IEA-Advanced Motor Fuels ANNUAL REPORT 2022

Switzerland

Technology Collaboration Programme
by IEA

Switzerland

Drivers and Policies

Important drivers for the transformation of the Swiss energy system according to the federal government's Energy and Climate Strategy 2050 are the Energy Act, the Electricity Supply Act, and the CO_2 Act.[1] Targets are to gradually phase-out nuclear energy, increase energy efficiency, ramp up renewables, and achieve net-zero greenhouse gas emissions by 2050.

Laws are periodically adapted to new boundary conditions or strengthened in their effect in order to keep track on the recent development. New or revised acts are subject to an optional referendum and can be rejected by the public. That happened to the revised CO_2 Act, which was rejected in June 2021. At the same time, the Federal Council approved a dispatch on the Federal Act on a Secure Electricity Supply from Renewable Energy Sources.[2] With this bill, which entails a revision of the Energy Act and the Electricity Supply Act, the government aims to support Switzerland's transition to a sustainable and climate-friendly energy system while also ensuring a high level of security of supply. Large-scale electrification is needed in transport and heating (heat pumps) if Switzerland is to meet the goals of the Energy Strategy 2050 and its long-term climate strategy. This calls for a rapid and substantial increase in the use of renewables in domestic power generation.

Further measures are also needed to improve grid and supply security. The Federal Council aims to create a legal basis for greater planning certainty and incentives to invest in expanding renewable electricity production and grid integration. In 2022 the parliament discussed the draft law and, under the impact of the energy crisis, added numerous amendments to further accelerate the construction of renewable power generation facilities.

Based on an initiative submitted in November 2019, the Federal Council elaborated a Federal Act on Climate Protection Goals, Innovation and Strengthening Energy Security.[3] The draft law was submitted to parliament for consideration in June 2021 and passed in mid-2022. Because a referendum was successfully filed against it, a referendum will be held in the summer of 2023.

The energy crisis caused by the Russian invasion of Ukraine in 2022 had an impact on the debates in the parliament. The risk of an electricity shortage and a gas supply failure in winter requires a significant increase of domestic power generation from renewable sources, the need for renewable fuels, and a reduction of the energy consumption. However, the revised laws must be balanced in order not to fail a referendum.

CO_2 Emission Regulations for Cars

CO_2 emission regulations for new cars apply in Switzerland just as they do in the EU. As of 2021, under the World Harmonised Light-Duty Vehicles Test Procedure (WLTP), the average level of emissions from cars registered in Switzerland for the first time may not exceed 118 gCO_2/km, while the maximum level of CO_2 emissions from delivery and light articulated vehicles (collectively referred to as *light commercial vehicles)* will be 186 gCO_2/km. These targets correspond to those previously applied based on the New European Driving Cycle (NEDC) measurement procedure of 95 gCO_2/km for new cars and 147 gCO_2/km for new light commercial vehicles. Each importer's vehicle fleet must comply with an individual target based on these values. If the target is exceeded, the importer will pay a penalty. In 2021 the average CO_2 emissions of passenger cars achieved 129.8 gCO_2/km and exceeded the target value by 11.8 gCO_2/km and was 58.7% lower than in 2020 (28.6 gCO_2/km). This had a positive effect on the penalty that dropped from EUR 122.5 million (USD 144.9 million) in 2020 to EUR 26.0 million (USD 30.7 million) in 2021.[4] The narrowing of the gap between the target maximum CO_2 emissions and the emissions of newly registered vehicles was influenced primarily by a significant decline in sales of gasoline and diesel vehicles and a marked increase in hybrid and electric vehicles.

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1 https://www.bfe.admin.ch/bfe/en/home/policy/energy-strategy-2050.html/
2 SFOE, 2021, Federal Act on a Secure Electricity Supply from Renewable Energy Sources.
3 Bundesgesetz über die Ziele im Klimaschutz, die Innovation und die Stärkung der Energiesicherheit, 30.09.2022,
4 SFOE, 2022, "Vollzug der CO_2-Emissionsvorschriften 2021."

CO_2 Emissions Compensation: Motor Fuels

Importers of fossil motor fuels are required to compensate a certain amount of the CO_2 emissions caused by transport. They may carry out their own projects or acquire certificates. The compensation rate in 2021 was 12% and will rise to 23% in 2024.[5] From 2022 onwards, a minimum of 15% must be compensated by domestic measures. The Swiss Petroleum Association established the Foundation for Climate Protection and Carbon Offset (KliK). It launches and subsidizes projects to reduce CO_2 emissions in fields such as transportation, industry, buildings, and agriculture. Another measure to reduce CO_2 emissions is to blend fossil fuels with biofuels as Switzerland is under no obligation to blend fossil fuels; this is the only driver for blends.

Mineral Oil Tax Reduction for Natural Gas and Biofuels

To support the target for CO_2 emissions, a reduction – or even an exemption – for environmentally friendly motor fuels was enacted in 2008. Biofuels that satisfy minimum environmental and social requirements are completely or partially exempt from the mineral oil tax. As a result, the tax reduction for biofuels is now EUR 0.69 (USD 0.82) per liter, compared to fossil fuels. The mineral oil tax reduction is valid until the end of 2024.[6] To offset the loss of tax revenue from this tax cut, the fossil fuel tax will be gradually increased until 2028.

Advanced Motor Fuels Statistics

The following numbers and statements are based on 2021 statistics.

Final total energy consumption in Switzerland in 2021 amounted to 797,720 terajoules. This represents an increase of 6.7% compared to the previous year, which was heavily impacted by the coronavirus pandemic; energy consumption in 2020 was down 10.6% compared to 2019. In 2021, the situation had normalized somewhat and energy consumption increased again.

