

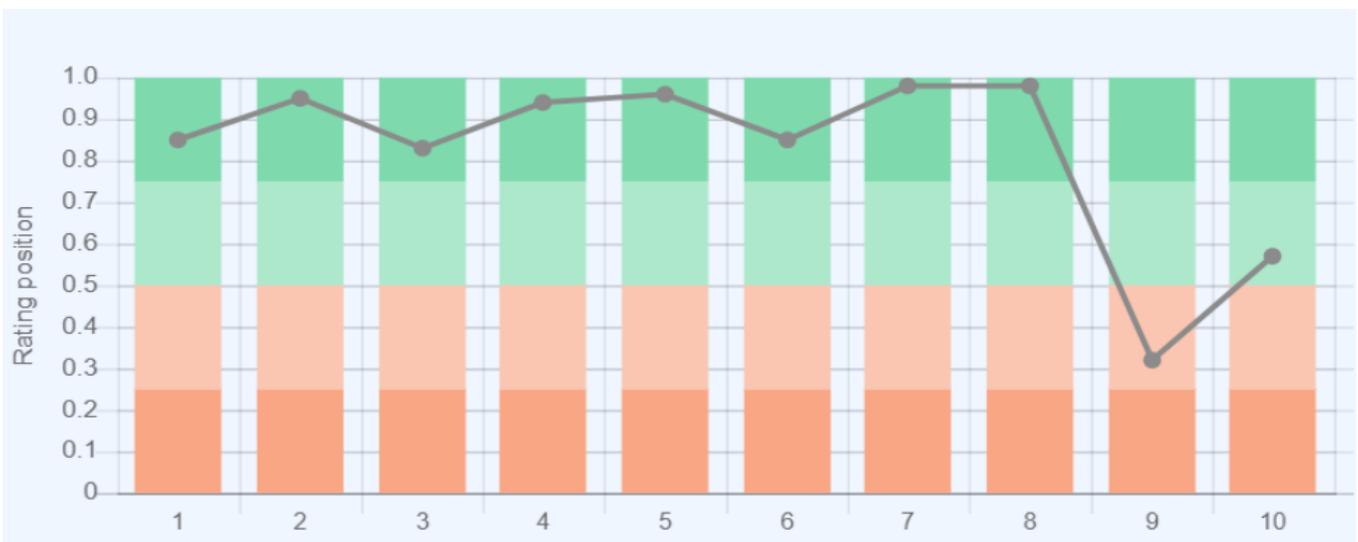
# Energy Industry in Switzerland



## General State of the Economy

Switzerland, officially the Swiss Confederation, is a state in Western Europe, consisting of 20 cantons and 6 half-cantons. The country borders France (to the west), Germany (to the north), Italy (to the south) and Austria and

Liechtenstein (to the east). Switzerland is the 135<sup>th</sup> largest country in the world, and is home to around 8,5 million people, as of 2022. In terms of population density, the country is 69<sup>th</sup> in the world from 247 countries considered [1,2,3].



Sources:

1. GDP (purchasing power parity), 2020 est. / The World Factbook/Library/Central Intelligence Agency \*228
2. GDP - per capita (PPP), 2020 / The World Factbook/Library/Central Intelligence Agency \*229
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5. The Global Competitiveness Index 2019 / Rankings / Reports / World Economic Forum \*141
6. High-technology exports (current US\$) 2019-2020 / United Nations, Comtrade database through the WITS platform / License: CCBY-4.0 / Data \*134
7. 2021 Index of Economic Freedom / International Economics / The Heritage Foundation \*178
8. Reserves of foreign exchange and gold, 2017 est. / The World Factbook / Library / Central Intelligence Agency \*195
9. Annual average GDP growth in %, for the last 10 years (2011-2020) / World Bank national accounts data, and OECD National Accounts data files / License: CC BY-4.0 \*206
10. Public debt (% of GDP), 2017 est. / The World Factbook / Library / Central Intelligence Agency (from smallest to largest) \*210

\* Total number of countries participating in ranking

Figure 1. Economic indices of Switzerland

Switzerland is a federal republic, official languages are German, French, Italian, and Romansh.

Switzerland has one of the strongest and most stable economies in the world, which is reflected in the Figure 1. A significant role in the country's economy is played

by the financial services sector and the manufacturing industry. For all the ten indices shown Switzerland ranks higher than the world average, in the top 25% of the leading countries in the world included in the rating. Some indicators demonstrate absolute values.

Since the early 1990s, the country has experienced a steady growth in GDP at purchasing power parity, both in general and per capita [4,5]. GDP at purchasing power parity increased from \$523.1 billion (38<sup>th</sup> in the world) in 2017 to \$590.7 in 2020 (35<sup>th</sup> in the world) [3]. The country's GDP at purchasing power parity per capita is significantly higher (11<sup>th</sup> in 2020), and has also been demonstrating positive dynamics; from \$62,100 in 2017 to \$68,400 in 2020 [3]. The inflation rate in Switzerland changed from 0.5% in 2017 to 0.3% in 2019 [3]. According to the Global Competitiveness Report 2019, presented by the World Economic Forum, Switzerland was 5<sup>th</sup> out of a total of 141 countries considered. This rating measures the effectiveness of the use of the country's own resources for sustainable development. In addition to a number of economic indicators this index also takes into account such variables as education, health, level of innovation, etc. In the list of countries that exported high-tech products in 2019-2020, Switzerland placed 20<sup>th</sup> out of 134 countries.

## Energy resources

Switzerland has practically no reserves of fossil energy resources [3], or significant renewable energy resources. A selection of basic indicators of this type of resource is presented in Table 1.

