (-88%)

Table 3: Greenhouse gas emissions in 2040 and 2050, including international aviation (in Mt CO_2eq). Source: EP 2050+ ZERO basis scenario, Prognos/TEP Energy/Infras/Ecoplan 2020, unpublished detailed data.

The remaining emissions in 2050 are to be balanced by CCS and NET. CCS could make a reduction contribution of around five million tonnes of CO_2eq by 2050. Negative emissions of around 6.8 million tonnes of CO_2eq would be required. Targets for NET or for NET plus CCS can in turn be set based on these figures. The following figures have been produced for 2040 and 2050 broken down by sector:

[78] IPCC (2018).

	1990	2018	2040	2050
Buildings	16.7	11.2 (-33%)	2.9 (-82%)	0.4 (-98%)
Industry (excl. CCS)	13.6	11.2 (-18%)	7.8 (-43%)	5.9 (-57%)
Transport	14.9	15.0 (+1%)	6.4 (-57%)	0.0 (-100%)
Agriculture	7.7	6.6 (-14%)	5.4 (-30%)	4.6 (-40%)
Waste	1.1	0.7 (-37%)	0.5 (-49%)	0.5 (-52%)
Synthetic greenhouse gases	0.3	1.7 (+625%)	0.4 (+80%)	0.3 (+22%)
International aviation	3.1	5.3 (+74%)	5.2 (+71%)	0.0 (-100%)
Total (excluding CCS and NET)	**57.2**	**51.8 (-10%)**	**28.7 (-49%)**	**11.8 (-79%)**
CCS and NET in Switzerland			1.7 *(of which CCS: 1.3)*	7.0 *(of which CCS: 5.0)*
NET abroad			0.0	4.8
Total (incl. CCS and NET)	**57.2**	**51.8 (-10%)**	**27.1 (-53%)**	**0.0 (-100%)**

Table 4: Greenhouse gas emissions by sector in 2040 and 2050 (in million CO_2eq or in per cent compared with 1990). Source: EP 2050+ ZERO basis scenario, Prognos/TEP Energy/Infras/Ecoplan 2020, unpublished detailed data.

10 Costs and benefits of the net-zero target

The aim of reducing greenhouse gas emissions to net zero by 2050 is to avoid dangerous disruption to the climatic system and to contain the negative impacts of climate change. These impacts include – in addition to the general increase in the average temperature – changes to precipitation patterns, the increase in extreme events (severe weather, storms, heatwaves), the melting of glaciers and the rise in the sea level. The main benefits of climate policy are reducing these impacts and the associated costs involved. A further benefit is reducing dependence on fossil energies which Switzerland imports entirely from abroad. Over the past ten years alone, over 80 billion francs have been transferred abroad for fossil energies. These funds could be invested in Switzerland.

The benefits must be weighed up against the investment costs for the implementation of emission-reducing measures. Further impacts on the economy and consumers will arise from structural change and changes to the price of goods, employment and foreign trade. Finally, secondary effects must also be taken into account. This refers to effects that do not relate to the actual goal of climate policy and occur as a biproduct of the measures undertaken. Examples include the reduction of the emission of air pollutants by converting to renewable energies and lower noise pollution from transport by switching from combustion to electric engines.

The measures to reduce greenhouse gas emissions are mainly to be implemented over the next three decades. This means the investments – particularly for the conversion of the energy supply, the renovation of the building stock and the replacement of fossil fuels – will largely be incurred during this period. In contrast, the benefits will only become fully apparent long-term. Studies indicate that the costs of unchecked climate warming are limited up until the middle of the century, but then increase sharply towards the end of the century and beyond. A reduction in greenhouse gas emissions in line with the scientific recommendations will result in significantly lower costs long-term. The benefits of reducing emissions to net zero pay off long-term and significantly exceed the investments required.

