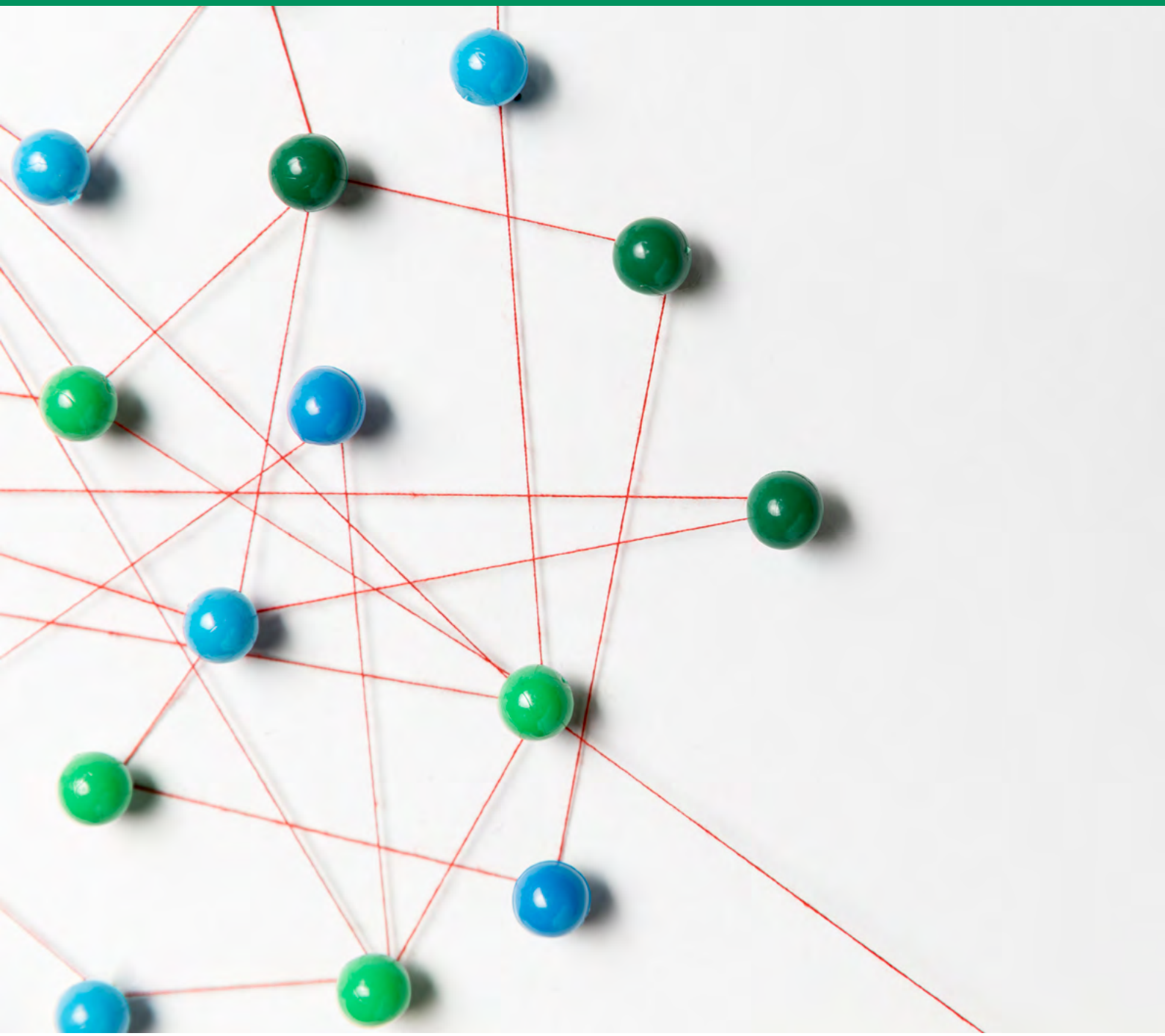

ENERGY STRATEGY 2050
MONITORING REPORT 2024
ABRIDGED VERSION[1]

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Federal Office of Energy SFOE

1 Based mainly on data up to 2023.

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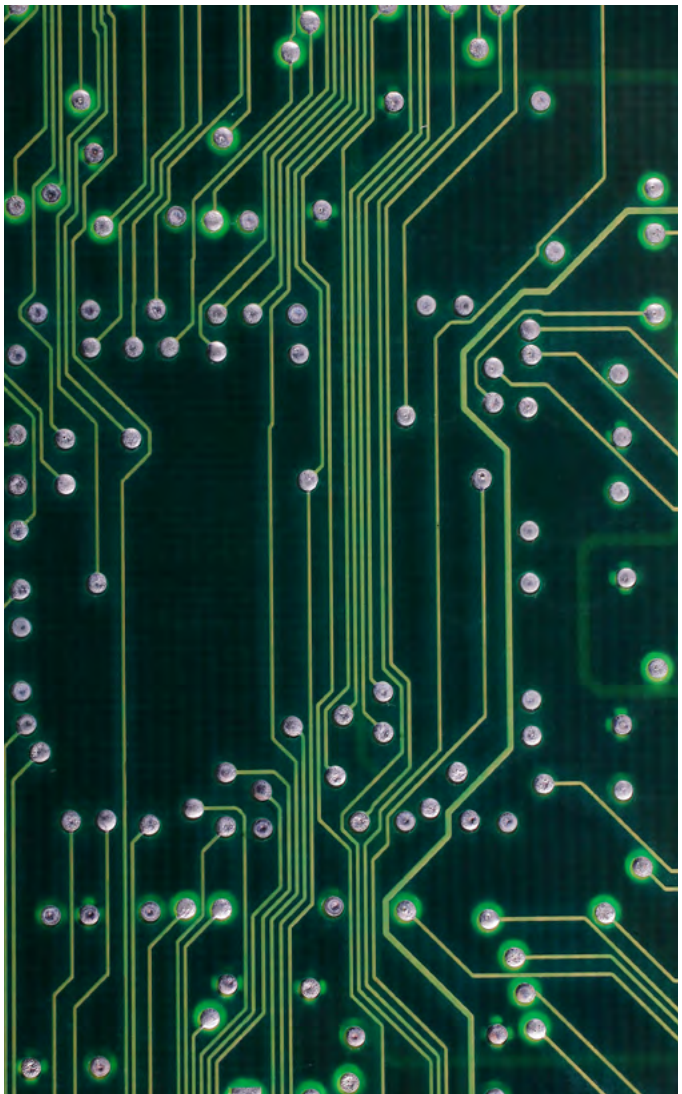


CONTENTS

INTRODUCTION

Energy Strategy 2050 guides the transformation of Switzerland's energy system. The strategy aims to phase out nuclear energy gradually, increase energy efficiency and renewable energy use, and reduce energy-related CO_2 emissions while ensuring secure and affordable energy supply. Current energy legislation, effective since the start of 2018, provides for gradual nuclear phase-out, though the Federal Council has recently reconsidered this decision (*see next page)*.

continuation ▶ ▶ ▶

In light of the 2050 climate target – requiring Switzerland to balance greenhouse gas emissions with natural and technical storage capacity from 2050 onwards – fossil fuels must be largely replaced by renewable electricity, particularly in transport and heating. With the Federal Act on a Secure Electricity Supply from Renewable Energy Sources (Federal Gazette, 2023), the Federal Council and Parliament have taken a comprehensive step towards advancing Energy Strategy 2050. Swiss voters approved the legislative package on 9 June 2024, with staged implementation beginning 1 January 2025. The Act establishes measures to rapidly and systematically expand domestic renewable power generation, improve power system integration, and strengthen long-term supply security. To further accelerate renewable energy expansion, the Federal Council approved an Energy Act amendment – the acceleration bill – in June 2023 (Federal Council, 2023g), currently under parliamentary review. This bill primarily aims to streamline licensing and appeals processes for large installations and simplify grid upgrade planning. It complements previously approved parliamentary bills expediting wind and solar energy projects.

As noted regarding the 2050 climate target, energy policy objectives closely align with climate policy, as approximately three-quarters of Switzerland's greenhouse gas emissions come from fossil fuel use. The SFOE's Energy Perspectives 2050+ demonstrate that Switzerland can restructure its energy supply by 2050 to meet this target while maintaining supply security (Prognos/TEP/Infras/Ecoplan, 2020). Energy Perspectives 2050+ provided key foundations for the Federal Council's 2021 Long-term Climate Strategy for Switzerland, which detailed the net-zero target (Federal Council, 2021a). The Federal Act on Climate Protection Goals, Innovation and Strengthening Energy Security (CIA), approved by Swiss voters on 18 June 2023, establishes the net-zero target as legally binding, setting interim goals and sectoral guidance values. Furthermore, the Act, effective from the start of 2025, includes time-limited support measures to advance fossol fuel replacement in buildings and industry. Switzerland aims to halve greenhouse gas emissions from 1990 levels by 2030. The revised CO_2 Act, approved by Parliament in spring 2024 and effective from the start of 2025, implements this target nationally, maintaining existing measures while introducing new targeted support measures and incentives for emissions reduction.

The energy system transformation, with increased renewable energy use, enhanced efficiency, and growing decarbonisation and electrification, requires particular attention to supply security. Beyond long-term considerations, Russia's attack on Ukraine and rising Middle East tensions have highlighted immediate and medium-term supply security concerns. Since February 2022, the Federal Council and Parliament have implemented various supply security measures. The Federal Act on a Secure Electricity Supply from Renewable Energy Sources mandates a hydropower reserve: reservoir operators retain energy for a fee from early February to mid-May for use when needed. The Act includes storage operators and large consumers with load reduction potential as additional electricity reserve components. The Winter Reserve Ordinance governs both hydropower reserve use and a supplementary thermal reserve comprising reserve power plants, emergency generators and CHP plants. The Federal Council adopted a dispatch for the statutory basis in early March 2024 (Federal Council, 2024j), with parliamentary discussion ongoing.

Given changed electricity market and energy policy conditions (climate targets, electricity demand, fossil gas-fired power plants as reserve only, geopolitical uncertainties), the Federal Council made a nuclear energy policy decision on 28 August 2024. While rejecting the 'Electricity for all at all times (Stop the blackout)' initiative, it plans an indirect counter-proposal this year, aiming to lift the new nuclear plant construction ban in the interest of technology openness (Federal Council, 2024k).

The restructuring of Switzerland's energy system under Energy Strategy 2050 requires long-term monitoring to track developments, progress, target achievement, measure benefits and economic costs, and enable timely, evidence-based responses to unwanted developments. Energy legislation provides the legal basis for monitoring (Arts 55ff Energy Act and Arts 69ff Energy Ordinance).

This 2024 monitoring report (abridged version, based primarily on data up to 2023) examines selected indicators across seven topics:

- **TOPIC** **ENERGY CONSUMPTION AND PRODUCTION**
- **TOPIC** **NETWORK DEVELOPMENT**
- **TOPIC** **SUPPLY SECURITY**
- **TOPIC** **EXPENDITURE AND PRICES**
- **TOPIC** **CO_2-EMISSIONS**
- **TOPIC** **RESEARCH AND TECHNOLOGY**
- **TOPIC** **INTERNATIONAL ENVIRONMENT**

↗ Additional indicators are dealt with in **the full version of the monitoring report**: www.energymonitoring.ch

↗ **Key figures on the current energy supply situation** are available on the SFOE's Energy Dashboard at **www.energydashboard.ch**

ENERGY CONSUMPTION AND PRODUCTION

Enhancing efficiency to reduce energy and electricity consumption stands as a primary objective of Energy Strategy 2050 and a key pillar of energy legislation. Equally important is expanding renewable electricity production to partially offset declining nuclear power plant capacity. This topic's indicators primarily comprise Energy Act targets for per capita energy and electricity consumption, alongside goals for expanding renewable electricity production and hydropower. Parliament has established new binding targets for 2035 and 2050 through the Federal Act on a Secure Electricity Supply from Renewable Energy Sources, effective 1 January 2025. The following charts and analysis therefore incorporate these new binding targets.

FINAL ENERGY CONSUMPTION PER PERSON AND YEAR

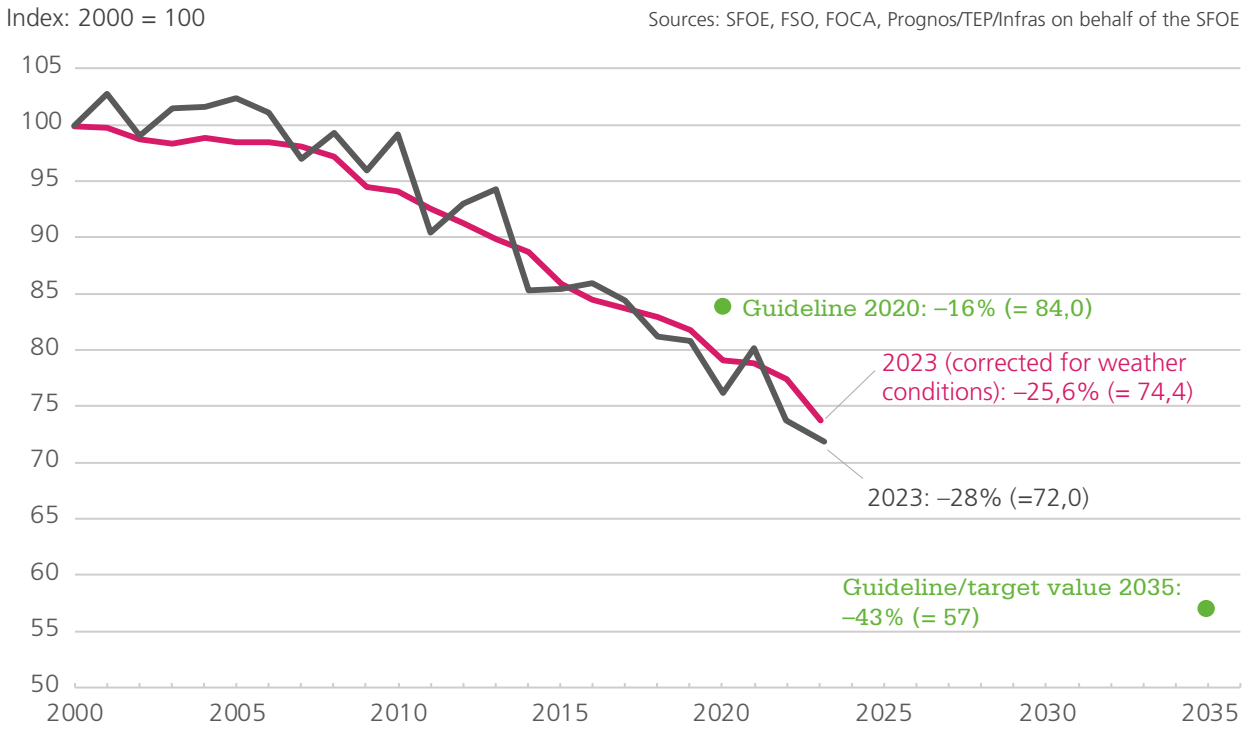


Figure 1: Final energy consumption[2] per capita since 2000 (indexed)

Final energy consumption per capita has fallen since 2000, as **Figure 1** shows. The decrease reflects a 9.5% drop in absolute final energy consumption between 2000 and 2023 (10.9% excluding international aviation), while population grew by 23.7% during this period. The current Energy Act targets a 43% reduction in per capita final energy consumption from 2000 levels by 2035. The Federal Act on a Secure Electricity Supply from Renewable Energy Sources makes this 2035 target binding. In 2023, per capita final energy consumption was 78.6 gigajoules (21.8 MWh), 28% below 2000 levels. Weather-adjusted figures show a 25.6% decrease. To achieve the 2035 target, weather-adjusted per capita final energy consumption must decline by 2.2% annually going forward. The past decade's average annual reduction was approximately 1.9%. In 2023, absolute final electricity consumption increased by 0.3% compared to 2022. The rise primarily reflects increased international air traffic consumption. However, the impact of cooler weather on heating energy consumption (heating degree days up 1.8% year-on-year) was more than offset by energy-saving efforts, efficiency improvements and substitution effects. Absolute final energy consumption decreased over the entire period under review (from 2000 to 2023), as the consumption-reducing effects outweighed consumption-driving factors. Consumption was primarily driven by volume effects: all 'pure' growth effects were counted, such as the overall economic output (excluding structural effects), population, energy reference areas and the motor vehicle inventory. Such effects that tended to increase consumption were counteracted by political measures and technological advances. Substitution effects from energy source changes also helped reduce consumption between 2000 and 2023. These include replacing heating oil with natural gas and increasingly with district heating, ambient heat, wood and electricity, as well as substituting petrol with diesel and, more recently, electricity (sources: SFOE, 2024a/FSO, 2024/FOCA, 2024/Federal Gazette, 2023/Prognos/TEP/Infras 2024a+b).