The level of global horizontal radiation in most of the country does not exceed 3.5 kWh/m<sup>2</sup>/day [6]. In the western and south-western parts of the country, this figure can reach 3.7 kWh/m<sup>2</sup>/day [6]. The distribution of wind resources is as follows: in most of the country the wind speed does not exceed 5.0 m/s [7], while in the north-west of the country the wind speed can reach 5.5 m/s at a height of 90 metres.

**Table 1. Renewable energy resources of Switzerland**

Resource/explanations	Solar Potential (GHI)*	Wind Potential (50 m)*	Hydro power Potential**	Geothermal Energy Potential	Bio Potential Agricultural area	Bio Potential Forest Area	Municipal Solid Waste
<b>Value</b>	<3.5	<5.0	41	80.00	38.7	31.5	703
<b>Unit</b>	kWh/m <sup>2</sup> /day	m/s	TWh/year	MW	% of land area	% of land area	Kg per capita
<b>Year</b>	2017	2017	2008	2016	2018	2018	2020
<b>Source</b>	[6]	[7]	[8]	[11]	[9]	[10]	[12]

\*for the majority of the territory of the country

\*\*economically exploitable capability

In 2020 the level of municipal waste generation in Switzerland was 706 kg per person, higher than, for example, France (538 kg per person) [12]. This resource is a valuable raw material for recycling or producing energy, the

According to the Index of Economic Freedom, which is based on freedom of business, freedom from government intervention, property protection, and freedom from corruption, Switzerland was 4<sup>th</sup> in 2021 out of the 178 countries considered, being the absolute leader among European countries. In terms of gold reserves and foreign exchange reserves, in 2017 Switzerland was 3<sup>rd</sup> in the world, behind Japan and China. According to the indicator for the average GDP growth in percentage over the last 10 years, in 2020 the country was 141<sup>st</sup> out of 206 countries, ahead of Germany and Norway.

In terms of public debt, calculated as a percentage of the country's GDP, Switzerland was ranked 119<sup>th</sup> out of 210 countries considered in 2017.

For more information on the Swiss economy see the attached link library by clicking [here](#).

The economically exploitable capability of hydro power in the country is 41 TWh/year, comparable with hydro-power potential in countries such as Austria, Iceland and Italy and significantly higher than that of Germany and the United Kingdom [8].

In 2018, about 38.7% of the country was covered by agricultural land [9]. This area is decreasing, however the country is experiencing a slight increase in forested area, which covered 31.5% of the country in 2018 [10].

Switzerland has a large geothermal potential, but at the moment the country does not produce electricity from this source. Switzerland's geothermal energy potential is unusually large, totalling 80,000 TWh (annual electricity consumption in the country is about 60 TWh) [11].

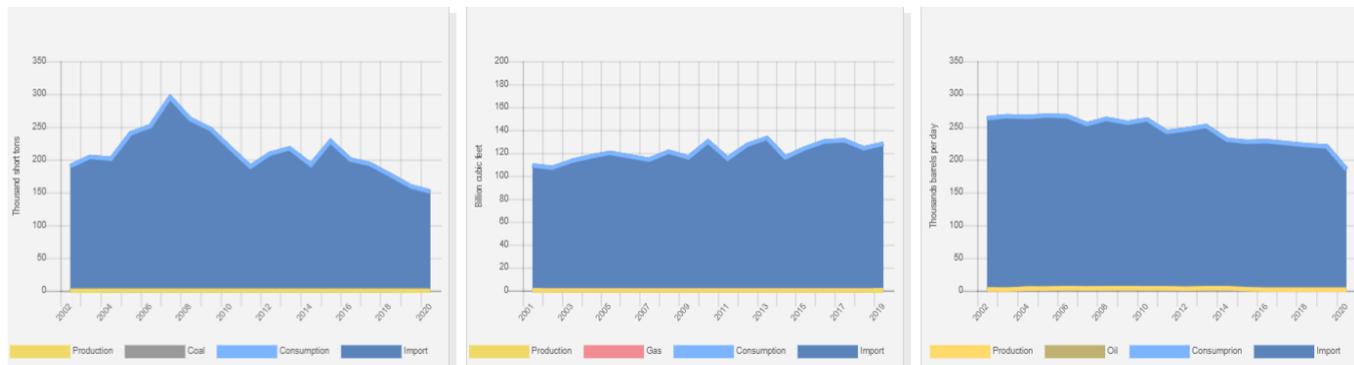
technologies of which have reached a very high level of development in Switzerland.

A detailed list of sites and special reports on Swiss energy resources can be found [here](#).

## Energy Balance

According to the BP Statistical Review of World Energy 2022, total primary energy consumption in Switzerland in 2021 was 1.07 exajoules, around 34.6% of which was from oil; 15.9% from nuclear energy; 31.8% from hydropower; 12.1% from natural gas; 8.4% from renewable energy, and less than 1% from coal [13].

Using the data from [3,13] we calculated the value of Switzerland's GDP per unit of energy use in 2018 to be \$19.6 taking into account the PPP in 2011. The volume of oil consumption since 2002 to 2020 remained practically unchanged, not exceeding 267,000 barrels/day. This figure has declined since 2010 (Fig.2), and in 2020 amounted to 185,000 barrels/day [14].