10.1 Benefits and cost savings of not taking action

Climate change causes an increase in damage to infrastructure, higher health costs, lower agricultural productivity and lower earnings in economic sectors severely affected by climate change, e.g. winter tourism. These and other impacts of climate change result in costs. The level of such costs depends on the future development of global greenhouse gas emissions, temperatures and other climate parameters. If inadequate or, in an extreme scenario, no measures at all are taken to combat climate change, the impacts and costs involved will increasingly rise over the course of time. In the event of excessive warming, there is the danger of reaching tipping points which will change the climate system permanently and irreversibly. Science indicates that even global warming of over 2° Celsius compared to the

pre-industrial level is likely to result in the permanent melting of the ice caps and irreversible changes to monsoon systems. The costs involved in reaching such tipping points are extremely high.

The aim of the climate policy is to reduce emissions of greenhouse gases harmful to the climate and in this way restrict climate change and its impacts. The benefits are the avoidance of the associated costs. Estimating these is methodically complex. Climate change results in costs in many areas which are not traded on markets at measurable prices. They include impacts on the ecosystems, biodiversity and more generally on the integrity of nature and landscapes. These costs are difficult to express in monetary terms and are therefore omitted from most studies available. It should also be noted that the benefits for Switzerland are heavily dependent on the development of global emissions. Containing climate change requires measures from all countries. Switzerland will contribute to these global efforts with its net-zero target but cannot stop the consequences of climate change alone.

Various studies exist for Switzerland which generally focus on specific sub-areas. They include, for example, the impacts of climate change on infrastructure, healthcare costs or economic productivity. Some studies evaluate the costs of climate change at macroeconomic level.[79] The existing studies show that the costs of not taking action – i.e. the costs of unchecked global warming – for Switzerland will reach an annual amount of up to four per cent of GDP by 2050.[80] If the development of GDP according to EP2050+ is taken as an approximate basis, these costs will amount to around CHF 38 billion. According to these estimates, annual costs of around one billion francs will be incurred on infrastructure from 2050 and annual costs of up to 11 billion francs in healthcare from 2060. If global efforts succeed in restricting climate change in line with the goals of the Paris Agreement, the costs will be much lower. In this case, the annual costs in 2050 would amount to a maximum of 1.5 per cent of GDP[81] which equates to around 14 billion francs. This means the benefits of reducing greenhouse gas emissions to net zero would stand at 2.5 per cent of GDP a year. This is roughly 20 to 30 billion francs. The figures available today on the costs of climate change should be regarded as conservative estimates. This is mainly due to a lack of comprehensive cost calculations that take account of all climate impacts. The actual costs of climate change – and so too the benefits of comprehensive reduction of greenhouse gas emissions – may be significantly higher.

These results are consistent with studies that adopt a global perspective. The much-cited report by the economist Nicholas Stern (Stern Report) maintains that unchecked climate change over the next two centuries would result in a fall in global GDP of 5 to 20 per cent a year on average. The costs of stabilising emissions at a level that restricts warming to a maximum of 2° Celsius would only amount to around 1 per cent of annual GDP.[82] The OECD's estimates are similar. It quantifies the costs of unchecked climate warming at up to 3.3 per cent of GDP for 2060 and at up to 10 per cent of GPD per year by the end of the century.[83] These high costs provide justification for rapid and decisive action. This will also be beneficial economically, as the OECD also maintains. With an integrated strategy on growth and climate change, economic output in the G20 countries could be one per cent higher on average by 2021 and 2.8 per cent higher by 2050 than if the recommended measures were not implemented. If the avoidance of economic damage is also factored in, economic output could be increased by almost five per cent by 2050.[84]

10.2 Investments required, operating and maintenance costs and energy cost savings

The conversion of the energy system requires investment in plants and infrastructure as well as emission-reducing and efficiency-increasing measures in buildings, transport and industry. Costs are also incurred on the operation and maintenance of these plants. The withdrawal from fossil heating and motor fuels and increasing energy efficiency also results in savings on energy costs.

Even without the net-zero target, additional investments in the energy system of 1400 billion francs are required by 2050. With the net-zero target by 2050, the investment requirement increases by 109 billion

[79] Swiss Economics (2019), Vöhringer et al. (2019), EPFL (2017), Ecoplan (2007)

[80] Kahn et al. (2019). These impacts depend heavily on the underlying assumptions and scenarios and the impacts taken into account and may differ significantly depending on the study.

[81] Kahn et al. (2019)

[82] N. Stern (2006).