2 Excluding international air traffic

ELECTRICITY CONSUMPTION PER PERSON AND YEAR

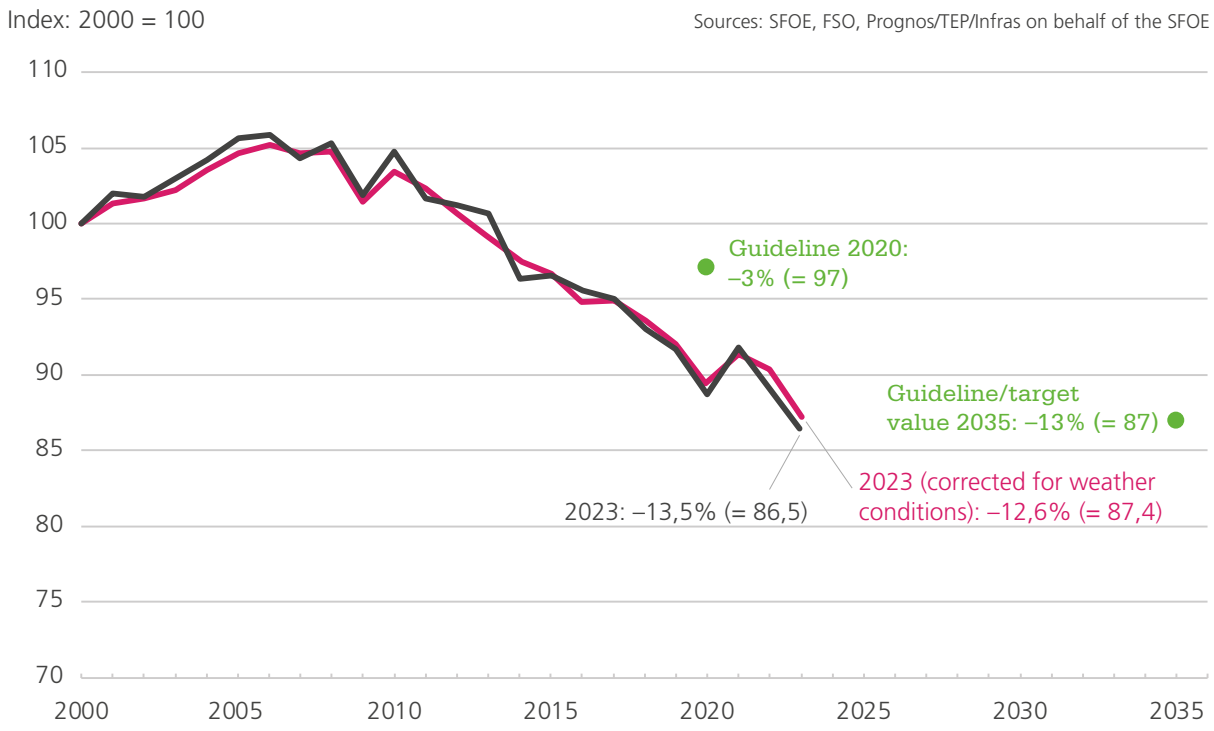


Figure 2: Development of per capital electricity consumption since 2000 (indexed)

Per capita electricity consumption grew between 2000 and 2006 as absolute consumption increased by 10.3% while population rose only 4.2%. Since 2006, the trend has declined, as shown in **Figure 2**. Absolute electricity consumption fell by 3% between 2006 and 2023, while population increased by 18.8%. Sharp declines in per capita consumption in 2009 and 2020 reflect economic slowdown and COVID-19 impacts respectively. The current Energy Act targets a 13% reduction in per capita electricity consumption from 2000 levels by 2035. The Federal Act on a Secure Electricity Supply from Renewable Energy Sources will make this 2035 target legally binding. In 2023, per capita energy consumption reached 22.7 gigajoules (6,308 MWh), 13.5% below in 2000 levels. Weather-adjusted figures show a 12.6% decrease (*red curve*). The past decade's weather-adjusted average annual decline was approximately 1.3%. According to Energy Perspectives 2050+, meeting the net-zero emissions target by 2050 requires significant medium-term electricity demand increases, complicating target achievement (electric mobility, (large-scale) heat pumps, hydrogen electrolysers, long-term negative emission technologies and CO_2 capture and storage systems). The 2035 target (–13%) requires additional efforts. In 2023, absolute electricity consumption decreased 1.7% versus 2022. Over the entire period under review (2000–2023), electricity consumption rose 7.1%. Consumption was driven by volume effects and increasing substitution effects from energy system electrification (replacing fossil heating systems with heat pumps and conventional combustion engines with electric vehicles). These consumption-driving factors outweighed technological developments (structural measures for thermal insulation and the use of more efficient heating systems, electrical appliances, lighting, machines, etc.) and energy policy instruments (e.g. political requirements and the voluntary measures of SwissEnergy) (sources: SFOE, 2024a/FSO, 2024/Federal Gazette, 2023/Prognos/TEP/Infras 2024a+b/Prognos/TEP/Infras/Ecoplan, 2020).

ELECTRICITY PRODUCTION FROM RENEWABLE ENERGY (EXCLUDING HYDROPOWER)

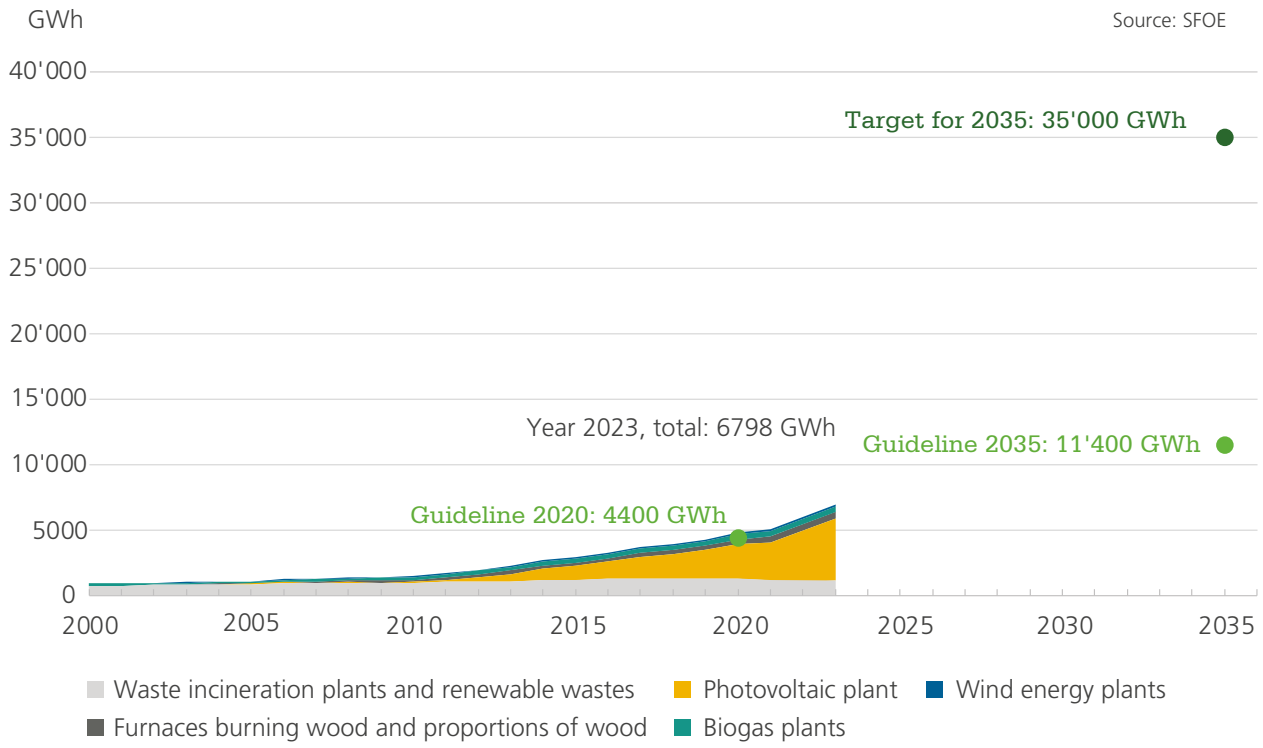


Figure 3: Development of electricity production from renewable energy (excluding hydropower) since 2000 (in GWh)

Current legislation guidelines (Art. 2 para. 1 Energy Act) for domestic production correspond to legal instruments' sphere of influence. These targets no longer align with the 2050 net-zero emissions target. The Federal Act on a Secure Electricity Supply from Renewable Energy Sources introduces new binding expansion and efficiency targets for 2035 and 2050 from 1 January 2025.

Renewable electricity production has increased since 2000, as **Figure 3** shows, accelerating from 2010. Production reached 6,798 gigawatt-hours (GWh) in 2023, representing 10.2% of overall net electricity production (excluding storage pumps consumption). Base year 2010 production was 1,402 GWh. In 2023, the net increase from 2022 was 786 GWh; since 2011 it has averaged 415.1 GWh per annum. The current Energy Act sets an 11,400 GWh target for 2035, requiring average annual net increases of 383.5 GWh. The Federal Act on a Secure Electricity Supply from Renewable Energy Sources, effective 1 January 2025, sets a 35,000 GWh target for 2035, requiring significantly higher annual increases of 2,350.2 GWh. Technology breakdown shows uneven expansion across renewable power generation types. Since 2010, photovoltaics (PV) has shown the strongest absolute growth, now representing about 68% of new renewable power generation (excluding hydropower). Other technologies show more modest growth: electricity from waste incineration plants and renewable waste (2023 share: 15.4%), furnaces burning wood and wood fuels (2023 share: 7.9%), biogas (2023 share: 6.1%), and wind energy plants (2023 share: 2.5%). Switzerland currently has no operational geothermal power plants (sources: SFOE, 2024a/Federal Gazette, 2023).

ELECTRICITY PRODUCTION FROM HYDROPOWER PLANTS

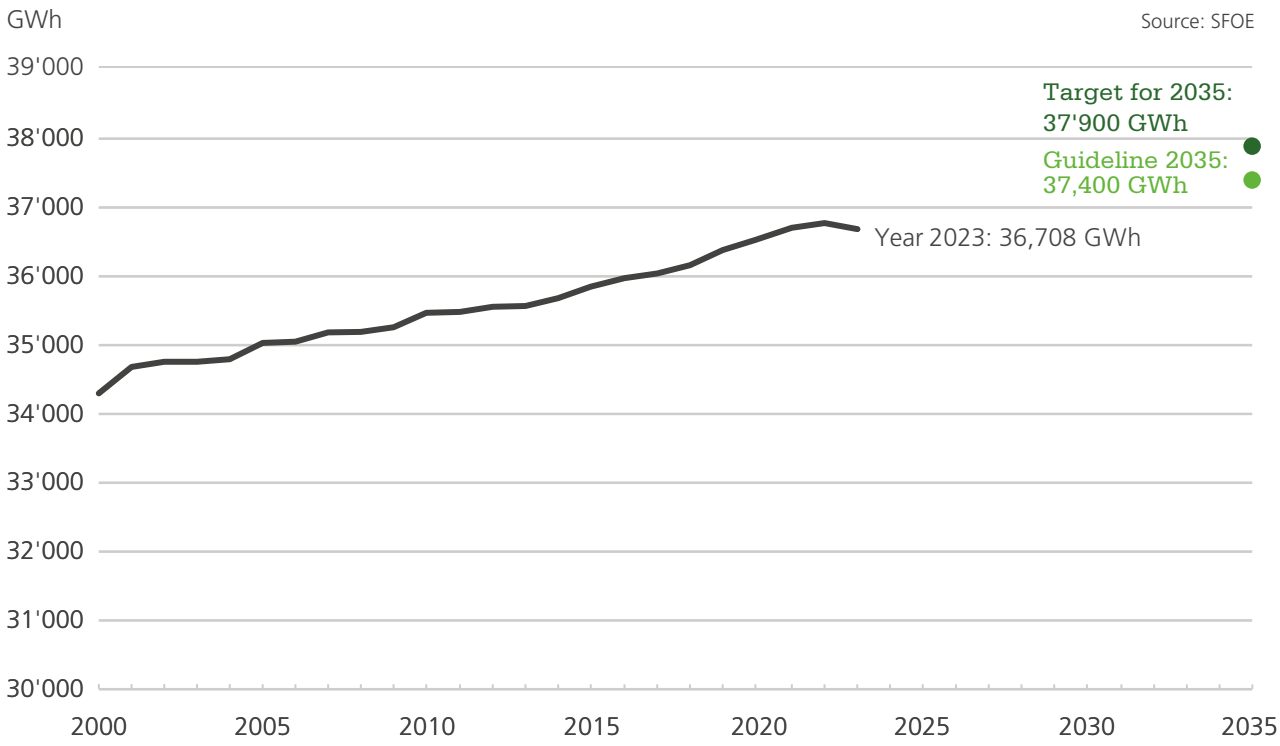
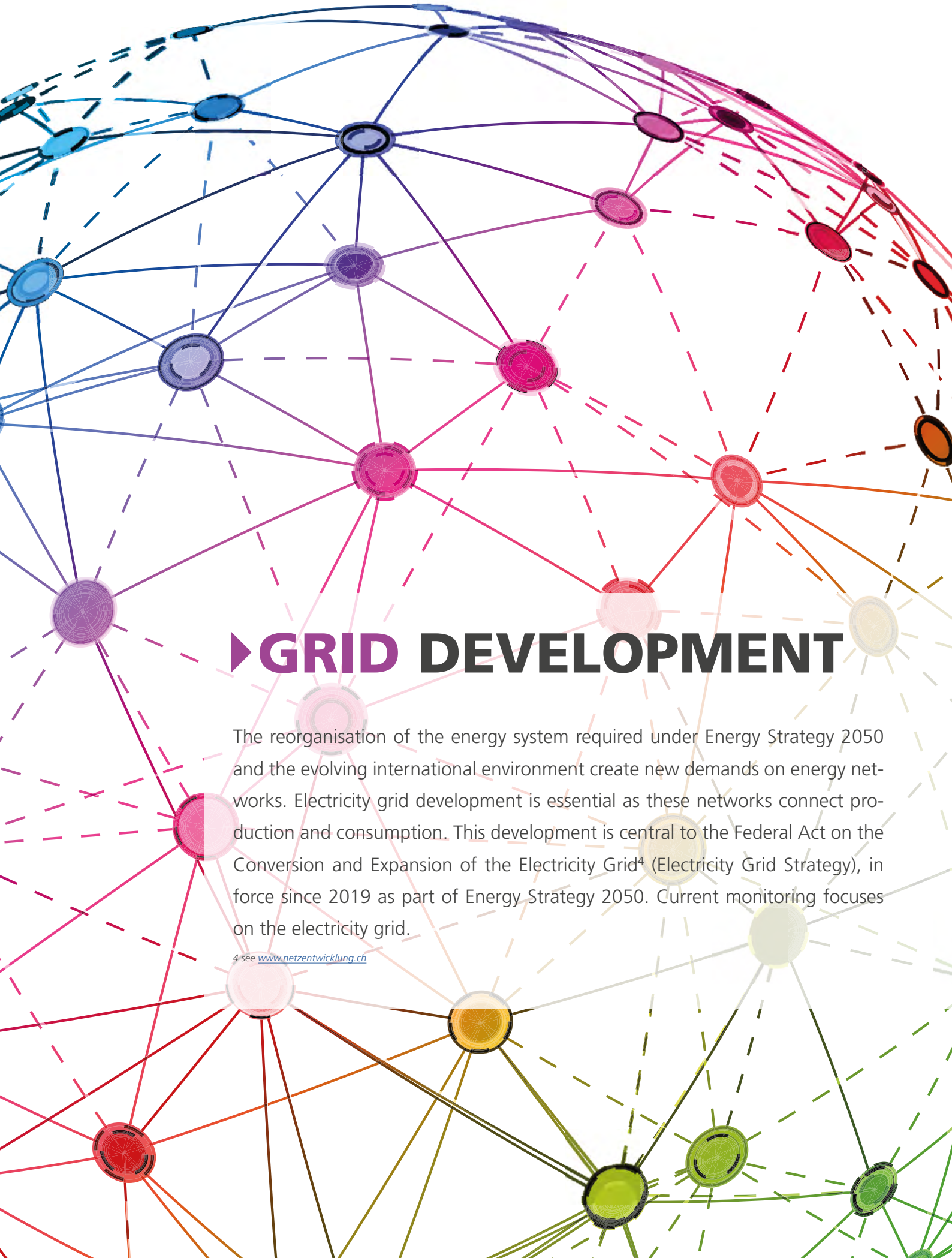


Figure 4: Anticipated average production of electricity[3] from hydropower plants (in GWh) since 2000

Figure 4 demonstrates nearly continuous growth in hydropower plant electricity production since 2000, primarily through new installations and existing facility expansion and optimisation. In 2023 the anticipated average production (as of 1 January 2024) was 36,708 GWh. Base year 2011 (as at 1 January 2012) recorded 35,488 GWh. Meeting the current Energy Act guideline requires a net increase of approximately 1,900 GWh between 2011 and 2035. By the year under review, 63.8% of this increase had been achieved. In 2023, anticipated average production fell by 66 GWh from the previous year. This was mainly due to the below-average hydrology in Ticino and Graubünden in recent years. Since 2012, the anticipated average production has increased by 95 GWh per year on average. Achieving the 2035 target requires an average annual net increase of 58 GWh. The Federal Act on Secure Electricity Supply from Renewable Energy Sources sets a binding target of 37,900 GWh for 2035, requiring an average annual increase of 99 GWh (source: SFOE, 2024f).

3 Anticipated average production including anticipated production from small hydropower plants <300kW (according to statistics for hydropower plants in Switzerland, WASTA), excluding average energy requirement for all storage system pumps (assujming 83% efficiency) and excluding electricity required for recirculation. Note: The base year, time series and chart were subsequently adjusted following an extraordinary correction by WASTA (see SFOE press release of 5 May 2022).

↗ For more detailed indicators regarding **ENERGY CONSUMPTION AND PRODUCTION** see the full monitoring report.



GRID DEVELOPMENT

The reorganisation of the energy system required under Energy Strategy 2050 and the evolving international environment create new demands on energy networks. Electricity grid development is essential as these networks connect production and consumption. This development is central to the Federal Act on the Conversion and Expansion of the Electricity Grid[4] (Electricity Grid Strategy), in force since 2019 as part of Energy Strategy 2050. Current monitoring focuses on the electricity grid.

4 see www.netzentwicklung.ch

STATUS AND DURATION OF PLANS FOR THE TRANSMISSION GRID

Energy Strategy 2050 and the Electricity Grid Strategy create reliable conditions for a needs-based, timely development of the electricity grid to guarantee the security of electricity supply. They provide standards for assessing the need to expand and modernise Switzerland's electricity grid, optimise the licensing procedures for line projects and the criteria for deciding whether to place cables underground or use overhead transmission lines. The regulations are intended to increase transparency in the grid planning process and improve acceptance of grid plans in general. The focus will be on the Swiss transmission network, which will have to guarantee the safe and sufficient transmission of energy fed in from domestic production centres, as well as imported energy over long distances to centres of consumption. In addition, it will have to compensate for fluctuating rates of energy fed in from renewable sources, which cannot be compensated for at the lower grid levels, through imports and exports, as well as cope with the complementarity of the various types of power plant.

PROCESS AND PHASES OF A TRANSMISSION NETWORK PROJECT

PRELIMINARY PROJECT: As the basis for the sectoral plan procedure, national grid operator Swissgrid draws up a preliminary project with the key parameters of the grid plan and ensures that the concerns of the cantons affected by the project are considered as early as possible in the planning stage. For the purposes of the monitoring programme, the preliminary project phase begins as a rule with the initiation of the project, and ends when the application is submitted for the project to be incorporated in the sectoral plan for transmission lines. If a plan is not yet in either the preliminary or the construction project phase, and is thus in an early stage of planning, it is designated in the monitoring programme as a **project proposal.**

TRANSMISSION LINES SECTORAL PLAN: If a transmission line project will have a substantial impact on the area and the environment, a sectoral plan procedure has to be carried out before the planning approval procedure can be initiated (*see below*). The Transmission Lines sectoral plan applies to the power lines network. The Swiss Federal Office of Energy (SFOE) is responsible for this sectoral plan, with the support of the Federal Office for Spatial Development (ARE). In the first stage of the sectoral plan procedure, a **planning zone** is determined, and in the second stage a **planning corridor** is selected for the path of the transmission line. At the same time as the planning corridor is defined, a decision is made as to which **transmission technology** is to be employed (overhead line or underground cable). The sectoral plan procedure begins when Swissgrid submits a corresponding application, and ends when the decision is taken on the planning corridor by the Federal Council in the corresponding detailed plan. This plan is binding for all authorities, which means they have to take it into consideration when approving the project and in any other spatial development activities.