Source: U.S. Energy Information Administration (Dec 2021) / <https://www.eia.gov/>

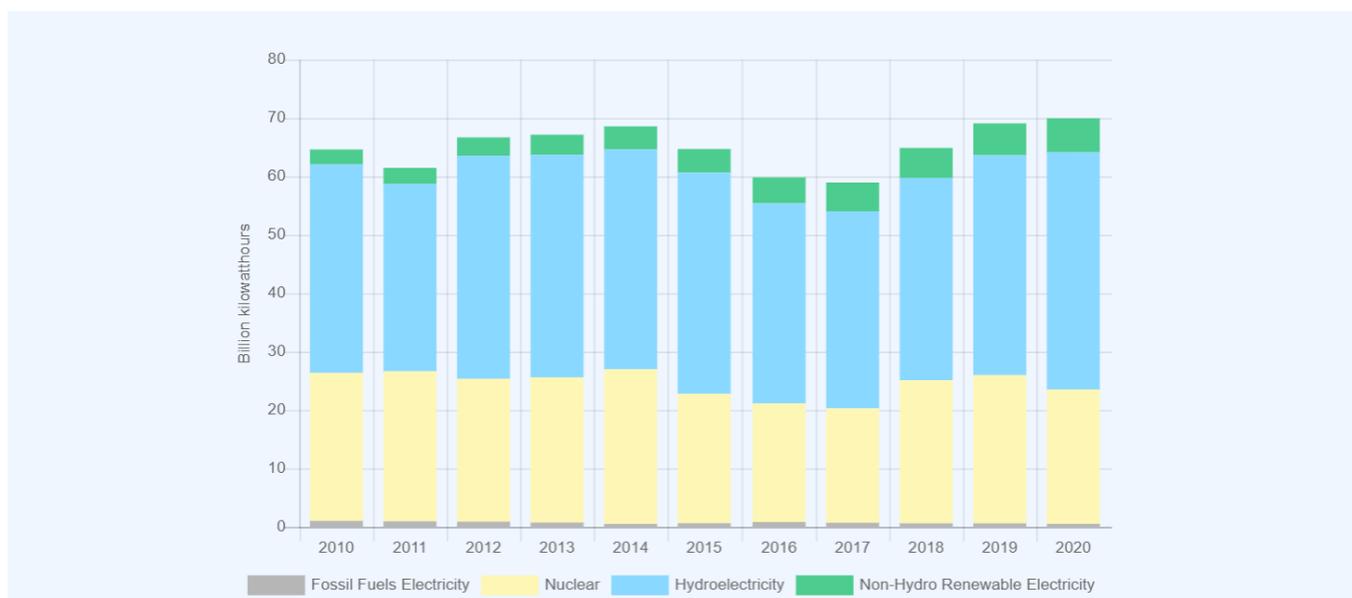
Figure 2. The production and consumption of fossil fuels in Switzerland (coal – left, gas – in the center, oil – right)

Oil imports, according to [3], amounted to 60,900 barrels/day in 2018, and imports of petroleum products amounted to 165,100 barrels/day in 2017. The consumption of natural gas in the country between 2001 and 2019 grew gradually, with small annual fluctuations, and did not exceed 131 Bcf [14]. According to [3] the import of natural gas into Switzerland was 3.578 Bcm in 2019.

Coal consumption in the country between 2001 and 2020 underwent fluctuations and in 2017 it amounted to 193 million short tons, and in 2020 to 151 million short tons

[14]. According to BP's report, in 2021 coal consumption was less than 0.005 exajoules [13]. For the past 10 years Switzerland has mainly relied on hydropower and nuclear energy for the production of electricity (Figure 3.).

According to the U.S. Energy Information Administration in 2020, Switzerland produced 68.91 TWh of electricity, where hydropower accounted for 57.4%, nuclear energy for 33.4%, renewables for 8.5%, and fossil fuels for only 0.7% (Fig.6).



Sources: U.S. Energy Information Administration (Dec 2021) / <https://www.eia.gov/>

Figure 3. Electricity production in Switzerland

Switzerland's position in the comparative diagram of energy index is shown in Figure 4. Due to the lack of significant reserves of fossil resources, the country is not represented for the first three indices

of the chart. In terms of the share of electricity production from renewable energy sources (excluding hydropower) in 2017 Switzerland was 70<sup>th</sup> out of 170 countries selected for consideration.



Sources:

1. Crude oil proved reserves, 2021 / International Energy Statistic/Geography / U.S. Energy Information Administration (Nov 2021)\*98
  2. Natural gas proved reserves 2021 / International Energy Statistic / Geography / U.S. Energy Information Administration (Nov 2021) \*99
  3. Total recoverable coal reserves 2019 / International Energy Statistic / Geography / U.S. Energy Information Administration (Nov 2021) \*81
  4. Combination production-consumption for Crude oil 2018 / International Energy Statistic / Geography / U.S. Energy Information Administration (Nov 2021) \*219
  5. Combination production-consumption for Natural gas 2019 / International Energy Statistic / Geography / U.S. Energy Information Administration (Nov 2021) \*123
  6. Combination production-consumption for Coal 2019 / International Energy Statistic / Geography / U.S. Energy Information Administration (Nov 2021) \*128
  7. Electricity – from other renewable sources (% of total installed capacity), 2017 est. / The World Factbook / Library / Central Intelligence Agency \*170
  8. GDP per unit of energy use (PPP per unit of oil equivalent), 2020 \*66
  9. Primary energy consumption - BP Statistical Review of World Energy 2021/BP;GDP (purchasing power parity) - The World Factbook/Library/Central Intelligence Agency
  10. Energy use (primary energy use of oil equivalent per capita) 2020 \*127
  11. Primary energy consumption – BP Statistical Review of World Energy 2021; Population - United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019, custom data acquired via website. Retrieved 15 November 2021\*66
  12. The Global Energy Architecture Performance Index Report (EAPI) 2017 / Rankings / Reports / World Economic Forum
  11. Electric power consumption (kWh per capita), 2016 \*217
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  12. Combination of electricity production-consumption (kWh)/The World Factbook/Library/Central Intelligence Agency \*216
- \* Total number of countries participating in ranking