[83] OECD (2015).

[84] OECD (2017).

francs in total or by eight per cent. Then there are additional operating costs of around 14 billion francs in total. Reaching the net-zero target eliminates costs for importing fossil energies which results in savings of around 50 billion francs.[85] The cumulative additional costs over the period 2020 to 2050 amount to 73 billion francs in total.

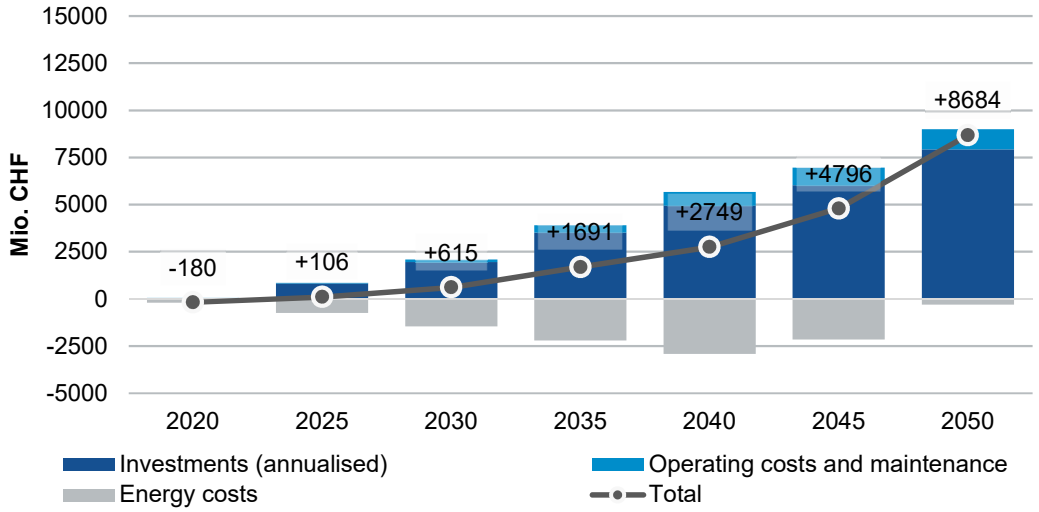

Figure 30: Development of annualised investments, operating and maintenance costs and energy cost savings in the ZERO basis scenario of the EP2050+ (in million CHF, difference compared to the 'Business as usual' scenario, excluding international aviation). Source: Prognos/TEP Energy/Infras/Ecoplan 2020.

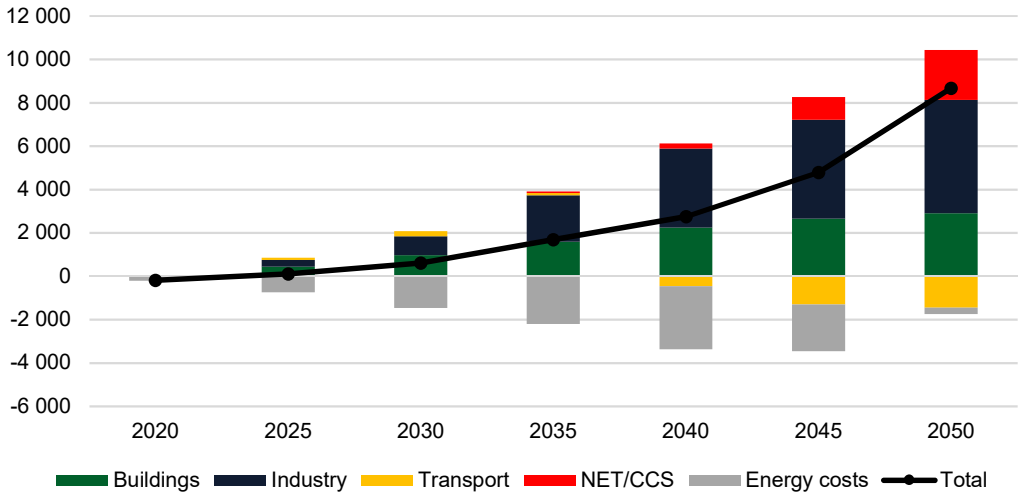

Figure 31: Development of costs (investment and operating costs; aggregated energy cost savings) by sector in the ZERO basis scenario of the EP2050+ (in million CHF, difference compared to the 'Business as usual' scenario, excluding international aviation). Industry including electricity, district heating, other conversion measures. Source: Prognos/TEP Energy/Infras/Ecoplan 2020, unpublished detailed information.