CONSTRUCTION PROJECT: Once the planning corridor has been defined, Swissgrid's plan is developed within the scope of a detailed construction project. The company has to guarantee that the line will be

In April 2015, national grid operator Swissgrid submitted a strategic grid plan[5], which took into consideration the gradual phasing out of nuclear power in accordance with Energy Strategy 2050, including suitable projects to upgrade and expand the transmission grid by 2025. The current monitoring process will follow the status and duration of plans at the transmission network level, including Swissgrid's Strategic Grid 2025 (sections 1 to 10), as well as other projects, some of which are initiated by third parties (*Figure 5*).

The energy scenario framework legally introduced with the Electricity Grid Strategy forms a central basis for network planning. For grid operators, the scenario framework constitutes a politically supported basis on which to determine the grid expansion requirements and to compile or update their own multi-year planning. The Federal Council approved the first such scenario framework in November 2022 and it is therefore binding for the authorities (Federal Council, 2022a). Swissgrid is currently updating its multi-year planning on the basis of the scenario framework and will subsequently submit it to ElCom for review. Swissgrid will then publish the Strategic Grid 2040 with the comprised projects, probably in spring 2025.

The Federal Council wants to further accelerate the conversion and expansion of the electricity grids. Among other things, transmission lines are to be implemented as overhead lines in the future. On 26 June 2024, it therefore opened a consultation on a revision of the Electricity Act, which lasted until 17 October 2024 and is currently being evaluated (Federal Council, 2024d). Further measures to speed up the planning process for the expansion of the electricity grid are also provided for in the 'acceleration bill' for the construction of solar, wind and hydropower plants (Federal Council, 2023c). The Federal Council adopted the dispatch in June 2023, and it is currently being discussed in Parliament (it is envisaged that the federal government will directly define the planning corridor in transition lines sectoral planning instead of first defining a planning area).

5 see www.swissgrid.ch > Strategic Grid

constructed using the specified transmission technology and that the route lies within the defined planning corridor. In this monitoring procedure, the construction project phase begins as a rule with the definition of the planning corridor (which corresponds to the end of the sectoral plan phase) and ends when Swissgrid submits the planning approval application to the Federal Inspectorate for Heavy Current Installations (ESTI). In projects for which no sectoral plan is used, the start of the construction project is based on the corresponding standard of the SIA (Swiss Association of Engineers and Architects).

PLANNING APPROVAL PROCEDURE (PAP): Swissgrid now submits the detailed construction project to ESTI, together with the application for planning approval. This signals the start of the planning approval procedure. ESTI is responsible for examining the dossier and granting planning approval. In the planning approval procedure, projects are closely examined in order to verify that they comply with the relevant safety requirements and legal provisions, especially those of environmental and area planning legislation. At the same time, the procedure examines network projects to ensure that they are reconcilable with the interests of private individuals (property owners, local population). If the Inspectorate is unable to deal with all objections or settle disputes between the involved federal authorities, it forwards the documentation to the SFOE, which then proceeds with the planning approval procedure and grants planning approval provided the project is in conformity with the legal requirements. A decision is also made on any objections (e.g. concerning expropriation orders). The parties involved can appeal against such decisions to the Federal Administrative Court, and subsequently in certain cases to the Federal Supreme Court. If the SFOE approves the application for planning approval and no other objections are submitted within the legally binding deadlines, planning approval becomes final and Swissgrid can realise the transmission line project.

REALISATION: For monitoring purposes, the start of the realisation phase corresponds to the date of the legally binding planning approval decision, and ends when the facility is put into operation.

NETWORK PROJECT	DESCRIPTION AND MAIN AIMS	CURRENT STATUS[6]	PLANNED DATE OF OPERATION[7]
1. Chamoson–Chippis	▪ New 30km 380-kV overhead transmission line between Chamoson and Chippis ▪ Dismantling of almost 89km of power lines in Rhône plain ▪ Transfer of production from hydropower plants in Valais ▪ Improved connection between Valais and the Swiss and European ultra-high-voltage networks ▪ Contribution towards network security in Switzerland	In operation	Concluded in 2022 and in operation
2. Bickigen–Chippis (Gemmi line)	▪ Modernisation of Bickigen and Chippis substations and the existing 106km route by increasing the voltage to 380 kV ▪ Installation of a 220/380 kV coupling transformer in the Chippis switching facility ▪ Improved transfer of electricity production from Valais ▪ Contribution towards security of supply in Switzerland	SFOE PAP	2029
3. Pradella–La Punt	▪ Increase of the level on the existing 50km route from 220 to 380 kV ▪ Modification and expansion of Pradella switching system for 380 kV ▪ Elimination of existing bottleneck ▪ Contribution towards network security in Switzerland and Europe	In operation	Concluded in 2022 and in operation
4. Chippis–Lavorgo 4.1. Chippis–Mörel (Rhône Valley line) 4.2.Mörel–Ulrichen (Gommer line) 4.3. Chippis–Stalden 4.4. Airolo–Lavorgo	▪ Increase in voltage to 380 kV on 124km Chippis–Mörel–Lavorgo axis (Chippis–Stalden remains at 220 kV) ▪ Dismantling of existing lines over 67km ▪ Supplements main supply axis for Ticino ▪ Elimination of a critical supply bottleneck	4.1. SFOE planning approval procedure 4.2. Realisation (Mörel–Ernen)/in operation (Ernen–Ulrichen) 4.3. Realisation (Agarn–Stalden)/SFOE planning approval procedure (Chippis–Agarn) 4.4. SFOE planning approval procedure	2032
5. Beznau–Mettlen 5.1. Beznau–Birr 5.2. Birr–Niederwil 5.3. Niederwil–Obfelden 5.4. Mettlen–Obfelden	▪ Optimisation of existing 40km route by increasing voltage to 380 kV and upgrading of 24km stretch ▪ Elimination of structural bottlenecks ▪ Creation of necessary conditions for combining the flexibility of domestic hydropower with fluctuating energy from wind and photovoltaic plants	5.1. In operation 5.2. Preliminary project 5.3. Construction project 5.4. Construction project	2031
6. Bassecourt–Mühleberg	▪ Upgrading of the existing line over a length of 45km by increasing the voltage level to 380 kV because decommissioning Mühleberg nuclear power plant will lead to withdrawal of some feed-in at the 220 kV grid level ▪ Contribution to Swiss grid security and supply security	In operation	Concluded in 2023 and in operation

Figure 5: Overview of network projects, status and proposed date of operation (status: 15 October 2024)

6 As at 15 October 2024

7 According to Swissgrid planning

NETWORK PROJECT	DESCRIPTION AND MAIN AIMS	CURRENT STATUS	PLANNED DATE OF OPERATION
7. Magadino	▪ Installation of transformers between the 220 kV and 380 kV grids ▪ The aim is to improve the transfer of energy ▪ generated in Maggia Valley by hydropower ▪ Contribution to security of supply in Ticino	Project proposal	2035
8. Génissiat–Foretaille	▪ Upgrading of (replacement of cable) the existing 220 kV twin lines over a length of 17km ▪ Eliminates frequent bottlenecks which occur for imports from France	In operation	Concluded in 2018 and in operation
9. Mettlen–Ulrichen 9.1. Mettlen–Innertkirchen 9.2. Innertkirchen–Ulrichen (Grimsel line)	▪ Upgrade of the existing 220 kV line to accommodate a future increase to 380 kV220-kV-Leitung auf rund 88 km auf 380 kV ▪ Important for the connection of new pump storage power plants to the 380 kV network and transfer of energy to the rest of Switzerland	9.1. Sectoral plan procedure 9.2. Preliminary project / Construction project[8]	2040
10. All'Acqua–Vallemaggia–Magadino	▪ New 220 kV line through the Maggia Valley ▪ Existing line built in the 1960s will be dismantled, thus lessening the impact on the protected areas in Upper Ticino ▪ Increase of capacity to convey energy generated in hydropower plants in Maggia Valley ▪ Greater security of supply in the southern Alps – today, production at power plants has to be curbed	Sectoral plan procedure	2035
11. Flumenthal–Froloo	▪ Replacement of around 33km of existing 145 kV distribution network lines with a new 220 kV ultra-high-voltage line, as part of the Strategic Grid ▪ New line will improve security of supply in the Greater Basel area and throughout Switzerland ▪ The project is intended to relieve the burden on developed areas between Flumenthal and Therwil – the new line is planned as far from settlements as possible ▪ After operation commences, the existing distribution network line will be dismantled	Sectoral plan procedure	2036
Nant de Drance connection NdD_1 Le Verney/ Rosel–Bâtiaz NdD_2 Bâtiaz–Châtelard NdD_3 Châtelard–Nant de Drance	▪ Connection of Nant de Drance pump storage power plant to the ultra-high-voltage network ▪ Part of the strategic network in the initial Swissgrid network ▪ Contribution towards integration of new renewable energy sources	NdD_1 In operation NdD_2 In operation NdD_3 In operation	Concluded in 2022 and in operation

Figure 5: Overview of network projects, status and proposed date of operation (status: 15 October 2024)

8 Projects 9.2. Innertkirchen–Ulrichen (Grimsel line) is treated as a 'preliminary project' by Swissgrid as long as there are several variants (with / without bundling of the Grimselbahn rail project). In the ES2050 monitoring, the project is referred to as a 'construction project' because the sectoral plan procedure corridor decision for the power line has been taken in principle.

NETWORK PROJECT	DESCRIPTION AND MAIN AIMS	CURRENT STATUS	PLANNED DATE OF OPERATION
ASR (Axe Stratégique Réseau) in the Geneva area	▪ Underground cabling of existing 220 kV line from Foretaille-Verbois over a length of about 4.5km alongside Geneva airport	Realisation	2025
Obfelden–Samstagern OS_1 Schweikrüti (Mast 46)–Kilchberg OS_2 Kilchberg–Wollishofen (Frohalp) OS_3 Wollishofen (Frohalp)–Waldegg OS_4 Obfelden–Waldegg	▪ Expansion and/or substitution of the existing 150 kV line between the Obfelden substation, the planned substation at Waldegg, and the Samstagern substation with a 380/220 kV line. ▪ Improvement to the energy supply of the consumer centres of Zurich and the region of Thalwil.	OS_1 Realisation OS_2 Construction project OS_3 Construction project OS_4 Construction project	2030
Grynau–Siebnen	▪ Replacement of existing 220 kV line with a 380 kW line (closing the gap in the 380 kV network) ▪ Improvement of supply security in the Lake of Zurich region/Linth plain and 1. Increase in import capacity from the north	SFOE planning approval procedure	2028
Amsteg–Mettlen AM_1 Abschnitt Lauerz AM_2 Eyschachen bei Altdorf	▪ AM_1: Swissgrid to place the line outside landslide area above Lauerz (SZ) ▪ AM_2: Swissgrid and Swiss Federal Railways to install ultra-high-voltage lines in the Uri valley floor. 2.This will relieve the burden on the developed areas in Attinghausen and the Werkmatt developed area in Uri.	AM_1 Construction project AM_2 In operation	2040
Airolo–Mettlen	▪ Bundling of infrastructure in the second tube of the Gotthard Road Tunnel ▪ Cabling of the existing 220 kV line from Airolo–Mettlen in the Gotthard sector planned over a length of 18km ▪ Important element of the north-south connection for electricity supply in Switzerland and Europe ▪ Dismantling of existing overhead line over a 23km stretch with more than 70 masts that currently traverse the Gotthard Pass and run through the Schollenen Gorge in the canton of Uri	ESTI planning approval application	2029
Marmorera–Tinzen	▪ Ultra-high-voltage line between Marmorera and Tinzen in the Albula region (canton of Graubünden) no longer corresponds to latest status of technology and needs to be replaced (220 kV as today). ▪ This line plays a significant role in the transfer of energy from Bergell hydropower plants to consumer centres in the central plateau.	Sectoral plan procedure	2032

Figure 5: Overview of network projects, status and proposed date of operation (status: 15 October 2024)

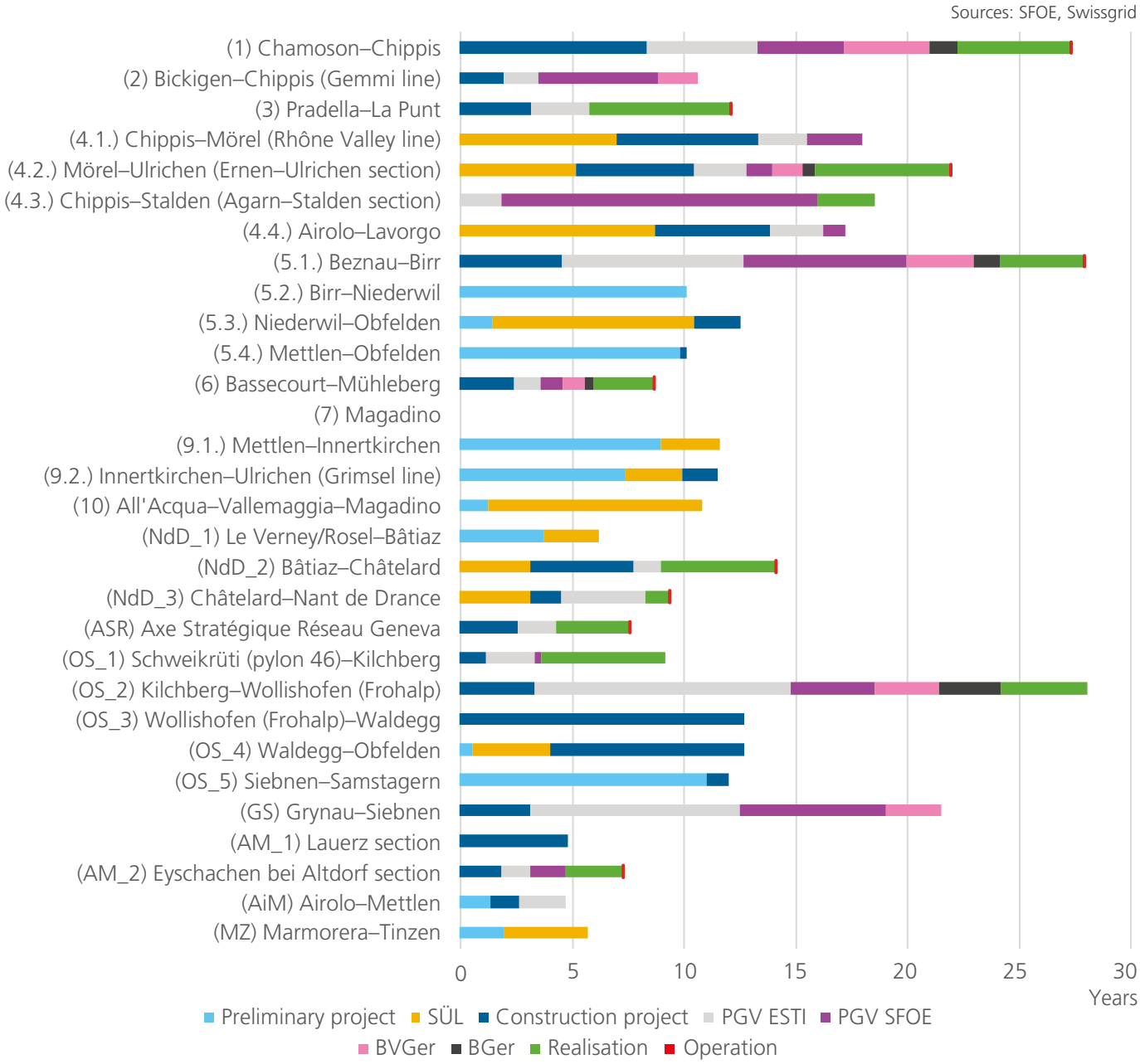


Figure 6: Accumulated duration of project phases of selected network plans in years at network level 1 as at 15 October 2024 in years[9]

Figure 6 shows the duration of the individual project phases for the network projects listed above. The duration is presented in a simplified manner in that any supplementary loops in the course of the project (i.e. if the procedure is returned to the SFOE after a decision by the Federal Administrative Court and/or the Federal Supreme Court) are not shown separately. If specific project phases have to be gone through again as a result of a court decision, the overall duration of single project phases is presented as if each was unique and proceeded linearly.

*9 **Remarks on method of use**: a) In the case of grid plans with a long preliminary period the duration was calculated from the relaunch of the project concerned; b) in the case of plans with a long preliminary period, it is not always possible to establish the preliminary project phase and the construction project phase, which is why they are not shown in the figure in some cases; c) assumptions were made in agreement with Swissgrid about some dates which are no longer known; d) when the courts refer a planning approval procedure decision to the SFOE, half of the supplementary duration of the procedure is allotted to the planning approval procedure phase and half to the construction project phase.*

BRIEF DESCRIPTION OF THE PLANNING AND REALISATION STAGES OF EACH NETWORK PROJECT (STATUS: 15 OCTOBER 2024):

1. Chamoson–Chippis
Construction of the new line from Chamoson to Chippis in the canton of Valais was initiated before the Transmission Lines sectoral plan was developed, and the project was the subject of planning and approval phases for many years. An important milestone was reached in 2017: in its decision of 1 September 2017, the Federal Supreme Court dismissed the appeals against the ruling of the Federal Administrative Court of 14 December 2016 and confirmed the decision by the SFOE of 19 January 2015 concerning the planning approval procedure. Swissgrid then proceeded with the realisation of the new overhead transmission line project. The actual building work got under way in 2018. After four years of construction, Swissgrid put the line into operation at the end of September 2022. In some cases the dismantling of third party lines, which was ordered in connection with the project, is still outstanding, but this has no impact on the Chamoson–Chippis line.

2. Bickigen–Chippis
The Transmission Lines sectoral plan procedure could be dispensed with for the project to increase the voltage and modernise the existing line between Bickigen and Chippis, because the project only had a modest impact on the area. After a construction project phase of around two years, the PAP commenced with an application to ESTI in mid-2015, and almost two years later the dossier was passed on to the SFOE. The SFOE granted planning approval in February 2022. However, various appeals were lodged against this decision with the Federal Administrative Court. The court partially upheld the appeals in mid-December 2023 and referred the planning approval dossier back to the SFOE for reassessment in line with its reasoning. The proceedings must now undertake further clarifications with regard to a possible reduction of corona noise (caused by tiny discharges under high-voltage lines) and with regard to non-ionising radiation. Implementation of the project is expected to be delayed by a further two years until 2029 due to the appeal proceedings and the referral to the SFOE.

3. Pradella–La Punt
As part of the project to increase grid capacity, a second continuous 380 kV circuit will be added to the 50km line between Pradella and La Punt. This will substitute the transfer of energy on the existing 220 kV overhead transmission line between Zernez and Pradella from the Ova Spin power plant. The energy generated at Ova Spin power plant will be transported over a 110 kV valley cable. No sectoral plan procedure was necessary because of the minimal impact on the area. The construction project and planning approval procedure phases each lasted about three years. The implementation phase started in mid-2016 and Swissgrid put the line into operation in November 2022.