Figure 4. Energy indices of Switzerland

In the Energy Architecture Performance Index 2017, which is based principally on the level economic growth, environmental safety, and energy independence of the country, including access to energy, Switzerland was the absolute leader out of the 127 countries considered. Over the last 8 years the country has gained 1 position in the rating. Switzerland was in the top quarter of the ranking in terms of GDP per unit of energy use in 2020 – 2<sup>nd</sup> out of 66 countries, but this indicator per capita is significantly lower – 29<sup>th</sup> place.

## Energy Infrastructure

A territorial map showing the distribution of the largest infrastructure projects of the fossil-fuel sector in Switzerland is shown in Figure 5 – there are a number of faci-

ties for the processing, storage and transportation of fossil fuels. In terms of electricity consumption per capita, the country is 34<sup>th</sup> in the world, however, for the indicator of combination of electricity production-consumption, Switzerland was 105<sup>th</sup> in the ranked list of 216 countries.

More information on the energy balance of Switzerland can be found [here](#).

ties for the processing, storage and transportation of fossil fuels. The share of imported energy resources in the total balance of energy production was more than 46.2% (Fig. 5).

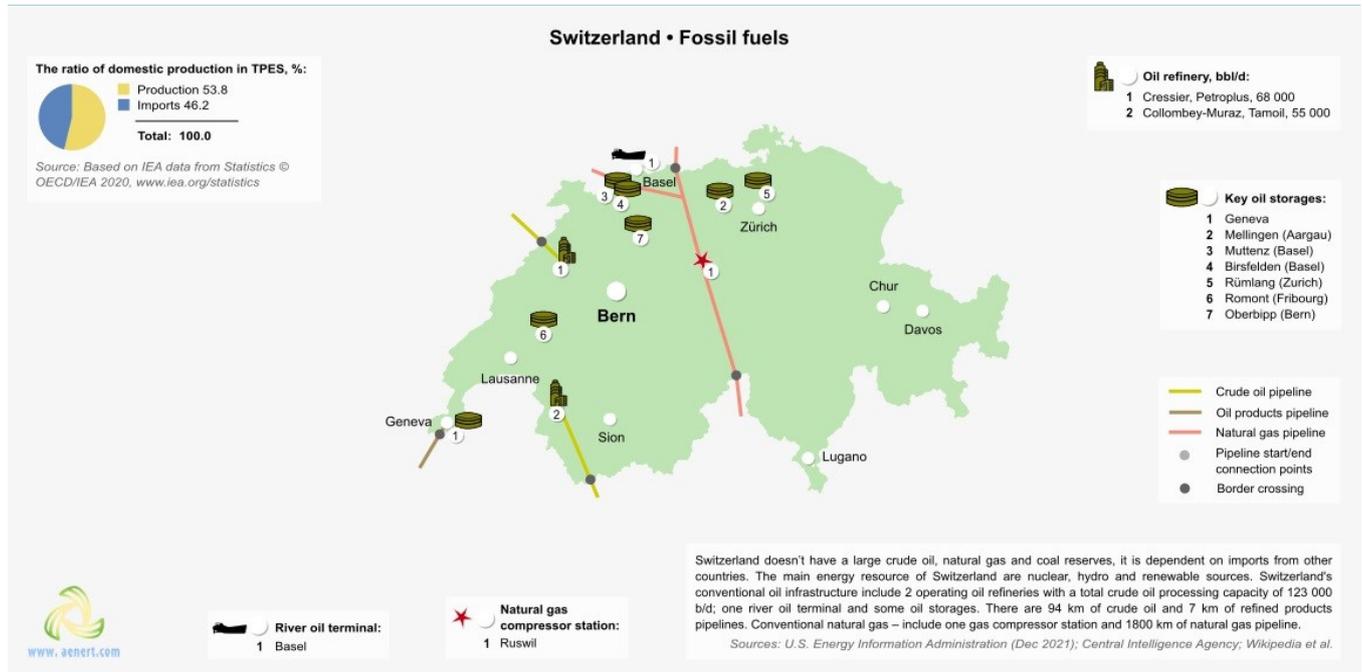


Figure 5. Basic infrastructural facilities of the fossil fuel sector in Switzerland

There are two oil refineries: Cressier, with a capacity of 68,000 barrels/day; and Collombey-Muraz with an installed capacity of 45,000 barrels/day, though it has been suspended since March 2015 [15].

Oil is delivered to Switzerland by rail and pipeline transport, and through a water terminal located in Basel (Fig. 5). The largest oil storage facility is located next to Geneva and has a total storage capacity of 850,000 m<sup>3</sup> [16].

Transportation of crude oil and petroleum products is carried via pipelines with a length of 94 km and 7 km, respectively (Fig. 5).

The Swiss gas system is represented by the gas compressor station Rhine Ruswil [17] and a network of pipelines with a length of 1,800 km (Fig. 5).

The map of the territorial distribution of the largest infrastructure facilities for electricity generation in Switzerland is shown in Figure 6.