The development shown in Figure 31 is broken down by sectors. In the buildings sector, the annualised investments required increase until around 2050 and then stabilise. By 2050, they amount to around 2.9 billion francs, including operating costs. A similar development is observed in the industry sector which has the highest investments due to the required conversion of the power supply system. By 2050, they stand at around 5.2 billion francs (annualised, including operating costs). In the transport sector the direct costs are lower long-term than in the 'Business as usual' scenario owing to lower infrastructure and maintenance costs (primarily due to a continual decrease in the cost of electric vehicles). In 2050 the difference is around 1.4 billion francs. In contrast, additional investment requirements arise owing to the use of CCS and NET. These investments are predominantly incurred after 2040 and stand at around

[85] In international aviation the changeover from fossil to synthetic fuels would enable additional savings to be made of CHF 14 billion, including any costs incurred on the import of synthetic fuels.

2.2 billion francs in 2050. The energy costs by 2050 are similar to those in the 'Business as usual' scenario due to the import of electricity-based fuels.

10.3 Summary

From a scientific perspective, there is no alternative to the reduction of greenhouse gas emissions to net zero if the goals of the Paris Agreement are to be achieved. It is not a question of whether a climate protection policy based on these goals should be pursued, but rather which measures should be used to achieve the targets. Net zero is achievable from a technological perspective. The decisive factor will be ensuring the transition to the net-zero goal is carried out in a socially acceptable, economically viable and eco-friendly way as far as possible and creating a suitable regulatory environment. The long-term benefits are likely to exceed the investment required by the middle of the century, but most definitely over the long-term. The extremely high potential costs of inadequate climate protection justify decisive action, both globally and in Switzerland.

It should be noted that a cost-benefit analysis is only possible to a limited extent for various reasons which makes exact quantification difficult. The studies available are based on different assumptions, take account of different cost and benefit aspects, use different parameters[86] and cover different time horizons. As a result, the figures from the preceding sections cannot be compared directly. It is clear that the reduction of greenhouse gas emissions to net zero is urgently required if global warming is to be limited to a maximum of 1.5° Celsius. Unless this goal is systematically pursued, serious and sometimes difficult-to-estimate consequences involving high costs are anticipated. These costs would be much higher than those required to cut greenhouse gas emissions to net zero. Continuing as before is therefore no longer an option. The investment costs required to attain the net-zero target will predominantly be incurred over the next 30 years but will make a major contribution to avoiding much higher subsequent costs. The reduction of emissions to net zero will pay off long-term as various studies on the impacts at global level clearly indicate. Put simply, climate protection will incur costs, but no climate protection will cost a great deal more.

[86] The costs are generally expressed in francs per tonne of CO_2eq saved and the benefits in francs per degree Celsius of warming avoided.

Literature references

2°Investing Initiative (2017): Non-Financial Message in a Bottle – How the environmental objectives of retail investors are overlooked in MIFID II – PRIIPS implementation. Paris / New York / London / Berlin.

2°Investing Initiative / Wüest Partner (2020): Bridging the Gap: Measuring progress on the climate goal alignment and climate actions of Swiss Financial Institutions. On Behalf of the Federal Office for the Environment. Bern.

Banktrack (2018): Banking on Climate Change. Fossil Fuel Finance Report Card 2018.

Bretscher Daniel / Ammann Christof / Wüst Chloë / Nyfeler Aurelia / Felder Daniel (2018): Reduktionspotenziale von Treibhausgasemissionen aus der Schweizer Nutztierhaltung. (Potential for reducing greenhouse gas emissions in Swiss livestock farming) Agrarforschung Schweiz 9 (11+12), pp. 376–383.

CH2018 (2018): CH2018 – Climate Scenarios for Switzerland, Technical Report, National Centre for Climate Services, Zurich, 271 pp.