4. Chippis–Lavorgo
Operation of the entire Chippis–Lavorgo network project is scheduled for 2032. It comprises several sub-projects, the current status of which is described below:

4.1. Chippis–Mörel (Rhône Valley line)
The project for the construction of the new line underwent a sectoral plan procedure and took almost six and a half years. The planning application procedure was initiated by ESTI in late March 2019. In June 2021, ESTI passed on the procedure to the SFOE. Within the scope of the planning approval procedure, the SFOE is examining the application from the canton of Valais, together with sectoral plan related issues in the Agarn–Mörel segment due to a new cabling study. Based on the insights gained from these issues, the SFOE had to request supplementary documents and studies from Swissgrid regarding a potential cabling of the line in the Chippis–Agarn segment (Pfyn forest).

4.2. Mörel–Ulrichen
Construction of the new line underwent planning and approval phases lasting several years; the section between Ernen and Ulrichen has been in operation since mid-October 2019; in the Mörel–Ernen section, the cabling study ordered by the Federal Supreme Court for the 'Binnegga–Binnachra–Hockmatta–Hofstatt' area (crossing the Binna) was submitted to the SFOE; the SFOE approved the overhead line version on 23 December 2016 and dismissed all objections. Objections to the decision were submitted to the Federal Administrative Court, which confirmed on 26 March 2019 that the overhead power line variant would be implemented. No appeal was lodged with the Federal Supreme Court, and the ruling is now legally binding. Construction of the line is in progress.

4.3. Chippis–Stalden
A planning approval procedure for the Agarn–Stalden segment took several years for the SFOE to process, and was concluded and became legally binding in the spring of 2022. It has since been in the realisation phase. This concerns a procedure under former legislation for which no sectoral plan procedure could be initiated. In 2012, it was determined in the sectoral plan procedure for the line from Chippis to Mörel that the Chippis–Agarn segment (Rhône Valley line) would have to be fed parallel to the Rhône Valley line through the Pfyn forest. Accordingly, the planning application for the construction of this segment was submitted to ESTI at the end of March 2019, together with the planning application for the Rhône Valley line. In June 2021, ESTI passed on the application to the SFOE. The planning approval procedure for the Chippis–Agarn section is therefore also pending with the SFOE *(see 4.1 Chippis–Mörel)*.

4.4. Airolo–Lavorgo
The project for the construction of the new line underwent a sectoral plan procedure lasting almost nine years and the construction project planning took a full four years. At the end of April 2020, Swissgrid submitted the planning approval dossier to ESTI, which transferred it to the SFOE in mid-September 2022. The SFOE suspended the ongoing planning approval procedure temporarily because various documents had to be revised. The project has been suspended again since mid-March 2024 until probably mid-January 2025.

5. Beznau–Mettlen
Operation of the overall Beznau–Mettlen project is planned for 2031. It comprises several sub-projects, the current status of which is described below:

5.1. Beznau–Birr
The line with partial underground cabling of 'Gäbihubel' at Riniken was initiated before the Transmission Lines sectoral plan was developed, and went through planning and approval phases lasting many years. A key milestone was reached in 2016: the SFOE's planning approval became final and the realisation got under way. Contrary to the original plan, construction work for the cable route could only commence in August 2018. Since then, work has progressed rapidly and on 19 May 2020, Swissgrid began to operate the line, including the cited partially cabled section in which a longer section of the 380 kV ultra-high-voltage line was placed underground.

5.2. Birr–Niederwil
The preliminary project for the section of the line was completed in September 2022. The next steps are currently being clarified.

5.3. Niederwil–Obfelden
The voltage increase was subject to a preliminary project phase lasting around 18 months and underwent a sectoral plan procedure lasting several years. A significant interim stage was reached in 2016 with the definition of the planning zone. In late August 2022, the Federal Council defined the planning corridor. Swissgrid subsequently initiated the development of the construction project.

5.4. Mettlen–Obfelden
This section was in the preliminary project phase for a number of years. This was temporarily suspended to await the Federal Council's decision on the planning corridor and on the transmission technology (*see 5.3*). In June 2024, the SFOE decided that a transmission lines sectoral plan procedure can be dispensed with, as the project to increase the operating voltage from 220 to 380 kV has no significant impact on space and the environment. Swissgrid is now preparing the PAP dossier for submission to ESTI.

6. Bassecourt–Mühleberg
The Bassecourt–Mühleberg extra-high-voltage line was licensed by ESTI to operate at 380 kV in 1978, but it has been operating at 220 kV to date. No sectoral plan procedure was required for the envisaged increase in voltage because of the minimal impact the project would have on the area. After a construction project phase lasting about two and a half years, Swissgrid submitted the PAP dossier to ESTI on 30 June 2017. A number of objections to the project were submitted. ESTI handed the dossier over to the SFOE on 24 August 2018 and the planning approval was granted on 22 August 2019. A number of objectors lodged appeals against this decision with the Federal Administrative Court. In its ruling of September 2020, the latter dismissed the objections it examined. The ruling was referred to the Federal Supreme Court. In its ruling dated 23 March 2021, the court dismissed the objections, and implementation was initiated; the line went into operation with a voltage of 380 kV on 21 November 2023.

7. Magadino
A preliminary study proposing several options is currently being compiled in order to subsequently initiate the preliminary project. According to Strategic Grid 2025, operation was originally foreseen for 2018, but according to updated plans it is now planned for 2035.

8. Génissiat–Foretaille
Swissgrid has adapted the scope of the project and reduced it to eliminate the bottlenecks between France and Switzerland. The original plan to strengthen the Foretaille–Verbois line on the Swiss side with a transmission line facility has been abandoned. Additional cables on the French side of the Génissiat–Verbois line and the corresponding modification of protection for the line in Switzerland and France are sufficient in the opinion of Swissgrid; the bottleneck in France has been eliminated. The project was concluded in 2018 and the line is in operation.

9. Mettlen–Ulrichen
Operation of the overall project is currently planned for 2040. It comprises two sub-projects, the current status of which is described below:

9.1. Mettlen–Innertkirchen
This section of line was in the preliminary project phase for a number of years. At the end of June 2020, Swissgrid applied to the SFOE to initiate a sectoral plan procedure for a new line into Innertkirchen substation. However, at the beginning of June 2021 the project was cancelled at the request of the applicant because the line is now to be integrated into the sectoral plan procedure for the complete stretch. The sectoral plan procedure for the complete stretch started in late June 2021. The SFOE announced the planning area in mid-November 2022. In May 2023, Swissgrid submitted the documents for the second phase of the sectoral plan procedure to the SFOE. This phase, which has been ongoing since then, involves defining the planning corridor.

9.2. Innertkirchen–Ulrichen (Grimselleitung)
Upgrading of the existing 220 kV line to 380 kV between Innertkirchen and Ulrichen (Grimsel line) along its full length is a key element in Network Strategy 2025. Swissgrid applied for a sectoral plan procedure for this line at the beginning of July 2020. The Federal Council determined two potential planning corridors in February 2022: if the Grimselbahn project is realised on time, the line will be bundled with the rail project and mounted in a cable tunnel

running parallel to the railway tunnel; alternatively, the line will be laid in a cable tunnel between Innertkirchen and Oberwald. In both cases the line between Oberwald and Ulrichen will be an overhead line.

10. All'Acqua–Vallemaggia–Magadino
Planning of the line project in the All'Acqua–Maggiatal–Magadino area (and of the above-mentioned sub-project 4.4. Airolo–Lavorgo) is based on a comprehensive study carried out in 2013 concerning the reorganisation of the ultra-high-voltage network in Upper Ticino to coordinate the refurbishment and modernisation of lines in coordination with spatial planning. Subsequently, the preliminary project phase was prepared, and the sectoral plan procedure was initiated in 2015. In 2016, a significant stage in the project was attained when the planning area was defined. In view of its length, the project was divided into three segments for the implementation of the sectoral plan procedure so that it could be carried out in manageable stages. However, the definition of the planning corridor on the Avegno to Magadino stretch has been delayed due to the question concerning the location of the Magadino substation, which is in the perimeter of the 'Piano di Magadino' biosphere reserve. The hearing is currently under way for all three stages of the planning corridor proposed by the SFOE, and a decision on it is expected from the Federal Council at the end of 2024. Operation of the new 220 kV line is planned for 2035.

11. Flumenthal–Froloo
The preliminary project for the new 220 kV transmission line between Flumenthal (SO) and Froloo (in the commune of Therwil, BL) was launched in 2018. In early April 2022 Swissgrid submitted an application to the SFOE to start the sectoral plan procedure. Operation is planned for the end of 2036.

(Source: SFOE/Swissgrid, 2024/Swissgrid 2015)

↗ Description of other selected projects:
full version of the monitoring report.

UNDERGROUND CABLING

Source: ElCom

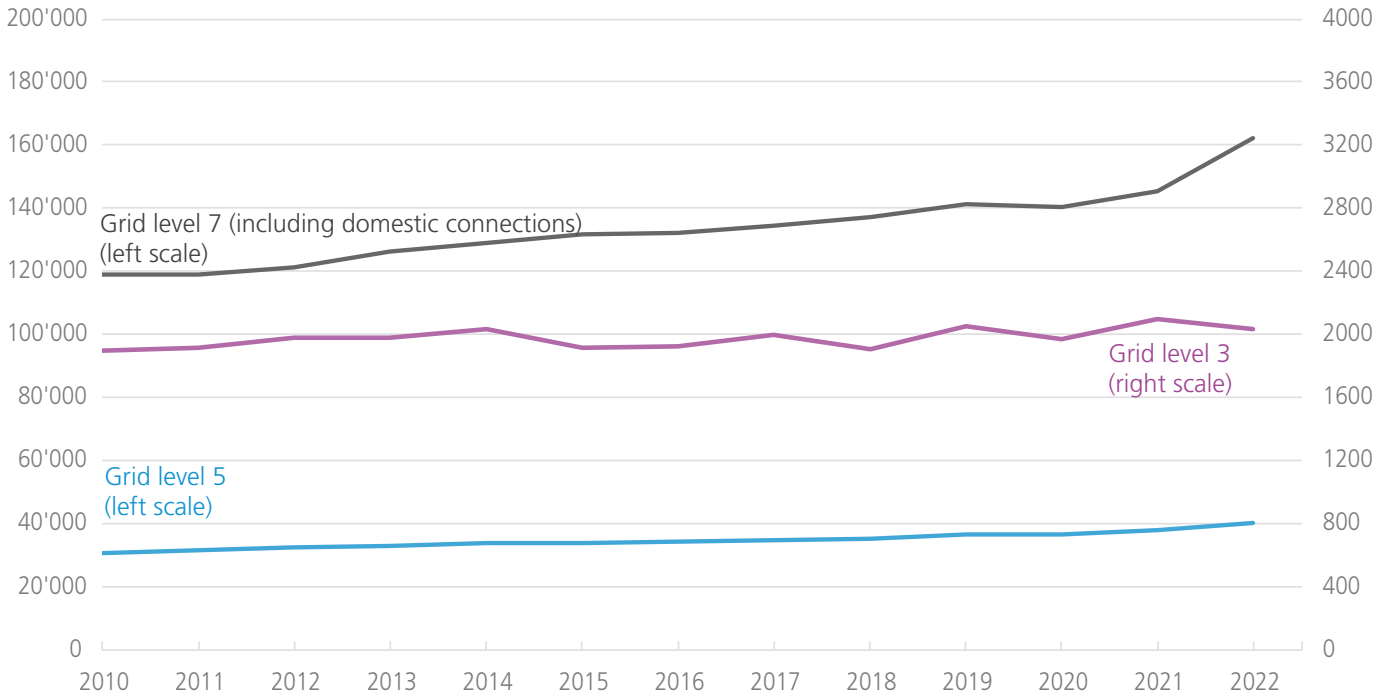


Figure 7: Inventory of underground cabling in the distribution network (in kilometres)

Laying electricity cables underground can contribute to greater acceptance of line construction by the population so that projects can be completed more quickly. Furthermore, as a rule the quality of the landscape is improved and the risks of electrocution and of birds colliding with installations can be avoided. However, whether to construct a transmission line (network level 1) as an overhead line or place it underground has to be decided on the basis of objective criteria[10] on a case-by-case basis. As mentioned, the Federal Council wants to further speed up the conversion and expansion of the electricity grid. As part of a revision of the Electricity Act, one of its proposals is therefore that transmission lines should in future be realised as overhead lines in principle. The consultation ran until 17 October 2024. In accordance with the Federal Act on the Conversion and Expansion of the Electricity Grid (Electricity Grid Strategy), distribution network lines (network levels 3, 5 and 7) should be placed underground provided a specific cost factor is not exceeded (cost overrun factor). For this reason, the monitoring process primarily observes the development of the use of underground cabling at the distribution network level. This also provides information concerning the impact of the cost overrun factor.

More cables have been placed underground at all network levels in the distribution network to varying extents since 2010, as shown in **Figure 7**. Generally speaking, there is more underground cable in use at lower network levels; network level 7 in particular consists almost entirely of underground cable. At network level 5 too, cabling is widespread, especially in urban areas. In contrast, only a slight increase in the number of underground lines can be observed at network level 3, and to a lesser degree than at all other levels (*see purple curve in the upper graph with differing scale*). The trend towards underground cabling is not so pronounced at this level. In addition, repeat-

ed declines in underground cabling were observed (most recently between 2021 and 2022), the reasons for which are not clear. The total length of the three transmission network levels (overhead transmission lines and cables, including domestic connections) is 225,844 kilometres, of which around 90% consists of underground cables. To date, very few lines have been laid underground in the transmission network (grid level 1), which has a total length of 6,700 kilometres. However, in the case of the Beznau–Birr line (*see p. 21*) with partial cabling at Gäbihubel near Bözberg/Riniken, a longer section (around 1.3 kilometres) of a 380 kV extra-high-voltage line was laid in the ground and put into operation. As part of the connection of Nant de Drance pumped-storage power plant, the Bâtiaz–Le Vernay section was also laid underground. The new 2 x 380 kV cable replaced the existing 220 kV overhead line that crossed the Rhône Valley over a distance of 1.2 kilometres. This section has been in operation since early April 2022 (*see Figure 5*). A further underground cable project involving a transmission line concerns the replacement of the existing 220 kV line over a length of 4.5 kilometres for the ASR project in the canton of Geneva. In addition, the 220 kV extra-high-voltage line between Airolo and Mettlen is to be cabled in the Gotthard road tunnel between Airolo and Göschenen over a length of around 18 kilometres (sources: ElCom, 2024/SFOE/Swissgrid, 2024).

10 see SFOE transmission lines evaluation model: Overhead lines versus underground cables (admin.ch). As part of a revision of the Electricity Act, the Federal Council is proposing, among other things, that an overhead line principle should apply in the transmission grid in future (see Figure 5). Underground cables would have to be considered only if certain criteria are met, such as if an overhead line would impair protection against non-ionising radiation or the protection of objects that are of national importance in terms of nature and cultural heritage protection.

SMART METERS

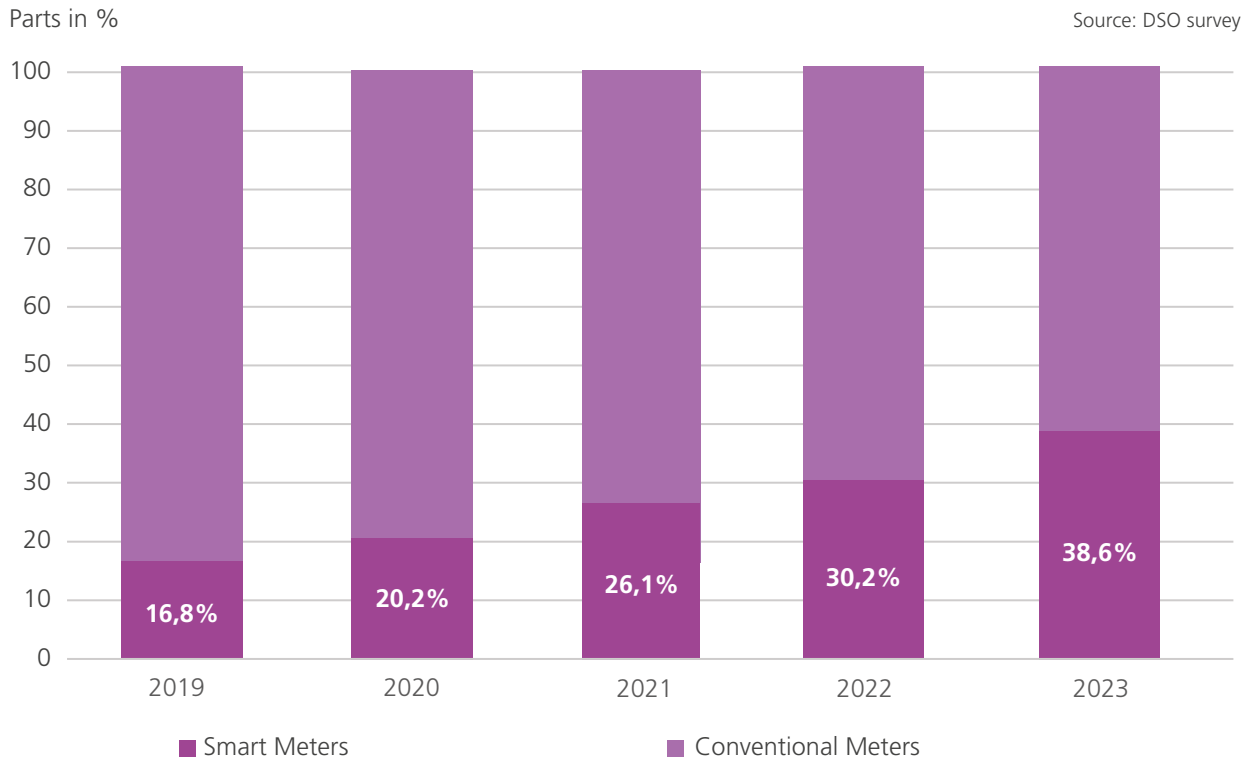


Figure 8: Share of smart meters compared with conventional meters[11]

Smart meters are a central component of intelligent networks. Their introduction is regarded as an important initial step towards creating smart networks. The Electricity Supply Ordinance therefore specifies the applicable minimum technical requirements and calls for the introduction of such systems. After an interim period of 10 years from the entry into force of the Electricity Supply Ordinance at the beginning of 2018 (i.e. by the end of 2027), 80% of all metering systems in a network zone will have to comply with the corresponding requirements; the remaining 20% may remain in use until they no longer function. According to information from distribution system operators, in 2023 there were 2,240,109 smart meters installed and in operation throughout Switzerland. This represents a proportion of around 39%, as shown in **Figure 8**. The proportion has constantly increased during the past few years (source: DSO, 2024).