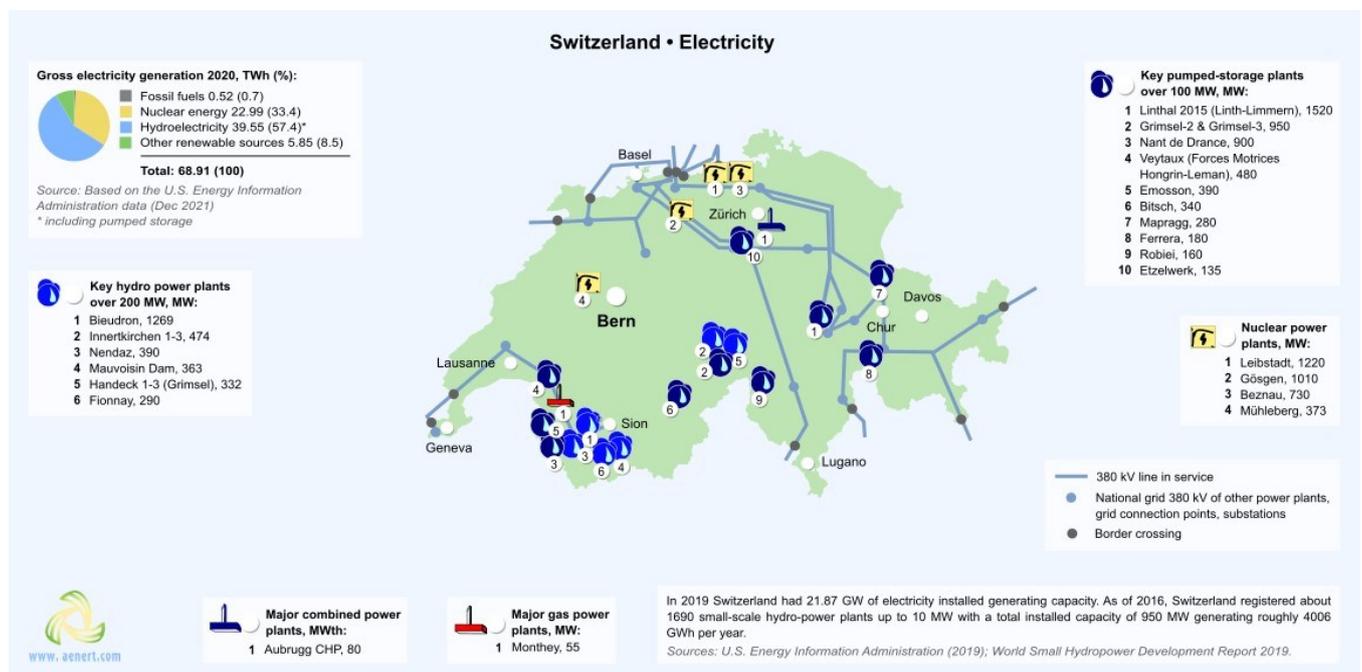


Figure 6. Electricity production in Switzerland

According to the U.S. Energy Information Administration, the share of hydropower in electricity production in Switzerland in 2020 was 57.4% (Fig. 6), which is represented by both pumped storage plants and large and small hydroelectric power stations (Fig. 6). The largest hydroelectric power plant is Bieudron with an installed capacity of 1,269 MW. The main pumped-storage complex is Linthal 2015 (Linth-Limmern), with an installed capacity of 1,520 MW [18,19]. At the beginning of 2022 Switzerland registered more than 1,500 small-scale hydropower

plants up to 10 MW with a total installed capacity of 1,900 MW generating 6,300 GWh annually [20]. The country has a number of stations for the production of electricity from fossil fuel, including 4 nuclear stations with a total capacity of more than 3,330 MW; the largest is - Leibstadt (1,200 MW). There is one gas power plant – Monthey (55 MW) and Aubrugg CHP combined power plant (80 MW) [21,22,23]. Figure 7 shows the main infrastructure facilities in Switzerland for the production of renewable energy.