Chevalier, Gabriel / Diamond, Larryn W. / Leu, Werner (2010): Potential for Deep Geological Sequestration of CO_2 in Switzerland: A First Appraisal. In: Swiss Journal of Geosciences 103, 427-455.

EAWAG (2018): Review of "Source category 5D – Wastewater treatment and discharge" in Switzerland. On behalf of the Federal Office for the Environment FOEN.

Ecoplan (2007): Auswirkungen der Klimaänderung auf die Schweizer Volkswirtschaft (nationale Einflüsse) (Impacts of climate change on the Swiss economy – national impacts). On behalf of the Federal Office for the Environment and the Federal Office of Energy. Bern.

Ecoplan (2017): Wirkungsabschätzung zur CO_2-Abgabe. Aktualisierung bis 2015 (Impact assessment of CO_2 duty. Update to 2015). On behalf of the Federal Office for the Environment, Bern/Altdorf.

Ecoplan (2019): Branchenszenarien 2014 bis 2030/2060. Aktualisierung 2018. (Sector scenarios 2014 to 2030/2060. Update 2018) On behalf of the Federal Office of Energy, Bern.

Eggen Mirjam / Stengel Cornelia (2019): Rechtliches Gutachten Berücksichtigung von Klimarisiken und -wirkungen auf dem Finanzmarkt. (Expert legal opinion on the consideration of climate risks and impacts on the financial market) On behalf of the Federal Office for the Environment. Bern/Zurich.

EPFL (2017): Assessing the impacts of climate change for Switzerland. On behalf of the FOEN. Lausanne.

European Commission (2018): Action Plan: Financing Sustainable Growth, COM(2018) 97, Brussels.

European Commission (2016): Summary of the Responses to the Public Consultation on Long-Term and Sustainable Investment, Brussels.

Federal Council (2020): Explanatory report on the popular initiative "For a healthy climate (Glacier Initiative)" and on the direct counterproposal (Federal decree on climate policy) of 2 September 2020. Bern.

Federal Council (2020): Sustainability in Switzerland's financial sector – Situation analysis and positioning with a focus on environmental aspects. Bern.

Federal Council (2020): Digital Switzerland Strategy. Bern.

Federal Council (2020): What role can negative CO_2 emissions play in Switzerland's future climate policy measures? Report in fulfilment of postulate 18.4211 submitted by Thorens Goumaz of 12 December 2018. Bern.

Federal Council message on the complete revision of the CO_2 Act post-2020 of 1 December 2017. Federal Gazette 2018 247.

Federal Council message of 12 February 2020 on the development of agricultural policy from 2022 (AP22+). Federal Gazette 2020 3955.

Federal Council message on international cooperation 2021–24 (International Cooperation Strategy 2021–24), preprint.

Federal Department of the Environment, Transport, Energy and Communications DETEC (2017): Switzerland Future Mobility – DETEC Guiding Framework 2040. Bern.

Federal Department of Foreign Affairs (2020): Foreign Policy Strategy 2020–23. Report to the Federal Council. Bern.

Federal Office for Agriculture (2011): Climate Strategy for Agriculture. Bern.

Federal Office for Spatial Development (2016): Transport Outlook 2040 – Development of Passenger and Freight Transport in Switzerland. Bern.

Federal Statistical Office (2015): Population projections for Switzerland 2015–45. Neuchâtel.

Federal Office for the Environment (2013): Forest Policy 2020 - Visions, objectives and measures for the sustainable management of forests in Switzerland. Bern.

Federal Office for the Environment (2020): Federal government measures for a resource-conserving, future-proof Switzerland (Green Economy). Report to the Federal Council. Bern.

International Energy Agency IEA (2018), *World Energy Outlook 2018*, IEA, Paris.

IPCC, 2018: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [V. Masson-Delmotte / P. Zhai,/ H.-O. Pörtner / D. Roberts / J. Skea / P.R. Shukla / A. Pirani / W. Moufouma-Okia / C. Péan / R. Pidcock / S. Connors / J.B.R. Matthews / Y. Chen / X. Zhou / M.I. Gomis / E. Lonnoy / T. Maycock / M. Tignor / T. Waterfield (eds.)]. In Press.