11 Data based on survey of distribution network operators (plausibility check only possible to a limited extent).

↗ For more detailed indicators regarding **GRID DEVELOPMENT** see the full monitoring report.

SECURITY OF SUPPLY

During the transformation of the energy system, with the increased use of renewable energy, improved energy efficiency and growing decarbonisation and electrification, particular attention must be paid to security of supply. One of the objectives of Energy Strategy 2050 is to ensure the current high level of supply security is maintained in the long term. The matter of supply security is also embedded in the article on energy in the Federal Constitution and in the Energy Act. By categorising energy sources (diversification) and dependency on foreign supplies, the monitoring process tracks indicators that characterise key aspects of supply security development from an overall energy perspective. With the phase-out of nuclear power, the increased use of renewable energy, improved energy efficiency and the longer-term decarbonisation and electrification of the energy system, the electricity sector remains a central focus.

DIVERSIFICATION OF THE ENERGY SUPPLY

Figure 9 shows that oil products (combustibles and motor fuels, including aviation fuel in international air traffic) accounted for over 46% of final energy consumption in 2023. Electricity accounted for approximately 26% of overall final energy consumption and gas around 12%. Following a decline as a result of the COVID-19 pandemic, the share of oil-based motor fuels increased in 2023 by 1.5 percentage points year-on-year and was thus at roughly the same level as in 2000. This increase is primarily due to higher sales of aircraft fuel. Despite the cooler weather, the proportions of oil-based combustibles (–0.4 percentage points year-on-year) and gas (–1 percentage point) declined. The continuing high energy prices resulting from Russia's military attack on Ukraine heightened awareness due to the strained situation, and substitution effects are likely to have contributed to this. In the longer term (between 2000 and 2023), the proportion of oil-based combustibles has fallen by 13 percentage points as a result of the replacement of oil-fired heating systems and efficiency increases in buildings. For this reason, the proportions of all other energy sources (except coal) have increased: gas (+1.3 percentage points), electricity (+4 percentage points), wood and charcoal (+2.2 percentage points), and other forms of renewable energy (+3.8 percentage points) and district heat (+1.4 percentage points). Overall, the energy supply is broadly diversified, which contributes towards the high degree of supply security in Switzerland (source: SFOE, 2024a).

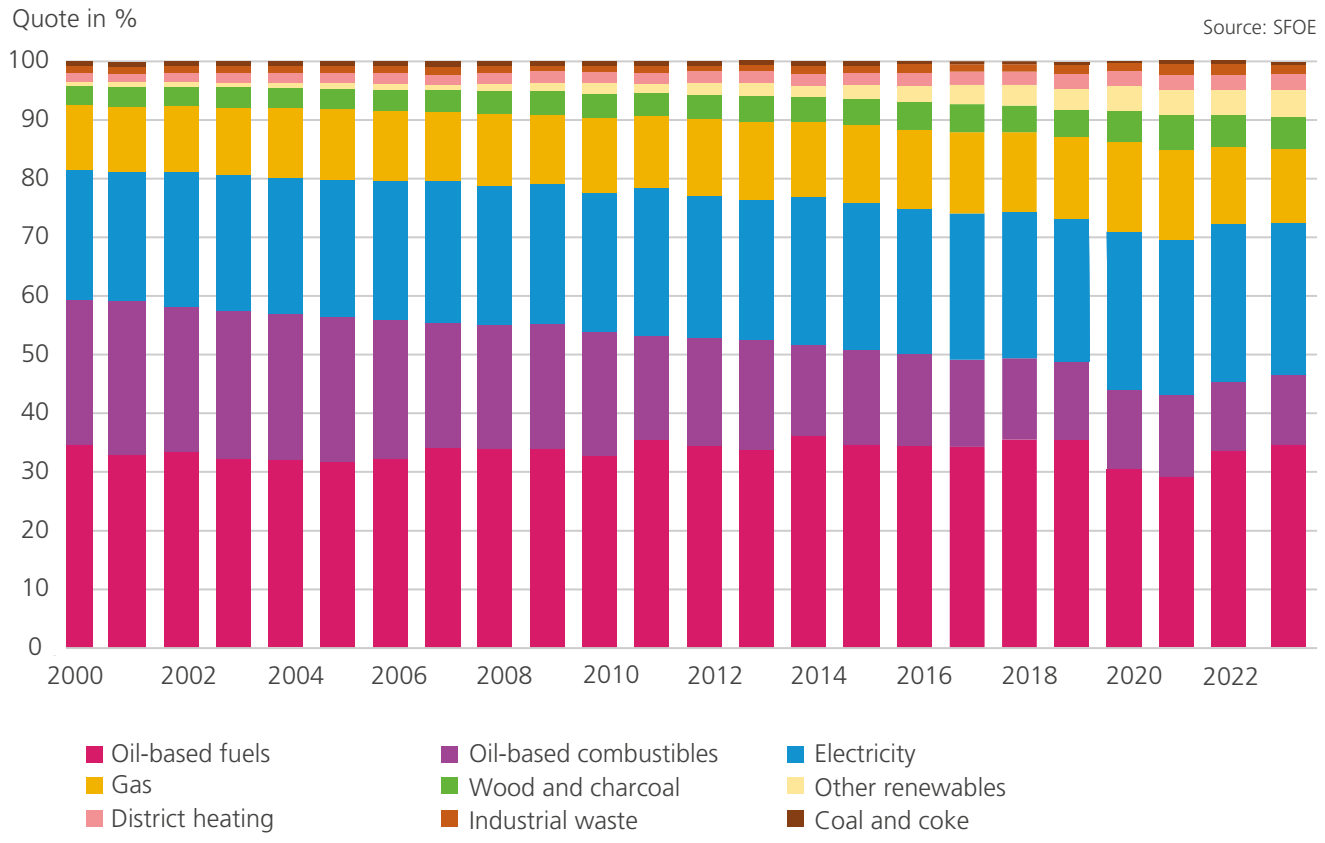


Figure 9: Diversification of the energy: proportion of energy sources to end energy consumption

DEPENDENCY ON IMPORTS

Switzerland's energy supply is characterised by a high degree of dependency on imports. This dependency can be reduced by expanding domestic renewable energies and improving energy efficiency. However, Switzerland remains part of the global energy market and is not aiming for energy self-sufficiency. Energy Strategy 2050 nevertheless aims to reduce the current high level of dependency overall. To analyse dependency on imports, monitoring is based on the MONET indicator system for sustainable development, looking at the development of gross energy imports (import surplus of energy sources and nuclear fuels[12]) and at the same time how much energy is produced domestically. This indicator shows the ratio between domestically produced and imported energy and thus Switzerland's dependency on energy imports.

Figure 10 indicates that the import surplus showed an upward trend between 2000 and 2006, after which it fell, though with occasional strong fluctuations. At the same time, domestic production has shown an overall increase since 2000. Following the prolonged drought in 2022, which led to a sharp decline in hydropower production, domestic generation increased again in 2023 and reached a level not seen since 2000. While hydropower remains the primary domestic energy source, other renewable

Source: SFOE

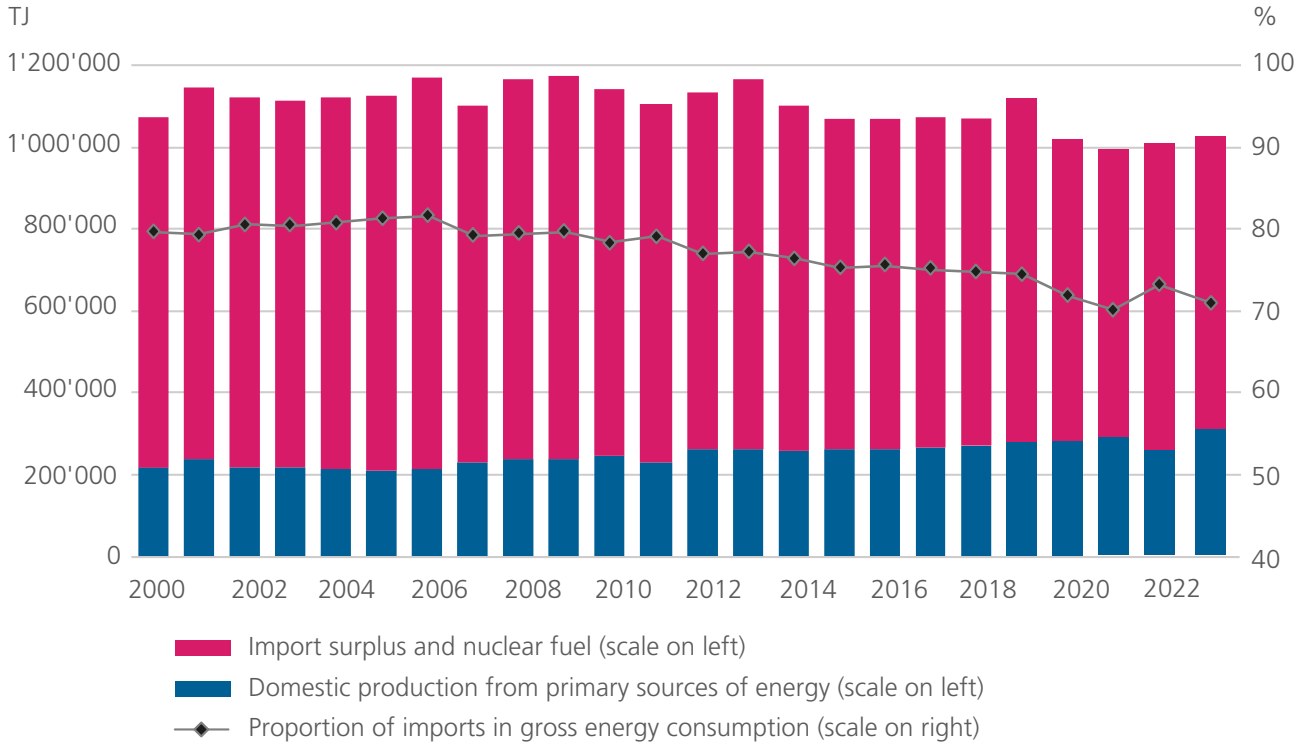


Figure 10: Import surplus and domestic production (in TJ) and proportion of energy imports to gross energy consumption (in %)

energy sources continue to show steady growth. Gross imports were mainly composed of fossil fuels and nuclear fuels. As indicated by the black curve on the graph, the ratio of imports to gross energy consumption (dependency on imports) increased from 2000 to 2006 and then declined until 2021. Import dependency rose again in 2022, primarily due to reduced domestic production and a sharp increase in aviation fuel imports. While dependency fell again in 2023, it remains high: the proportion of imports to gross energy consumption was 71.2% (compared to 73.7% in 2022, 70.7% in 2021 and 81.6% in 2006). This ratio should be interpreted cautiously as several factors influence it. Generally speaking, energy efficiency measures that reduce consumption – particularly of fossil fuel imports – and the expansion of domestic renewable energy production help reduce import dependency and strengthen supply security (sources: SFOE, 2024a/FSO/FOEN/ARE, 2024).

12 In the case of nuclear fuels, the thermal energy produced – not the electricity produced – is included in accordance with international conventions with an efficiency of 33%.

ELECTRICITY SUPPLY SECURITY: SYSTEM ADEQUACY AND WINTER PRODUCTION CAPACITY

The phase-out of nuclear energy under Energy Strategy 2050 and the longer-term decarbonisation of the energy system present major challenges for Switzerland's supply security. The Federal Act on a Secure Electricity Supply from Renewable Energy Sources, effective 1 January 2025, establishes various measures to improve long-term supply security. These measures include additional funding for expanded winter production (mainly hydropower storage plants and Alpine solar installations), the creation of an energy reserve, and increased use of renewable energy (Federal Council, 2023). Russia's military attack on Ukraine and the resulting concerns over gas shortages have brought immediate and mid-term supply security into sharp focus. The Federal Council implemented various measures in response, and in summer 2022 tasked the SFOE with preparing a study on short-term system adequacy for winter 2022/23. In 2023 ElCom also updated its supply security analyses for 2025.

In Switzerland, electricity supply security relies on the interplay between power plant capacity and the electricity grid that enables energy transmission and distribution. The cross-border electrical transmission grid supplements domestic power plant capacity with imports and is equally crucial for supply security. Switzerland's high level of interconnection means it is increasingly affected by conditions in neighbouring countries. As circumstances can change over time due to strategic shifts in other countries (particularly within the EU), regular comprehensive analyses of system adequacy are essential to assess the supply security situation accurately. System adequacy analyses are based on detailed supply situation modelling that reflects strategic approaches to production and consumption, while accounting for international exchange. Like all simulations, the modelling methods used in system adequacy studies have their limitations and require simplified assumptions. The underlying data assumptions about European and Swiss system developments – and their uncertainties, especially long-term – are particularly significant. Therefore, the resulting simulations should be viewed not as predictions but as indicators of developments considered critical from a system-wide perspective.

Study on short-term system adequacy (winter 2022/23): Due to the strained supply situation following Russia's military attack on Ukraine, a system adequacy study was conducted for winter 2022/23, commissioned by the SFOE in cooperation with ElCom and FONES. The study concluded that while Switzerland's electricity supply was not at immediate risk, shortages could not be ruled out in extreme circumstances. This assessment remains broadly applicable to the following winter, provided no new risk factors emerge from current developments.

The study examined and simulated various scenarios with different availabilities of gas and nuclear power plants. Combinations of meteorological conditions and power plant outages were also run through and the probability of bottlenecks calculated. Only in the scenarios with gas shortages or a combination of limited gas availability across Europe and the unavailability of Swiss nuclear power plants was it not possible to fully cover electricity consumption at all times. In the most likely scenarios, energy consumption can be covered by the measures listed below. A hydropower reserve will secure energy supply at the critical stage towards the end of winter. The provision of a temporary reserve power plant in Birr (canton of Aargau) and other reserve power plants and emergency generators can plug any gaps in power supply independently of the market. The other measures, such as increasing capacities in the transmission grid, the backstop for system-critical power companies, and the temporary reduction in

the residual flow in hydropower plants, will further strengthen winter supply. Voluntary efforts by businesses and individuals to use less energy also play an important part (source: SFOE/ElCom/FONES, 2022).

Towards the end of 2022, the SFOE published an SA study with **a timeframe up to 2040**. Based on Energy Perspectives 2050+, which includes the 2050 net-zero climate target, this study assessed medium and long-term electricity supply security. While it considered factors such as the absence of an electricity agreement, time constraints meant potential gas shortages were not included *(see p. 31: short-term SA study)*. The study identified three critical factors for Switzerland's supply security: hydropower, import capacity and broader European developments. With effective coordination between hydropower and imports, even significant shortages in Switzerland or Europe would remain manageable. Other key findings showed that:

- With the expansion of renewable energy, the European electricity supply system will become increasingly dependent on weather conditions. From a purely physical perspective and based on the assumed scenarios, dependence on weather conditions could lead to a maximum of 250 GWh of unmet electricity demand in Switzerland by 2040. From a market perspective, however, there are no problems for Switzerland as long as it is well integrated into the overall European system.

- Without European cooperation, Switzerland risks supply shortages from 2030 during certain weather patterns if current framework conditions (as of 2019) are not adapted for expansion of renewable energy. This analysis does not account for the impact of either the Federal Act on a Secure Electricity Supply from Renewable Energy Sources or the Federal Act on Urgent Measures for the Short-Term Provision of a Secure Electricity Supply in Winter.

- However, if the expansion of renewable energies is effectively sped up, there will be no supply bottlenecks even without cooperation – except in the case of very strong electrification in specific unfavourable weather conditions.

- If limited exchange capacities (due to lack of cooperation) coincide with major incidents in Switzerland or neighbouring countries (such as power plant outages), this would significantly impact Switzerland. In such situations, any additional domestic energy helps, with the flexibility of Swiss hydropower being particularly crucial, as additional energy can be optimally integrated into the system through pump usage or modified power plant schedules (source: University of Basel/ETH Zurich/Consentec, 2022).

Additionally, the European association ENTSO-E publishes the annual European Resource Adequacy Assessment (ERAA). The 2023 analyses show no significant supply bottlenecks for Switzerland **through to 2033**, although safety margins will remain low in coming years. As supply security has transnational implications, Switzerland's continued integration into the European system remains vital. The report also concludes that reduced exchange capacities between Switzerland and neighbouring countries negatively impacts both Switzerland and surrounding nations. To prevent such reductions, Swissgrid has established a technical agreement with the Italy North[13] capacity calculation region and is working toward an agreement with the CORE[14] region. The ERAA 2024 was submitted to ACER in November 2024 (source: ENTSO-E, 2023).

ElCom updated its analyses of medium- and long-term electricity supply security in 2023. It directed

Swissgrid to recalculate its **2025 supply security analysis** with modified scenarios, while also updating its calculations on **winter production capacity** through 2035 with new projections for nuclear power plant operating lives, electricity demand, and renewable energy expansion.

In the 2025 system adequacy study, stress scenarios were modified from the 2023 analysis to reflect recent experiences related to Russia's attack on Ukraine and the extremely low availability of French nuclear power plants. Assumptions about domestic power generation availability were also updated (particularly regarding Beznau I and II operation beyond 2025).

In the updated reference scenario, none of the 2025 simulations indicates supply issues. Even in the evaluated stress scenario (with gas shortage and low nuclear power plant availability), while shortages do not occur, they cannot be completely ruled out. In a worst-case scenario, an electricity shortfall of around 500 gigawatt hours (GWh) would be expected. If the relatively high assumed redispatch (power plant interventions to stabilise the grid) in the simulation is reduced by half, the electricity shortfall decreases to 113 GWh.

For the longer-term outlook to 2030 and 2035, ElCom has updated its winter production analysis. This focuses on power generation and domestic demand, while excluding foreign developments and import opportunities. The analysis thus provides simplified parameters for Switzerland's longer-term supply resilience, using two indicators. As in ElCom's previous white paper on winter production, one indicator measures Switzerland's winter import requirement. The other counts the number of days Switzerland could maintain self-sufficiency towards winter's end when seasonal storage facilities are largely depleted, assuming temporary import unavailability due to European supply constraints.

ElCom develops scenarios based on various projections from established institutions and policy objectives. The resilience benchmarks are the Parliament-defined winter import limits (5,000 GWh or 20% of average winter power consumption) or at least 22 days of self-sufficiency (approximately the current level). Both indicators show considerable uncertainty in supply resilience trends: to meet targets (assuming 60-year nuclear power plant operation), continuous output capacity reserves of between 0 and 1,400 MW would be needed by 2030, and between 0 and 2,100 MW by 2035, depending on the scenario.

Based on these studies, ElCom recommends thermal reserve power plant capacity of at least 400 megawatts (MW) for 2025, and 700 to 1,400 MW from 2030. Given the high uncertainty, a gradual approach is logical to allow reserve expansion if needed.