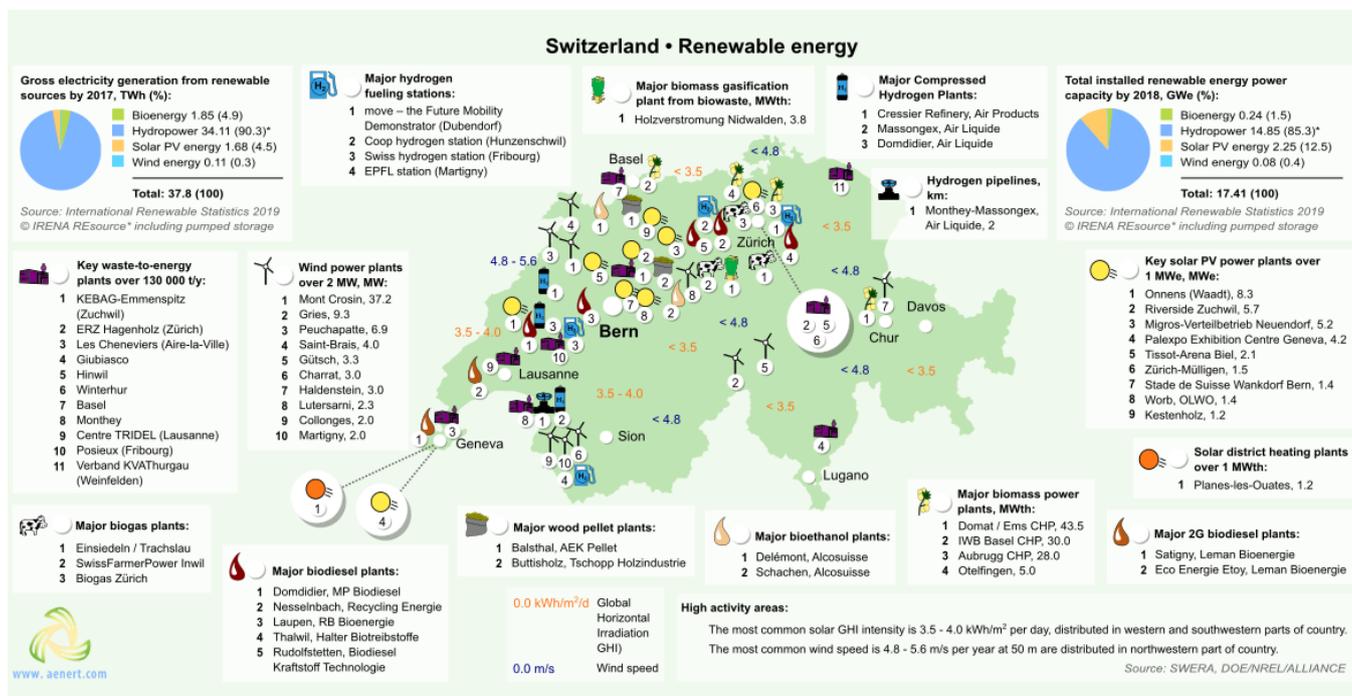


Figure 7. Renewable energy in Switzerland

In zones of high wind activity there are 11 large wind parks with a capacity of more than 2 MW each. In 2016 there were 37 wind farms in Switzerland [24]. The largest is Crosinc with an installed capacity of 37.2 MW [25].

As noted in the previous section, the level of global horizontal radiation in some parts of the country can reach 4kWh/m<sup>2</sup>, which is a sufficient resource for energy production [6]. As a result, a number of solar energy facilities are located on this territory, including 9 PV power plants that have a capacity of at least 1 MW. The largest is Onnens (Waadt) with an installed capacity of 8.3 MW [26]. Solar energy is also used in the heating systems of residential buildings. Planes-les-Ouates district heating plant has an installed capacity of 1.2 MW [27].

Switzerland is actively engaged in the production and use of hydrogen as an energy source for vehicles. As of January 2021 there are four hydrogen filling stations in operation in the country (Figure 7). There are several

Compressed Hydrogen Plants, the largest of which is managed by Air Products on the base of the Cressier Refinery and has a capacity of 7,814 Nm<sup>3</sup>/hr [28]. In the region of Monthey there is a 2 km long pipeline for hydrogen transportation, also managed by Air Liquid [29]. In 2019, about 1.87 TWh of electricity was generated from bioenergy in Switzerland (Fig. 7).

The country has biomass and municipal waste processing plants, torrefaction plants; biogas, biodiesel, bioethanol, and pellet production (Fig. 7).

The EMS Group manages the Domat biomass power plant, which is the largest in the country with a production capacity that exceeds 80 MW [30].

In Switzerland, several plants produce around 7,000 m<sup>3</sup> of biodiesel from vegetable oil waste, including Green Biofuel Switzerland AG [31]. Second generation biodiesel from cellulose is produced at two plants – Leman Bioenergie-Satigny and Eco Energie Etoy (Fig.7).

The main Swiss enterprises processing biomass are: Holzverstromung Nidwalden biomass gasification plant with general production capacity of 6500 MWth annually [32]; and Balsthal, capable of producing about 60,000 tons of pellets per year [33]. Switzerland also has enterprises for the production of biogas; one of the largest is Swiss Farmer Power capable of producing 2.5 million m<sup>3</sup> annually [34]. Varo Energy AG, Landor, Alcosuisse and BF Commodities SA produce bioethanol from agricultural and forestry wastes; Delemont bioethanol power plant can produce 230,000 hectolitres of pure ethanol per year [35].

The leader in the generation of electricity from municipal waste is KEBAG-chas, with an installed capacity of 11.8 MW [36].