Kahn M. / Mohaddes K. / Ng R. / Hashem Pesaran M. / Raissi M. / Yang J.-C. (2019): Long-Term Macroeconomic Effects of Climate Change: A Cross-Country Analysis. IMF Working Paper 19/215.

Lehmann Meta / Meyer Martin / Kaiser Nicole / Ott Walter (2017): Umstieg von fossilen auf erneuerbare Energieträger beim Heizungsersatz (Switching from fossil to renewable energies when replacing heating systems). Energy Research Unit, City of Zurich, Report no. 37, FP-2.8 research project.

Neu Urs (2020): Die Auswirkungen der Flugverkehrsemissionen auf das Klima. (The impacts of aviation emissions on the climate) In: Swiss Academies Communications 15 (9).

OECD (2015): The Economic Consequences of Climate Change, OECD Publishing, Paris.

OECD (2017): Investing in Climate, Investing in Growth, OECD Publishing, Paris.

Prognos/TEP Energy/Infras/Ecoplan (2020): Energy Perspectives 2050+ short report, on behalf of the Federal Office of Energy, Bern

Ragettli Martina S. / Röösli Martin (2020): Gesundheitliche Auswirkungen von Hitze in der Schweiz und die Bedeutung von Präventionsmassnahmen. Hitzebedingte Todesfälle im Hitzesommer 2019 – und ein Vergleich mit den Hitzesommer 2003, 2015 und 2018. (Health effects of heat in Switzerland and the importance of preventative measures. Heat-related deaths during the heatwave of 2019 – a comparison with the heatwaves of 2003, 2015 and 2018) Swiss Tropical and Public Health Institute. Basel.

Sotomo Research Institute (2020): Grundlagenstudie Flugticketabgabe Schweiz. (Study on air ticket levy in Switzerland). Zurich.

State Secretariat for Economic Affairs (2018): Langfristszenarien für das BIP (Long-term GDP scenarios), Bern.

Stern Nicholas (2006): The Stern Review on the Economics of Climate Change, HM Treasury, London.

Stiftung Risiko-Dialog (2019): The Role of Atmospheric Carbon Dioxide Removal in Swiss Climate Policy. Report on behalf of the Federal Office for the Environment, Bern.

Swiss Economics (2019): Bedeutung des Klimawandels für die Infrastrukturen der Schweiz – Stand der Literatur (Importance of climate change for Switzerland's infrastructure – current status of the literature). Zurich.

Vöhringer Frank / Vielle Marc / Thalmann Philippe / Frehner Anita / Knoke Wolfgang / Stocker Dario / Thurm Boris (2019): Cost and benefits of climate change in Switzerland, Climate Change Economics 10 (2), 1–34.

Zimmermann Albert / Nemecek Thomas / Waldvogel Tuija (2017): Umwelt- und ressourcenschonende Ernährung: Detaillierte Analyse für die Schweiz. (Eco-friendly and resource-conserving food: a detailed analysis for Switzerland) Agroscope,,Tänikon, Ettenhausen. Agroscope Science 55, 170 pages.

Glossary

CO_{2eq}	Greenhouse gases other than carbon dioxide (CO_2) are converted into CO_2 equivalent (CO_{2eq}) based on their climate impact to make them comparable.
CO_2 neutrality	Achievement of the net-zero target for carbon dioxide (CO_2) emissions
Climate neutrality	Meeting the net-zero target for all greenhouse gases (including all climate effects of international aviation) and taking account of 'grey emissions' generated abroad as a result of domestic consumption (consumption footprint).
Net zero	Equilibrium between emissions and capture, usually in relation to CO_2 or other greenhouse gases.
Net-zero target	Equilibrium for greenhouse gases between emissions, on one hand, and capture and storage in sinks on the other.
Difficult-to-avoid emissions	Emissions which, based on the information currently available, cannot be prevented with technical measures alone. If these emissions cannot be reduced by using alternatives or through avoidance, they must be balanced with negative emissions technologies.
Greenhouse gas neutrality	Meeting the net-zero target for all greenhouse gases excluding 'grey emissions' generated abroad as a result of domestic consumption (see 'climate neutrality').