Currently, the following supplementary reserves are available until spring 2026: reserve power plant Birr (AG), 250 MW capacity; reserve power plant Corneaux 1 (NE), 36 MW capacity; gas-fire combined cycle power plant Monthey (VS), 50 MW capacity; pooled emergency generators[15], approx. 110 MW capacity. At the end of July 2023, the SFOE launched the first tender for reserve power plants post-2026, seeking 400 MW capacity. The tender was abandoned in June 2024 due to excessive cost proposals. The SFOE has since begun direct negotiations with providers (sources: Swissgrid, 2023/ElCom, 2023/SFOE 2024f).

13 Italy, France, Austria and Slovenia

14 Austria, Belgium, Croatia, Czech Republic, France, Germany, Hungary, Luxembourg, the Netherlands, Poland, Romania, Slovakia and Slovenia

15 Continuous power operation is the aim for the emergency generators.

↗ For more detailed indicators regarding **SECURITY OF SUPPLY** see the full monitoring report.

EXPENDITURE AND PRICES

In addition to safety and environmental compatibility, a further significant dimension for a sustainable energy supply is economic viability. Energy Article 89 in the Federal Constitution and Article 1 of the Energy Act specify that a sufficient, diversified, safe, economic and environmentally compatible energy supply must be assured. The purpose of Energy Strategy 2050 is to successively reorganise Switzerland's energy system as a consequence of the phasing out of nuclear energy and other significant changes in the energy environment, without jeopardising the international competitiveness of Switzerland as a business location. The focus in this area is therefore on monitoring final consumer expenditure for energy and energy prices.

FINAL CONSUMER EXPENDITURE FOR ENERGY

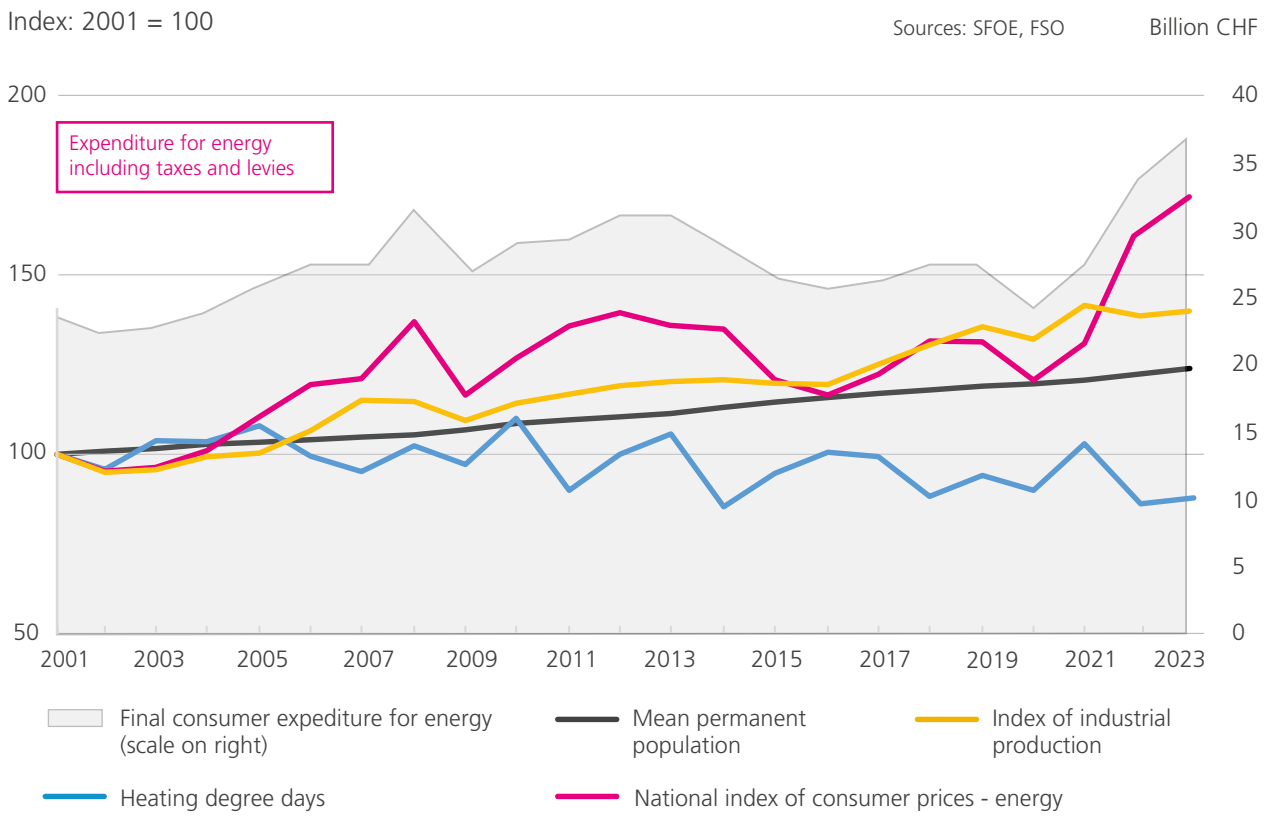


Figure 11: Final consumer expenditure for energy (estimates in billion Swiss francs) and significant influencing factors (indexed)

Figure 11 shows the evolution of final consumer expenditure for energy in Switzerland, which reached approximately CHF 36.4 billion in 2023. This followed the lowest point since 2004, which occurred in 2020 at CHF 24.1 billion. Expenditure then rose sharply: by 13% in 2021 (to around CHF 27.3 billion), by 22% in 2022 (to CHF 33.2 billion), and a further 10% last year. Rising energy prices drove this increase, with the energy component of the Swiss Consumer Price Index climbing 30% over two years. Between 2021 and 2023, expenditure increases were particularly marked for electricity (62%) and gas (40%). At CHF 18.4 billion, fossil combustibles and fuels (oil-based combustibles, motor fuels, gas, coal)[16] accounted for around half of total expenditure for energy in 2023 – the lowest proportion since 1980. Electricity costs amounted to CHF 16.9 billion, with wood and district heat accounting for the remaining CHF 680 million.[17] Between 2001 and 2020, energy expenditure increased by an average of 0.3% annually. In 2021 and especially in 2022 and 2023, expenditure rose sharply, resulting in 51% or CHF 12.3 billion more being spent on energy last year than in 2020. As a result, the annual growth rate of energy expenditure from 2001 to 2023 is 2.1%. The increase in industrial production (1.5% annually) and the population (0.9% annually) contributed to this. The parallel movement between final consumer expenditure and the energy price index is notable. This occurs partly because energy prices have limited short-term impact on consumer behaviour, which is more

influenced by relatively stable factors such as vehicle and housing numbers – an example of low short-term price elasticity of demand. The COVID-19 pandemic led to reduced energy consumption in 2020, particularly of motor fuel, resulting in exceptionally low energy expenditure when combined with low prices. While consumption and expenditure recovered in 2021, this was followed in 2022 and 2023 by sharp price increases and corresponding high expenditure – despite reduced consumption of heating energy (mainly gas and heating oil) and electricity, partly due to milder weather (fewer heating degree days). Energy efficiency improvements can reduce both consumption and final consumer expenditure (sources: SFOE, 2024a/FSO, 2024).

16 In 2023, 3.6% of consumed petrol and diesel were of biogenic origin, i.e. they are not oil products.

17 In addition to expenditure for energy and transport, all taxes and levies are included in energy expenditure (CO_2 levy, oil tax, value added tax, etc.).

ENERGY PRICES FOR INDUSTRIAL SECTORS: INTERNATIONAL COMPARISON

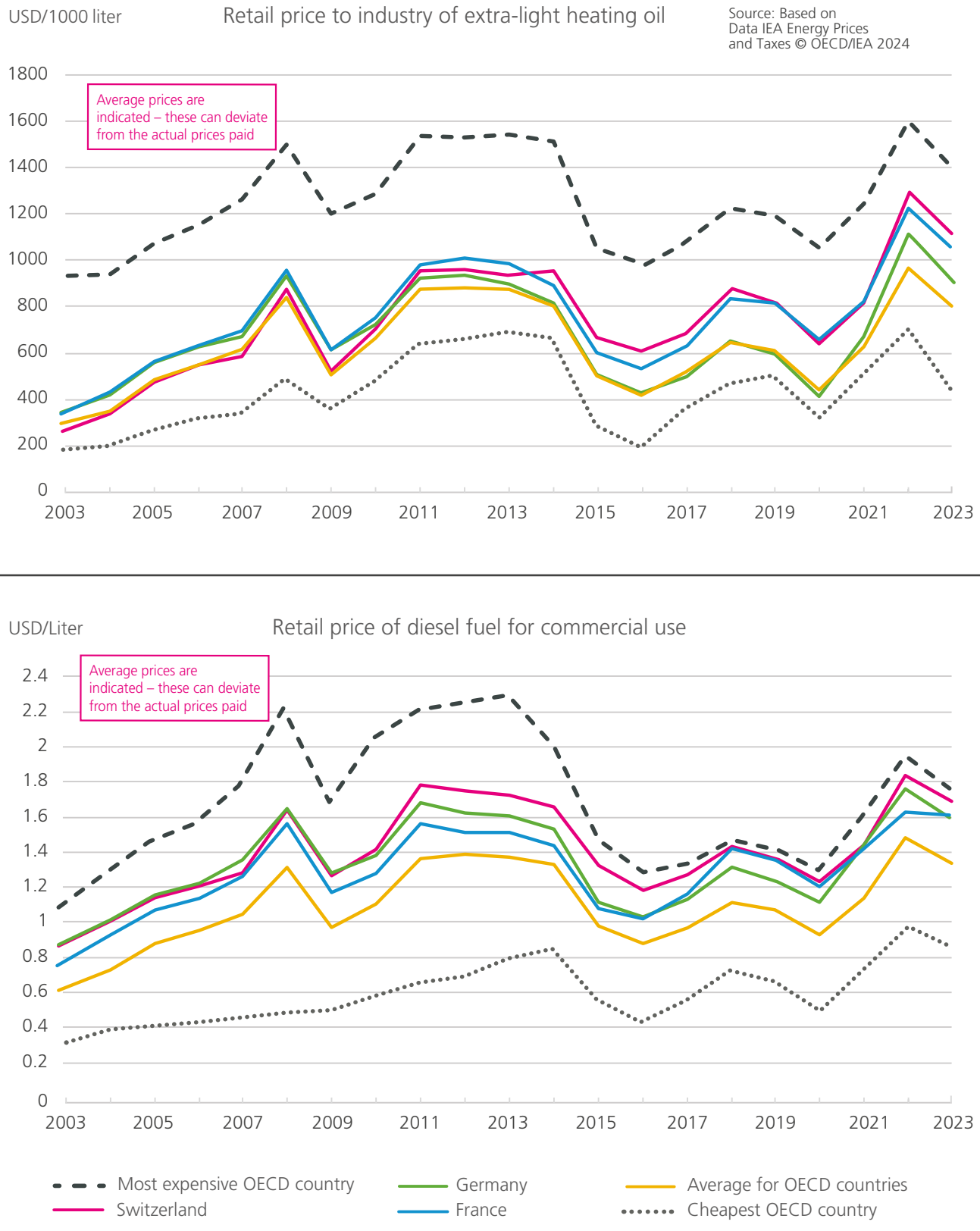


Figure 12: Average nominal final consumer prices for heating oil and diesel (including taxes) for industry, in USD (based on market exchange rates)

Energy prices rose sharply across all sources in 2022 following Russia's attack on Ukraine, with further increases in electricity and gas prices in 2023. To manage these rises, particularly in 2022, various national governments introduced direct subsidies for businesses and households, or temporary price controls such as reduced taxation. France, for instance, implemented a tax reduction in 2022 that lowered motor fuel prices, as shown by diesel prices in **Figure 12**.

Many of these measures, including French support, ended in 2023. Indirect measures, such as payments to individuals and businesses, did not affect sale prices and are therefore not reflected in the chart. Switzerland chose not to implement such price control measures. In general, prices in Switzerland are high by international standards. Price patterns in France and Germany suggest that Swiss price trends are strongly influenced by those on the European wholesale markets and by European regulations. On European wholesale markets, natural gas prices in particular have risen more sharply than the global OECD average in recent years. Electricity prices are strongly linked to gas prices, as gas-fired power plants continue to be used in Europe to meet electricity demand. Oil and its refined products, such as heating oil and diesel, are traded globally, which explains the similar price trends across most countries shown in the graph (*Figure 12*). Swiss **heating oil** prices remained above the OECD average in 2023, although they fell from their peak reached the previous year[18]. The price reductions in Switzerland were similar to those in the two neighbouring countries examined, France and Germany. However, longer-term analysis shows slightly steeper price increases in Switzerland compared to other countries. This may partly reflect the gradual increase in the CO_2 levy since its 2008 introduction, from CHF 12 to CHF 120[19] per tonne of CO_2. These increases were implemented because interim emissions reduction targets for fossil fuels set by the Federal Council every two years were not met. **Diesel** prices in Switzerland remained slightly higher than in France and Germany in 2023, near the OECD peak, though prices fell across all observed countries. In France, the 2022 diesel tax relief expired last year, bringing prices in line with Germany (*blue curve in Figure 12)*. The report does not track international petrol price comparisons as petrol is less relevant for industry (source: OECD/IEA, 2024a).

18 Note that these prices are not inflation-adjusted.

19 This rate has applied since 2022.

ENERGY PRICES FOR INDUSTRIAL SECTORS: INTERNATIONAL COMPARISON

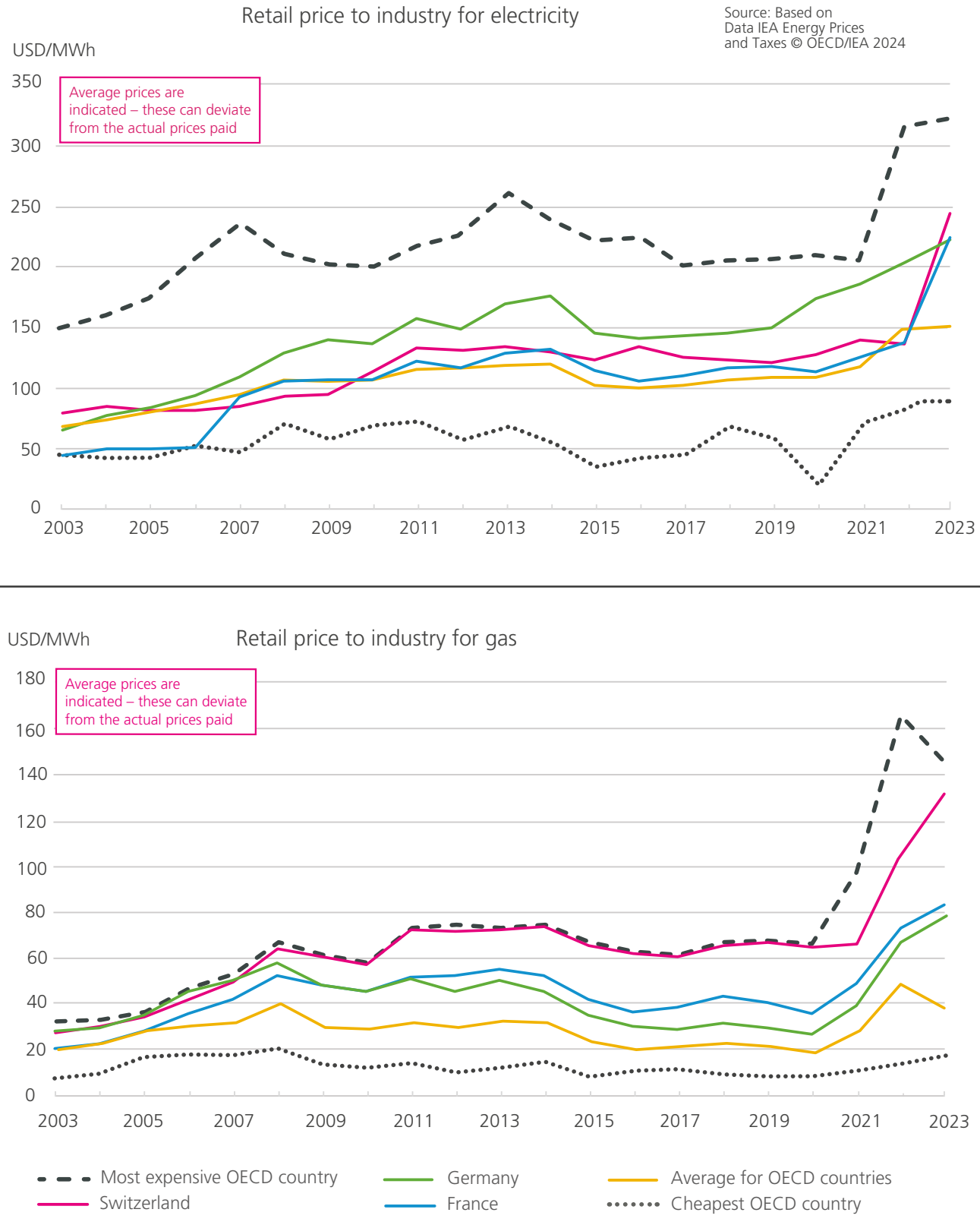


Figure 13: Average nominal end consumer prices of electricity and gas, including taxes for the industry sector, in USD (based on market exchange rates)

Industrial **electricity prices** in Switzerland (shown for the 10–20 GWh consumption category) depend on multiple factors, including production technologies, demand volume, timing flexibility, and market structure. These factors, shaped by energy policy, influence European wholesale electricity market prices, which significantly affect Swiss wholesale prices. End customers pay for grid usage and taxes as well as for the energy itself. Swiss electricity prices remained relatively stable compared to the OECD average until 2020 (*Figure 13*). In 2021 and particularly 2022,OECD countries, including Germany, experienced higher price increases than Switzerland. For data collection reasons, the sharp price increases on the European markets are not reflected in Swiss prices until 2023[20]. In 2023, Swiss prices even slightly exceeded those of Germany and France and were well above the OECD average. Although other costs, such as those for Swissgrid's ancillary services, also increased in 2023, the majority of the higher prices are due to the increased market prices for electricity on the European wholesale markets since 2022. Many industrial customers operate in the free market rather than basic supply, similar to their European competitors. For this reason, the actual price paid for electricity can vary greatly around the average price shown, with exposure to price fluctuations depending on procurement strategy. However, due to the staggered procurement of most companies over the years, the increased price level of the wholesale market is reflected over time in the final customer prices paid by the companies and shown here. The recent slight fall in wholesale prices will therefore be reflected in the coming reporting years. The differences in level between countries should be interpreted with caution, however. This is partly because electricity-intensive businesses may be exempt from certain levies included in the price. On top of this, a number of comparable countries subsidised major electricity users in order to cushion the electricity price increase. These direct subsidies are not visible in the chart either.