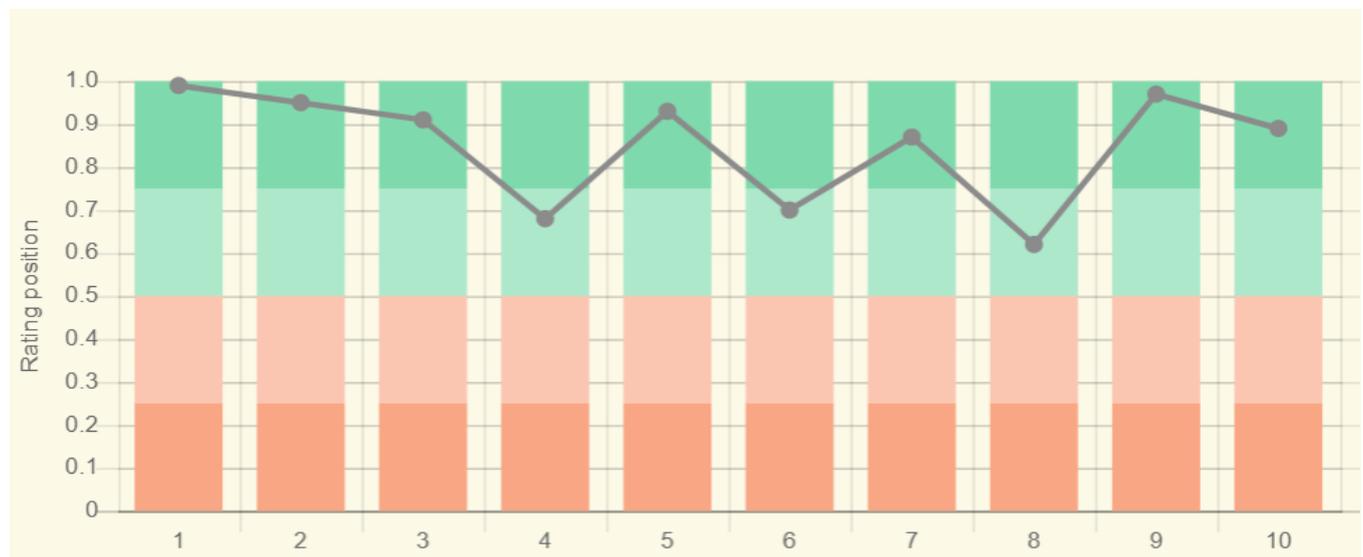
### Education and Innovation

The set of indices reflecting the position of Switzerland among other countries in the field of education and innovation can be seen in Figure 8. As can be seen from the diagram Switzerland has a successful academic culture. Switzerland placed one of the first places out of 132

As a part of the Energy Strategy 2050 adopted in Switzerland in 2017, in 2021 the government of Switzerland has presented a draft law to promote renewable energies. The country wants to increase electricity production from renewable energies from 4 TWh in 2019 to at least 17 TWh in 2035 and 39 TWh in 2050 [37].

For current information on the development of energy in the country see [here](#). More information about Swiss energy infrastructure is also available [here](#).

countries considered in the ranking of countries in the Global Innovation Index 2021 (see diagram). According to the number of patents granted to Swiss nations, both domestically and abroad, the country ranks 9<sup>th</sup> in the world. Similarly, by the number of patents in force, the country 10<sup>th</sup> in the world, indicating the country's favourable conditions for innovation.



Sources:

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  2. Patent Grants 2011-2020, resident & abroad / Statistical country profiles / World Intellectual Property Organization \*185
  3. Patents in Force 2020 / Statistical country profiles / World Intellectual Property Organization \*109
  4. QS World University Rankings 2022 \*97
  5. SCImago Country Rankings (1996-2020) / Country rankings / SCImago, (n.d.). SIR-SCImago Journal & Country Rank [Portal]. Retrieved 17 Nov 2021 \*240
  6. Internet users in 2018 / The World Factbook / Central Intelligence Agency \*229
  7. Internet users in 2018 (% Population) / The World Factbook / Central Intelligence Agency \*229
  8. Government expenditure on education, total (% of GDP), 2019 / United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics. License: CCBY-4.0 / Data as of September 2021 \*177
  9. Research and development expenditure (% of GDP), 2018 / UNESCO Institute for Statistics. License: CCBY-4.0 / Data \*119
  10. Scientific and technical journal articles, 2018 / National Science Foundation, Science and Engineering Indicators. License: CCBY-4.0 / Data \*197 196
- \* Total number of countries participating in ranking

Figure 8. The indices of education and innovation in Switzerland

In terms of government expenditure on education as a percentage of the country's GDP, the country demonstrates a result higher than the world average – 68<sup>th</sup> out of 177 countries selected for consideration. Ten Swiss universities are included in the rating of the world's leading universities – “QS University Rating”. It is also worth noting that the country's GDP is high, therefore in absolute terms the level of government expenditure on education is considerable.

In terms of public expenditure on research and development as a percentage of GDP, Switzerland is 3<sup>rd</sup>, behind Israel and Republic of Korea. Switzerland is well positioned when considering the number of publications of specialists in scientific and technological journal and patent activities. The country is 16<sup>th</sup> out of 240 participating countries in the Scimago ranking, and in Scientific and Technical Journals Activities is ranked 21<sup>st</sup> out of 197 countries. Swiss universities, such as ETH Zurich – Swiss Federal Institute of Technology and the Swiss Federal Institute of Technology Lausanne train specialists in various fields of energy, including Environmental Engineering and Electrical Engineering.

In the field of synthetic fuel production, the patent leaders are Ammonia Casale SA, GTL.F1 AG, Casale Chemicals S.A., Ineos Bio SA, Methanol Casale SA, Casale S.A., GTL Microsystems AG. Research and development in this field is carried out by Eidgenössische Technische Hochschule Zürich (ETH), Paul Scherrer Institute (PSI), Ecole Polytechnique Federale de Lausanne. Rosen Swiss AG, Tarim Associates for Scientific Mineral and Oil Exploration AG actively patent their inventions in the field of unconventional oil, and research is conducted on the base of Weatherford Switzerland, Clairant Oil Services and Eidgenössische Technische Hochschule Zürich (ETH). The Swiss Federal Institute of Aquatic Science and Technology (EAWAG) and Eidgenössische Technische Hochschule Zürich (ETH) are actively engaged in research in the field of gas hydrates.

Syngenta Participations AG, Verenum Corporation, Omya International AG, Endress+Hauser Flowtec Aq are leaders in patenting in the field of production of hydrocarbons from reservoirs with low permeability. The leaders in the number of publications in this field are Weatherford

Switzerland, KPMG International Cooperative, Eidgenössische Technische Hochschule Zürich (ETH).

Syngenta Participations AG, Clariant International AG are leaders in the number of inventions in the field of coal seam methane, and Weatherford Switzerland and Eidgenössische Technische Hochschule Zürich (ETH) are actively engaged in research in the field.

Swiss companies actively patent inventions related to associated petroleum gas. Prominent companies include GTL Microsystems AG, Multi Source Energy AG, and among research organisations – Swiss Federal Laboratories for Materials Science and Technology.