Swiss **gas** prices exceed those in Germany and France, sitting around the OECD average. Switzerland was the OECD's most expensive country from 2010–2020, with the exception of 2012. Sweden overtook this position in 2021, partly due to its rising CO_2 levy (EUR 122/tonne in 2023[21]). Switzerland, France, and Germany saw significant price increases in 2022 and 2023, mainly due to higher European wholesale prices following Russia's military attack on Ukraine. The fact that Europe has to import more liquefied natural gas (LNG) means that Europe and Asia are competing for LNG supplies. As a result, European gas prices are now more closely aligned with gas prices in Asia, which in the past were generally higher than those in Europe.

The price gap with other OECD countries is substantial, particularly compared to Canada, the lowest-priced OECD country in 2023. This difference

reflects several factors: Wholesale prices for natural gas in North America are significantly lower than in Asia or Europe due to high domestic production. Switzerland's increased CO_2 levy, as reflected in the figures, though some companies[22] can receive exemptions with emissions reduction commitments. However, this is not shown in the current figures. In fact, such companies pay the end-user price but are able to apply for a refund of the levy. The CO_2 levy is only a partial explanation for the relatively high prices and is no explanation for the figures prior to 2008. Other potential explanations include the higher grid costs (due to low connection density per kilometre), and the intensity of competition. For example, the gas markets in the countries to which Switzerland is being compared were all fully opened up. In Switzerland, gas sales conditions in 2012 were regulated for major industrial customers on the basis of an association agreement, according to which a few hundred end users can freely choose their gas supplier. In June 2023, the Federal Council defined the parameters for the dispatch on gas supply legislation and proposed a partial opening up of the market, under which customers with consumption of over 300 MWh a year (i.e. major consumers), would get free access to the market. The Lucerne area has had a fully open gas market since June 2020 following a Competition Commission decision (sources: OECD/IEA, 2024/Federal Council, 2019c +2023e/COMCO, 2020).

20 Given that the producer and import price index for electricity is now collected quarterly rather than annually by the Federal Statistical Office as of 2023, the price increases in 2022 and 2023 are reflected cumulatively in the figures for 2023. This means it is not apparent that the actual increase in electricity prices for end customers was spread over both years.

21 Carbon taxation in Sweden, PowerPoint presentation (government.se)

22 Including companies in certain sectors that have a high tax burden in relation to their value added and whose international competitiveness would be greatly undermined as a result; see CO_2 Ordinance, Annex 7 (activities that qualify for exemption from levy with reduction obligations). These companies can apply to have the CO_2 levy refunded. Large CO_2-intensive companies participate in the emissions trading system and are (also) exempt from the CO_2 levy.

↗ For more detailed indicators regarding **EXPENDITURE AND PRICES** see the full monitoring report.

CO_2 EMISSIONS

Energy and climate policy are closely linked, as around three quarters of Switzerland's greenhouse gas emissions stem from fossil fuel use. Energy Strategy 2050 helps reduce fossil energy consumption and thus energy-related greenhouse gas emissions. This supports climate policy targets set out in the Federal Act on the Reduction of CO_2 Emissions (CO_2 Act) and the Federal Act on Climate Protection Goals, Innovation and Strengthening Energy Security (CIA) (Federal Council, 2019b +2021a/Federal Gazette, 2022). Carbon dioxide (CO_2) is the most significant greenhouse gas by volume, primarily produced by burning fossil combustibles and fuels (heating oil, gas, petrol, diesel). The annual monitoring process tracks CO_2 emissions per capita, both overall and by sector, as well as in relation to other variables. The main source for indicators is Switzerland's greenhouse gas inventory, compiled annually by the Federal Office for the Environment (FOEN) according to UN Framework Convention on Climate Change requirements.

PER CAPITA ENERGY-RELATED CO_2 EMISSIONS

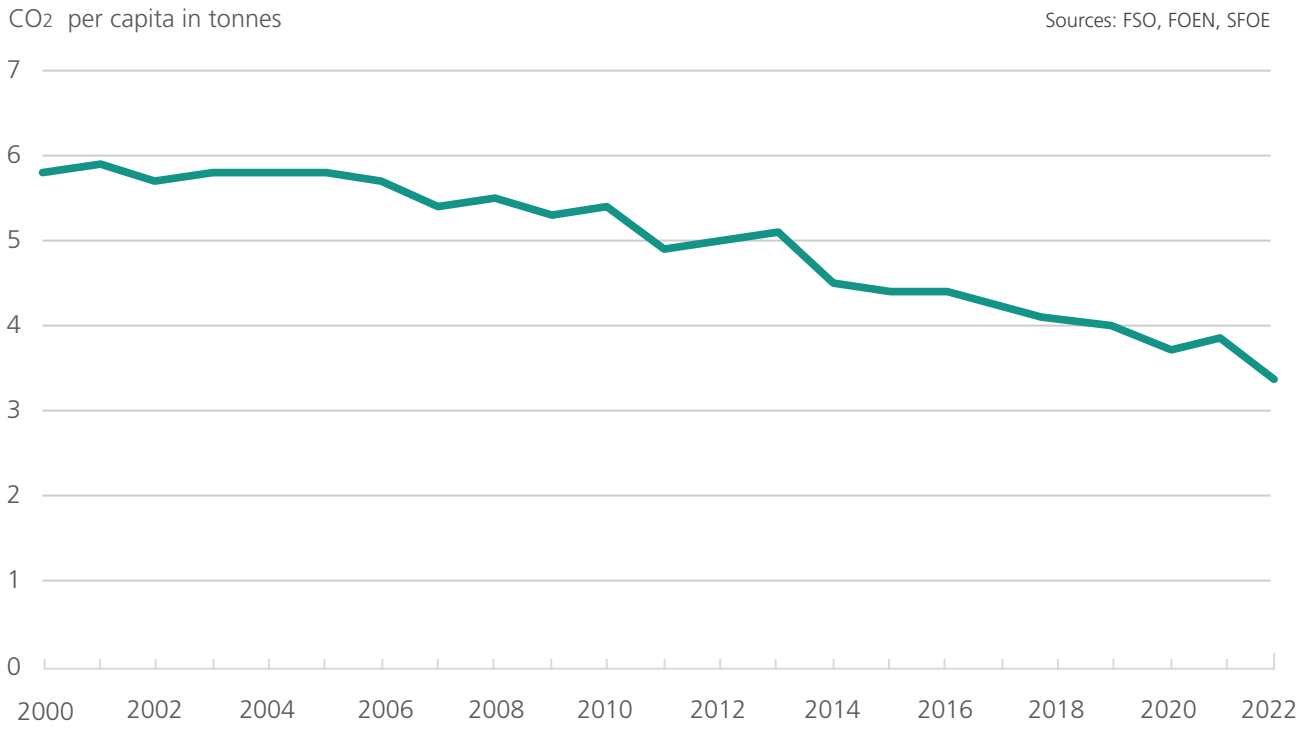


Figure 14: Per capita energy-related CO_2 emissions (in tonnes of CO_2 per capita)[23]

Energy Perspectives 2050+ outlines how Switzerland can restructure its energy supply by 2050 to meet the Federal Council's net-zero target (Prognos/TEP/Infras/Ecoplan, 2020). Energy-related CO_2 emissions must align with this target. In a net-zero world, where all avoidable emissions must be eliminated by 2050, Energy Perspectives 2050+ indicates around 0.4 tonnes of energy-related CO_2 will still be emitted per capita.

Energy-related CO_2 emissions per capita in Switzerland have steadily decreased since 2000, as shown in **Figure 14**. While CO_2 emissions from energy sources have fallen slightly since 2000 (*see Figure 15 below*), the country's population has grown continuously during this period. This suggests increasing separation between population growth and CO_2 emissions. In 2022, domestic per capita emissions were around 3.5 tonnes, almost 39% lower than in 2000 (5.8 tonnes).[24] This is relatively low by international standards, reflecting Switzerland's largely CO_2-free electricity production and significant service sector contribution to added value. However, achieving the net-zero climate target by 2050 requires faster reduction of energy-related CO_2 emissions per capita than previously achieved (sources: FOEN, 2024/FSO, 2024/SFOE, 2024a).

23 Differentiation according to the CO_2 Act (excluding international aviation, including statistical difference). Not weather-adjusted.

24 For comparison: Total greenhouse gas emissions per capita were approximately 4.7 tonnes in 2022, representing a reduction of almost 36% from 2000 levels (7.5 tonnes). In percentage terms, per capita energy-related CO_2 emissions have decreased slightly more than overall greenhouse gas emissions.

ENERGY-RELATED CO_2 EMISSIONS OVERALL AND BY SECTOR

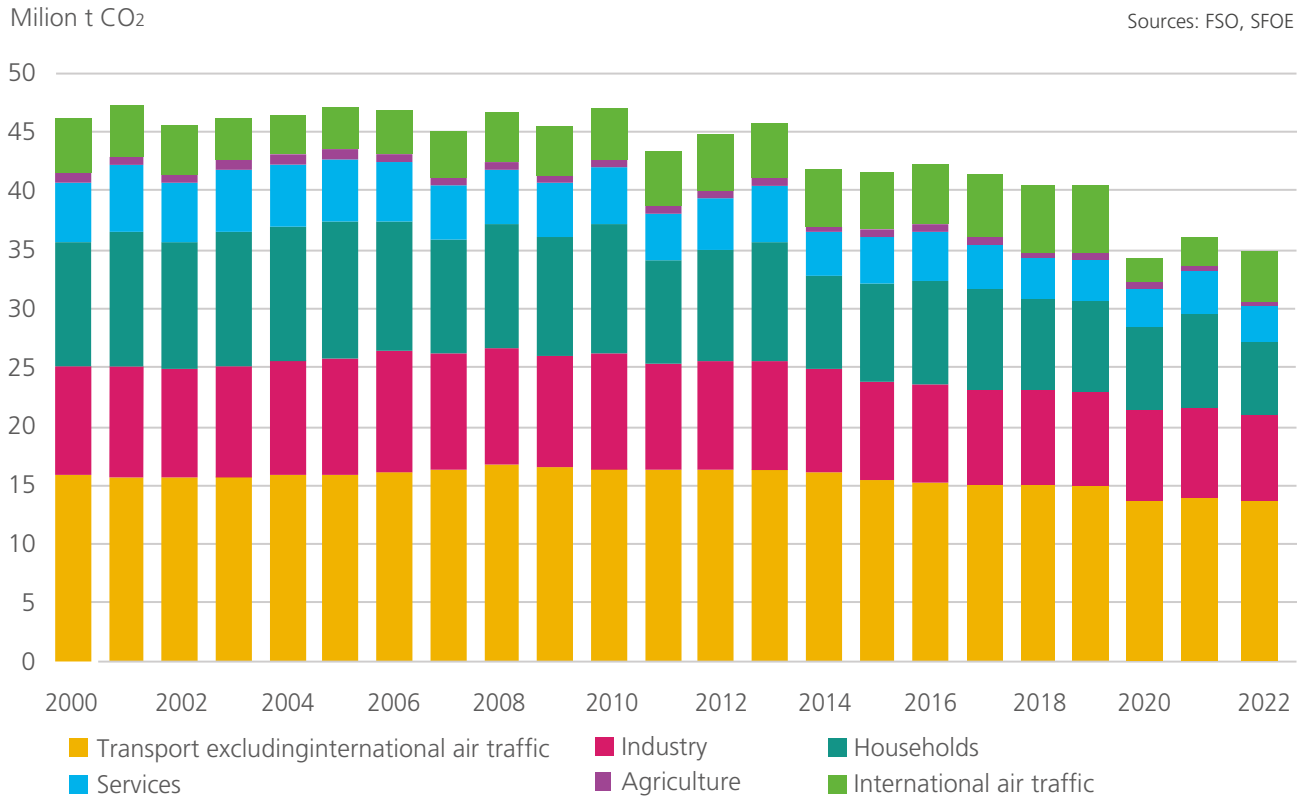


Figure 15: Total energy-related CO_2 emissions and by sector (in million tonnes of CO_2)

Total energy-related CO_2 emissions *(see Figure 15, including international aviation)* reached 34.9 million tonnes of CO_2 in 2022, marking a 24% reduction from 2000 levels. The **transport** sector represents the largest share (39% in 2022, excluding international air traffic), with motorised road vehicles accounting for most of these emissions.[25] Between 2000 and 2022, CO_2 emissions in the transport sector decreased by over 2 million tonnes. After a decrease at the beginning of the millennium, emissions from international air traffic have been constantly increasing since 2005 and in 2019 reached 5.7 million tonnes of CO_2. Owing to the COVID-19 pandemic, these emissions declined sharply in 2020, and were still well below previous levels in 2021 at 2.3 million tonnes and in 2022 at 4.2 million tonnes of CO_2 (proportion of 12%)[26]. In **industry** (2022 share: 21%), energy-related CO_2 emissions arise primarily from goods production and, to a lesser extent, from building heating. A modest decline since 2000 demonstrates the effectiveness of implemented measures, improved energy efficiency, and the separation of CO_2 output from industrial production. Variations over time mainly reflect economic conditions and climate patterns. In the **households** sector (2022 share: 18%), emissions largely stem from heating and hot water production. Emissions have decreased since 2000, despite increased heating space requirements. This indicates improved efficiency and adoption of lower-CO_2 technologies. With numerous fossil-based heating systems still in use, annual emissions remain heavily dependent on weather conditions, with higher emissions during colder winters and lower emissions during milder

ones. Similar patterns apply to the **services** sector (2022 share: 8%). Here, too, CO_2 emissions from energy sources have shown a slight decline since 2000, though levels fluctuate with weather conditions. In **agriculture** , energy-related CO_2 emissions have decreased slightly since 2000, with the sector's overall share of CO_2 emissions remaining very low (2022: 2%). For agriculture, energy-related CO_2 emissions are less significant than methane and nitrogen dioxide emissions.

Overall, sectoral shares of energy-related CO_2 emissions have changed minimally since 2000. Transport and industry sectors (excluding international aviation) have increased their share (from 34% to 39% and 20% to 21% respectively), while households and services sectors show slight decreases (sources: FOEN, 2024 / SFOE, 2024a).

25 In certain publications, the SFOE shows the proportion of transport to total greenhouse gas emissions, which is currently around one third (32%).

26 International air traffic is not included in international balances, so no results flow into the evaluation of climate policy targets. If air traffic were included, its proportion of overall CO_2 emissions would be around 12%. If this segment is allocated to the overall transport sector, the share would be 30%.

↗ For more detailed indicators regarding **CO_2-EMISSIONS** see the full monitoring report.

RESEARCH AND TECHNOLOGY

To achieve the long-term objectives, new developments in the technology sector will be required. To stimulate further development, Switzerland has allocated significantly more resources to energy research. Progress in research and technology cannot generally be measured directly with indicators. For this reason the annual monitoring process focuses on public expenditure for energy research as an indicator for efforts being made in this regard.

PUBLIC EXPENDITURE FOR ENERGY RESEARCH

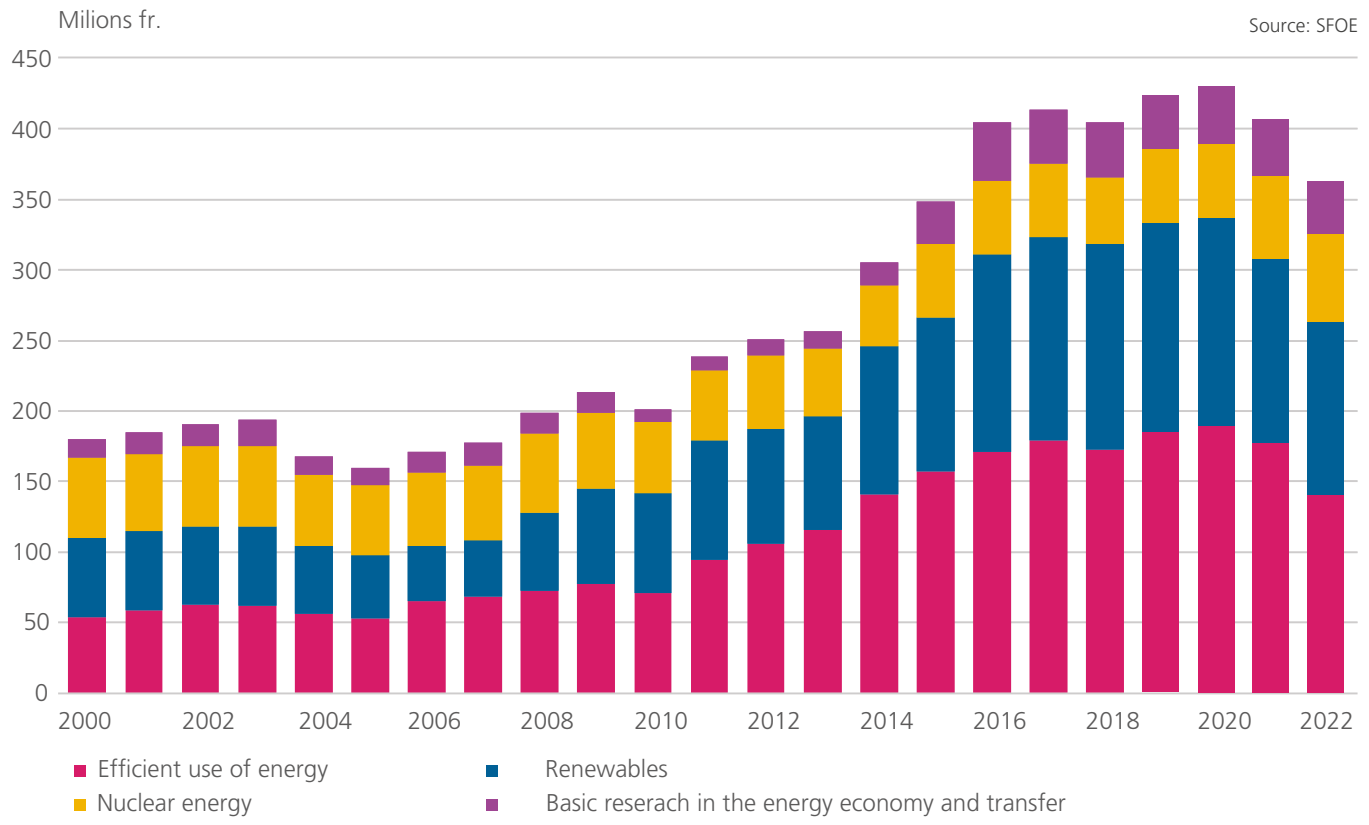


Figure 16: Public expenditure for energy research by field of research (in CHF million, real figures)[27]

As shown in **Figure 16**, public funding for energy research increased steadily between 2005 and 2020. A marked increase in expenditure has occurred since 2014 under Energy Strategy 2050 and the Coordinated Energy Research in Switzerland action plan. Key contributors include the development and establishment of Swiss Competence Centres for Energy Research (SCCERs) by Innosuisse, the National Research Programmes in the energy sector (NRP 70 and NRP 71) by the Swiss National Science Foundation (SNSF), and the expanded pilot, demonstration and flagship projects by the SFOE. In 2022, public sector expenditure reached CHF 365 million in real terms (2021: over CHF 408 million). The reduction from previous years reflects the conclusion of the SCCER energy funding programme in late 2020, resulting in reduced ETH Domain and Innosuisse contributions to Swiss energy research. The SCCER's successor programme, SWEET, has lower funding levels and is unlikely to fully offset this decline. Furthermore, it has been observed that Innosuisse projects have become smaller in scale and the number of EU projects has also fallen due to Switzerland's non-association – at least at the beginning of the Horizon Europe programme.