The leading patent holders in the field of bioenergy are Ineos Bio SA, Paul Scherrer Institut (PSI), RV LIZENZ AG, Hitachi Zosen Inova Ag, Plascoenergy IP Holdings. Eidgenössische Technische Hochschule Zürich (ETH), Paul Scherrer Institute(PSI), Ecole Polytechnique Federale de Lausanne are conducting research in this area. In 2016, specialists from Ecole Polytechnique Federale de Lausanne discovered a method for obtaining biofuel from lignin, the molecular structure of which has an energy density 30% greater than that of fuel obtained from sugar [38].

A large number of Swiss companies patent technical solutions in the field of energy production from renewable sources. In the field of solar energy –Alstom Technology, Ltd., Airlight Energy IP SA, TVP Solar S.A., Suncycle International GmbH. Leading research organizations in this field are Eidgenössische Technische Hochschule Zürich (ETH), Paul Scherrer Institute (PSI), Airlight Energy IP SA, Ecole Polytechnique Federale de Lausanne (EPFL). ABB Technology AG, VSL International AG, Wepfer Technics AG, ROMO WIND AG are leading patent holders in the field of wind power; research in this field is being conducted by Eidgenössische Technische Hochschule Zürich (ETH), Ecole Polytechnique Federale de Lausanne (EPFL), etc.

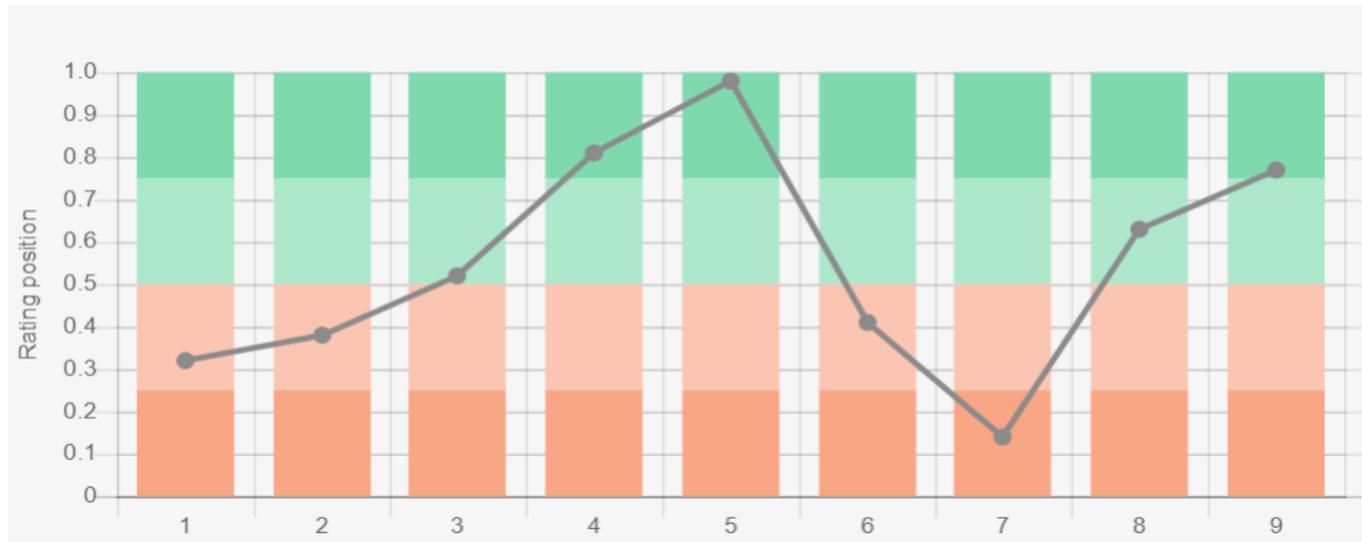
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*Additional information about education in the country can be obtained [here](#), and the list of research institutes [here](#).*

## Ecology and Environment Protection

The diagram of environmental indices presented in Figure 9 reflects, to some extent, the ecological situation in Switzerland. The country demonstrates a relatively high level of CO<sub>2</sub> emissions in general, and per capita.

Switzerland placed 12<sup>th</sup> out of the 61 countries responsible for more than 90% of global CO<sub>2</sub> emissions related to energy in the Climate Change Performance Index (CCPI) 2022.



Sources:

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- \* Total number of countries participating in ranking

Figure 9. Switzerland's environmental indices

In terms of forest area as a percentage of the country, Switzerland was 113<sup>th</sup> in the world in 2020, but demonstrated a positive trend in forest area change between 2010-2020, placing 44<sup>th</sup> in the world. The preservation of forests is a priority for the state.

The situation is brightened by a very high valuation of Environmental Performance Index (EPI) 2020, which focuses primarily on assessing the environmental performance of national governments policies, aimed at reducing the negative impact on the environment, and the rational use of natural resources. Here, Switzerland is third out of 180 countries surveyed.

However, according to the Environmental Vulnerability Index, which is based on years of observations and 50 indicators that include, for example, changing climatic characteristics or the quality of water resources, waste volumes, oil spills and other hazardous substances, etc.,

the country is 180<sup>th</sup> out of 234 countries, and is characterized as "highly vulnerable". The overall picture is aggravated by the Ecological Footprint Atlas rating, according to which Switzerland is among a number of ecological debtors.

Detailed information about the energy industry in Switzerland is available [here](#).

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  - [6] Solar resource data obtained from the Global Solar Atlas, owned by the World Bank Group and provided by Solargis / Global Solar Atlas / <http://globalsolaratlas.info/>
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The sources of charts and curves are specified under the images.