In line with Energy Strategy 2050 priorities, the largest funding allocations are directed towards **energy efficiency** (2022 share: 38.8%) and **renewable energy** (2022 share: 34.2%). Expenditure on **nu-**

clear energy research (nuclear fusion and nuclear fission) has remained constant since 2004, while its proportion of total spending increased from the previous year to 16.6% in 2022. **Basic energy research** accounted for 10.4% of expenditure (source: SFOE, 2023a+2024d).

27 Expenditure includes a share in overheads (indirect research costs) of the research institutions.

↗ For more detailed indicators regarding **RESEARCH AND TECHNOLOGY** see the full monitoring report.

INTERNATIONAL ENVIRONMENT

The international environment is important for Switzerland because our country is closely integrated into the international energy markets and is dependent on energy imports, particularly in the fossil fuel sector. Developments in Europe at the regulatory level are of central importance for Switzerland. International efforts to combat climate change also play a major role. The annual monitoring process focuses on a descriptive overview of substantial developments.

DEVELOPMENT OF GLOBAL ENERGY MARKETS

Fossil fuel prices have fallen from their 2022 peaks, but markets remain tight and volatile. The ongoing conflict in Ukraine is now compounded by risks of extended Middle East tensions. According to the International Energy Agency (IEA)[28], global renewable energy investments have risen 40% since 2020. This increase reflects both pressure to reduce CO_2 emissions and energy security concerns, particularly in fossil fuel-importing countries.

The IEA's predicted pace of change in major markets continues to accelerate. The US Inflation Reduction Act is expected to drive electric vehicles to half of new car registrations by 2030. China's projected photovoltaic and offshore wind power expansion by 2030 is now triple the IEA's 2021 forecast. Nuclear energy prospects have also improved in leading markets. Countries such as Japan, Korea and the United States support existing nuclear reactor life extensions, while several others are building new plants. Despite recent strong fossil fuel demand, signs of change are emerging. Alongside low-emission alternatives adoption, fossil fuel plant expansion has slowed. Sales of combustion engine vehicles and two/three-wheelers remain well below pre-pandemic levels. In the electricity sector, global coal and natural gas power plant expansion has halved compared to previous peaks. Gas boiler sales for households are declining, with heat pumps now leading in many European countries and the United States.

Crude oil: Global oil demand continued to moderate in 2024. Growth slowed to 710,000 barrels per day in the second quarter of 2024 year-on-year, marking the slowest quarterly increase since Q4 2023. Global supply rose by 150,000 barrels to 102.9 million barrels per day in June as oilfield maintenance eased and biofuels supply increased, offsetting a significant drop in Saudi output. Global refinery throughput is expected to rise by 950,000 barrels to 83.4 million barrels per day by 2024 and by 630,000 barrels to 84 million barrels per day in 2025. Weak demand and low profit margins affected Chinese and European crude oil processing in May 2024.

Crude oil prices recovered from six-month lows in June 2024, with Brent futures rising by USD 5 per barrel to USD 86 per barrel. Declining crude reserves and Middle East tensions contributed to price increases. Divergent regional economic developments and accelerated clean and energy-efficient technology adoption are gradually slowing oil demand growth. Emerging Asian economies, particularly China and India, account for all global oil demand growth, while Western economies show sharp demand decline.[29]

Natural gas: Natural gas markets expanded in the first half of 2024. Demand growth primarily reflects higher industrial gas consumption, increasingly concentrated in Asia, where both China and India returned to double-digit growth rates. Natural gas prices rose in major markets in Q2 2024, partly due to lower global LNG production and partly due to increasing geopolitical tensions. Natural gas demand is forecast to increase by 2.5% in 2024, driven mainly by rapidly growing Asian markets.

Coal: 2023 saw the largest net increase in global coal-fired power plant capacity since 2016. New capacity of 69.5 GW came online, led by China (47.4 GW) and India (11.4 GW). Japan (1) and the US (2) are planning new coal-fired power plants incorporating CCS (carbon capture & storage) technologies for CO_2-neutral operation. Twelve additional countries announced plans to join the Powering Past Coal Alliance[30] in 2023. This coalition promotes transition from coal-fired power to renewable electricity generation. Over 100 countries have committed to halting new coal plant approvals and suspending ex-

isting plans. In spring 2024, the G7 first adopted a concrete coal phase-out timeline: targeting the first half of the 2030s or a trajectory compatible with the 1.5 °C limit. Coal demand stems from electricity generation and steel production, with 70% of global steel production dependent on coal.

Coal production is expected to decline to 8,221 million tonnes by 2025, falling below 2022 levels. This reduction largely reflects anticipated Chinese coal production plateaus and Indian production growth being offset by sharp declines in other regions, including the United States, European Union and Indonesia.

CO_2 in European emission trading: Contracts up to 2026 range between EUR 90 and 100 per tonne of CO_2. Following significant fluctuations in the second half of 2022, the market has stabilised. In 2023, CO_2 prices varied between EUR 75 and EUR 95 per tonne. High CO_2 prices combined with low gas prices created favourable conditions for switching from coal to gas generation in 2023, after gas-fired power plants proved uneconomical during the 2022 energy crisis.

Electricity: The IEA projects global electricity demand growth of 4% in 2024, compared to 2.5% in 2023 with global demand at 27,970 TWh. This growth primarily reflects stronger demand in Asia and the United States, along with increasing power consumption from artificial intelligence (AI) server applications. The IEA anticipates further electricity demand growth in 2024 for China (+6.5%) and India (+8%) compared to 2023 and pandemic years. Global wind and solar energy expansion could surpass hydropower production in 2024. The share of renewable energies in the global electricity supply rose to 30% in 2023 and is expected to increase further to 35% by 2025; estimated renewable generation for 2023 is 8958 TWh (2022: 8,546 TWh). The IEA expects coal-fired power generation to decline slightly for the first time in 2025, following a 1.9% increase in 2023 when high gas prices boosted demand for alternatives. While coal-fired generation decline should be pronounced in the United States and Europe, increases in Asia will likely largely offset this. According to the IEA, fossil fuels remain the primary energy sources for US electricity generation, with natural gas leading at 43% in 2023, followed by renewable energy at 21%, and nuclear energy and coal at approximately 18% and 16% respectively. In 1990, renewable energy constituted only about 12% of electricity generation. Since 2008, natural gas has progressively replaced coal, with natural gas share now double that of coal; in 2008, these proportions were reversed.

Electricity consumption in the EU fell for the second year in a row in 2023 (–3% compared with 2022). This mainly reflects reduced industrial demand and consumption changes resulting from high energy crisis prices. Following record electricity prices in 2022, the market environment improved significantly in 2023, leading to lower wholesale prices. The European electricity benchmark[31] averaged EUR 95 per MWh in 2023 –57% lower than in 2022. Annual prices ranged from EUR 51 per MWh in Sweden to EUR 128 per MWh in Italy. The largest year-on-year price declines occurred in France (–65%) and Finland (–63%).

28 IEA World Energy Outlook 2023

29 https://www.iea.org/reports/oil-2024/executive-summary

30 https://poweringpastcoal.org/

31 Index of average wholesale electricity prices on the European market

DEVELOPMENTS IN THE EU

In June 2024, new elections for the European Parliament were held in the EU, marking the start of a new five-year legislative period. The new parliament re-elected Ursula von der Leyen as President of the European Commission on 18 July. Parliament is expected to approve new Commission members and portfolio allocations by late autumn, with the new Commission set to commence work on 1 November 2024. Ursula von der Leyen has outlined the Commission's new priorities for the next five years in the Strategic Agenda 2024–2025[32]. Key focuses include competitiveness and domestic market development while maintaining the green transition.

Under EU Commission President Ursula von der Leyen, the European Green Deal was a top priority in the legislative period ending in 2024. The EU wants to become the first climate-neutral continent by 2050 and transform into a modern, resource-efficient economy. On 14 July 2021, the European Commission proposed a comprehensive legislative package called **Fit for 55**, aiming to reduce net greenhouse gas emissions by 55% from 1990 levels by 2030. With the exception of the revision of the EU Energy Taxation Directive, which is blocked in the EU Council due to the unanimity requirement, the co-legislators, the EU Council and the European Parliament, agreed on all the legislative proposals in 2023 and have in large part already formally adopted them. The package covers the following areas:

- Revision of the EU emission trading system (EU-ETS)
- New ETS in road transport and buildings sector
- CO_2 emission reduction in non-ETS sectors
- Introduction of a Carbon Border Adjustment Mechanism (CBAM)
- Tightening of emissions standards for vehicles
- Revision of the Regulation on land use, land use change and forestry (LULUCF)
- Revision of the Energy Taxation Directive
- Revision of the Renewable Energy Directive
- Revision of the Energy Efficiency Directive
- Alternative Fuels Infrastructure Regulation
- Regulation on Sustainable Maritime Fuels
- Regulation on Sustainable Aviation Fuels

Commission presented a legislative proposal in December 2021 to revise the Energy Performance of Buildings Directive. It is due to be adopted in 2024, after the Commission proposed further changes as part of 'REPowerEU', the EU's plan to reduce its dependence on Russian fossil fuels as quickly as possible. It includes solar energy commitments, EU-wide harmonised building energy performance certificates, significant renovation requirements for inefficient buildings, and more stringent requirements for building charging stations.

In March 2023, responding to major disruption in the EU domestic market caused by the energy crisis, the European Commission proposed legislative reforms to revise electricity market design[33] and overhaul wholesale electricity market integrity and transparency rules (REMIT).[34] The complete revision was finalised in the first half of 2024 and adopted by the European Parliament and the Council. The electricity market design revision maintains fundamental market operations without reversing two decades of EU electricity market integration and liberalisation. Instead, it strengthens short- and long-term markets, reduces fossil gas dependency, and shields end consumers from price volatility. The REMIT revision expanded data delivery requirements to include markets such as balancing, strengthened the EU Agency for the Cooperation of Energy Regulators (ACER), and enhanced cooperation between ACER and the EU Securities and Markets Authority (ESMA). The European Parliament and EU Council adopted the revised REMIT provisions in February and March 2024 respectively. (Source: COM(2021) 550 final/COM (2022) 230 final)

32 Europe's choice. Political Guidelines for the next European Commission 2024–2029

33 Proposal for a Regulation of the European Parliament and of the Council amending Regulations (EU) 2019/943 and (EU) 2019/942 as well as Directives (EU) 2018/2001 and (EU) 2019/944 to improve the Union's electricity market design

34 Proposal for a Regulation of the European Parliament and of the Council amending Regulations (EU) No 1227/2011 and (EU) 201/ 942 to improve the Union's protection against market manipulation in the wholesale energy market

INTERNATIONAL CLIMATE POLICY

During the 28th UN Climate Change Conference (COP28) in Dubai in November/December 2023, **Paris Climate Change Agreement** signatories conducted their first progress review (global stocktake). The adopted review identifies gaps in climate change mitigation and adaptation, outlining recommendations for meeting Paris Agreement goals, including expanding renewable energy capacity and energy efficiency by 2030. Switzerland welcomed this outcome. Countries agreed through the global stocktake to transition away from coal, oil and gas by 2050. At COP28, participating countries agreed on the main features of the fund that had been adopted at COP27 for the benefit of the most vulnerable countries in dealing with damage caused by climate change (e.g. floods or droughts). Contribution requirements remain undefined. Switzerland advocated for contributions from all countries with high greenhouse gas emissions and sufficient financial means.

The Paris Agreement, adopted December 2015 and effective 4 November 2016, succeeded the Kyoto Protocol's second commitment period. It requires all countries to implement greenhouse gas emission reduction measures, aiming to limit the global average temperature increase to well below 2 °C above pre-industrial levels, while pursuing efforts to limit the increase to 1.5 °C. Additional objectives include enhancing adaptation to unavoidable climate change impacts and aligning financial flows with low-emission, climate-resilient development. All 197 parties have adopted the United Nations Framework Convention on Climate Change (UNFCCC), with 195 countries and the EU having ratified it.

Switzerland, which signed the Paris Agreement in 2015 and ratified it in autumn 2017, has set a target to halve total greenhouse gas emissions by 2030 compared with 1990 levels. For national implementation of the agreement by 2030, a partial revision of the CO_2 Act for the period after 2024 will take effect from 1 January 2025.

Switzerland's Paris Agreement ratification legally mandates climate change mitigation and adaptation measures. It maintains obligations to submit Biennial Transparency Reports to the UN Framework Convention on Climate Change Secretariat regarding greenhouse gas emission trends, planned reduction and adaptation measures, and international climate policy funding contributions. The Intergovernmental Panel on Climate Change (IPCC) released its 6th assessment cycle synthesis report at the end of March 2023, summarising climate change science, impacts, risks, mitigation and adaptation knowledge. This report informed the December 2023 Dubai climate conference (COP28), where member states conducted the Paris Agreement's first 'Global Stocktake' review. (Sources: Federal Council, 2023h + 2021a + 2019b/DETEC, 2024/FOEN, 2023/IPCC, 2021 + 2023).

SWITZERLAND'S INTERNATIONAL COOPERATION IN THE ENERGY SECTOR

Switzerland's negotiations with the EU (between 2007 and mid-2018) on a **bilateral electricity agreement** were halted after the EU linked progression to institutional agreement advancement. The Federal Council terminated institutional agreement draft negotiations on 26 May 2021. In February 2022, it approved the priorities for a negotiation package with the EU. The government is addressing outstanding issues with the EU in line with its priorities on the basis of a broad package approach, seeking market access and mutual cooperation. This encompasses previous Agreement areas – free movement, transport, aviation, agriculture and technical barriers to trade MRA – plus new electricity, food safety and health agreements. Following EU-Switzerland exploratory talks, the Federal Council adopted negotiating mandate parameters on 21 June 2023, specifying coverage, objectives and Swiss interest safeguards. The Federal Council adopted the final negotiating mandate on 8 March 2024. President Viola Amherd and European Commission President Ursula von der Leyen launched negotiations ten days later. The Federal Council noted concrete progress in several areas during the summer assessment. Further evaluation is scheduled for late autumn 2024.

With respect to **regional cooperation**, Switzerland maintained active, permanent observer status in the Pentalateral Energy Forum since February 2011. This forum facilitates voluntary cooperation among energy ministers from Germany, France, Belgium, the Netherlands, Luxembourg, Austria and Switzerland, addressing electricity market integration, grid operation, supply security and energy system future. At the end of March 2022, the Pentalateral countries signed a joint declaration to step up cooperation in natural gas storage. Previously, in December 2021, they signed an electricity sector risk preparedness Memorandum of Understanding, establishing further collaboration between the Pentalateral countries on risk preparedness in the electricity sector and regular joint crisis exercises. The most recent exercise was held in Brussels in October 2024, with FONES, ElCom and SFOE representatives participating from Switzerland. In December 2023, Federal Councillor Albert Rösti and Penta Forum ministers adopted a decarbonisation declaration, outlining their vision to decarbonise their interconnected electricity system by 2035 and establishing key guidelines for achieving this goal.

Energy sector interdependencies with neighbouring countries necessitate stronger **bilateral relations** in energy and climate matters. Given Russia's attack on Ukraine, as well as strained electricity and gas supply conditions and volatile energy markets, energy security and affordable supply remained central to bilateral discussions. In November 2023, Federal Councillor Albert Rösti met with the French Energy Transition Minister Agnès Pannier-Runacher in Paris to discuss energy supply, particularly electricity (and gas) imports, and bilateral matters including Doubs management. In early 2024, DETEC head Albert Rösti and Economics Minister Guy Parmelin met German Vice-Chancellor Robert Habeck at the World Economic Forum in Davos to address supply security issues. They agreed to finalise a trilateral gas sector solidarity agreement between Switzerland, Germany and Italy in 2024. During a working visit to Berlin, Federal Councillor Rösti, Vice-Chancellor Habeck and Italian Environment and Energy Security Minister Gilberto Pichetto Fratin signed this agreement on 19 March 2024, establishing mutual gas supply assistance for protected customers during emergencies.

In renewable energy, Switzerland promotes new energy sources like green hydrogen and positions itself within future European infrastructure (Hydrogen Backbone). Since 2024, Switzerland has participated as an observer in the Trilateral Working Group on the Hydrogen Southern Corridor alongside Austria, Italy and Germany.

In **multilateral cooperation**, Switzerland engaged with multilateral energy institutions, including the **International Renewable Energy Agency (IRENA)** in Abu Dhabi and the UN in Geneva, particularly UNECE's Sustainable **Energy Committee of the Economic Commission** for Europe, focusing on digital innovation, AI applications for climate-neutral energy policies, and technical cooperation with former Soviet republics. **International Energy Agency (IEA)** membership remains crucial. Switzerland participated in the IEA's 50th anniversary ministerial meeting in February 2024, where SFOE Director Benoît Revaz approved the 2024 Ministerial Communique. Switzerland values the IEA's role in member countries' energy security, international research, and energy transition support through system electrification. The Federal Council approved the modernised **Energy Charter Treaty**[35] in November 2022. In several rounds of negotiations, Switzerland had advocated adapting the Treaty to current decarbonisation requirements and new investment protection practices. EU deadlock prevented planned adoption in November 2022. In May 2024, the EU and EURATOM decided to withdraw, leaving member states to decide independently on Energy Charter participation and modernisation. To date, a majority of 18 EU member states have not yet expressed any intention of withdrawing from the Energy Charter Treaty. This indicates that the modernisation can be adopted at the Energy Charter Conference meeting in December 2024. Following this, DETEC will work with the EAER to draw up a bill submitted for consultation for the ratification of the modernised treaty. The Federal Council is expected to adopt the dispatch for the attention of Parliament at the end of 2025. Switzerland also maintains involvement in the UN's **International Atomic Energy Agency (IAEA),** focusing on global nuclear safety and security, safeguards, technical cooperation, and supporting member states' nuclear technology applications in medicine, water and agriculture (sources: Federal Council 2021d + 2022b + 2023f + l + 2024e + f + g) / DETEC, 2023 + 2024).

35 The Energy Charter Treaty (ECT) is a legally binding agreement in the energy sector between 53 states, covering investment protection and transit. The Treaty entered into force in 1998.

↗ For more detailed indicators regarding **INTERNATIONAL ENVIRONMENT** see the full monitoring report.

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