Gasoline and diesel consumption increased by a total of 1.6% (gasoline 2.2%, diesel 1.1%). Sales of aviation fuels increased markedly by 11.1%. However, this is still 42% lower than in 2019, i.e., before the pandemic. Overall, fuel consumption was thus 2.9% higher than in 2020. Transport fuels account for 30% of total Swiss energy consumption; all fossil fuels were imported. See Figure 1.

In 2021, 350,056 motor vehicles were newly registered in Switzerland. This represents an increase of 3.9% over 2020, but it is 14.6% less than new registrations in 2019. New registrations of passenger cars increased slightly, by 1.5%. The number of newly registered hybrid (+61.7%) and electric cars (+50.9%) rose again. Sales of gasoline-fueled cars dropped by 15.31% and sales of diesel-fueled cars dropped by 37.1%. Compared to 2019 totals, sales of those cars declined by 50.9%.

Despite the steep rise in sales of electric and hybrid passenger cars, their share of the total (4,688,235) is still very small. Figure 2 illustrates this fact, using passenger cars as an example. Hybrid vehicles have a share of 4.3% of the total passenger car fleet, whereas the share of electric vehicles amounts to 1.5%. Most of the electricity used in the transport sector is for railroad transportation.

[5] https://www.bafu.admin.ch/bafu/en/home/topics/climate/info-specialists/reduction-measures/compensation/motor-

[6] Mineralölsteuergesetz (MinöStG), Stand: January 1, 2022.

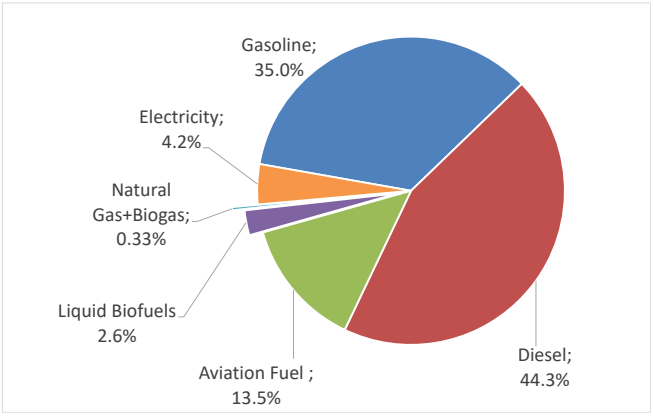

Fig. 1. Shares of Energy Sources in Energy Consumption for the Transportation Sector in Switzerland, 2021[7]

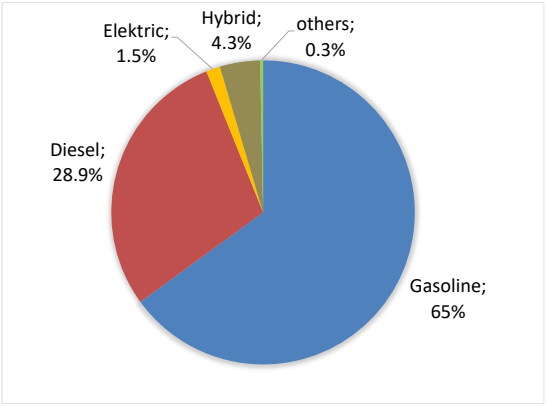

Fig. 2. Passenger Car Share by Fuel, 2021. Total Amount is 4,688,235[8]

As mentioned, importers of fossil motor fuels started blending fossil fuels with biofuels in 2014. The use of liquid biofuels rose from 29.4 million liters in 2014 to 230.5 million in 2021.

In 2021, 143.5 million liters of biodiesel and 82.7 million liters of bioethanol were used (see Figure 3). Hydrotreated vegetable oil (HVO) has been used in Switzerland only since 2016. It achieved a maximum in 2018 with 34.1 million liters and dropped to 4.2 million liters in 2021. Pure vegetable oil fuel is almost negligible (0.030 million liters). Upgraded biogas as a transport fuel remained at a low level of 3.1 million kg.[9]

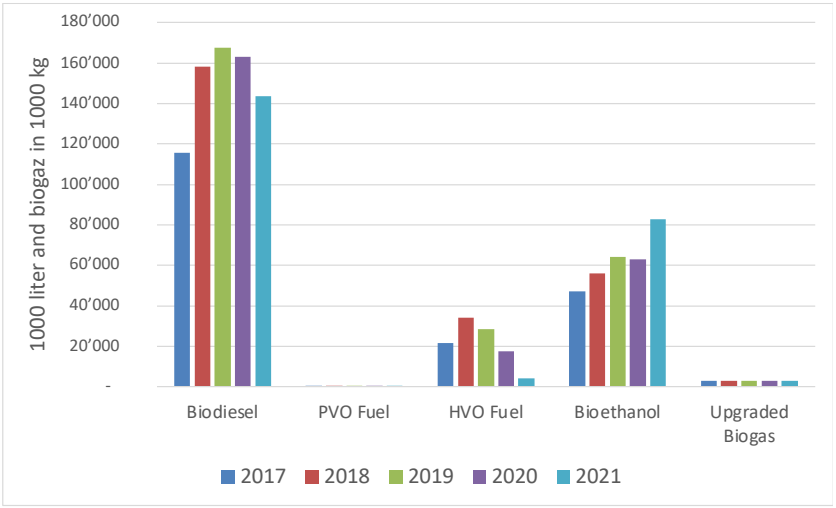

Fig. 3. The Use of Biofuels as Motor Fuels in Switzerland, 2016–2020

Only 9.9 million liters of biodiesel were produced in Switzerland; the remaining 133.6 million liters were imported (Germany, 40.0%; Japan, 33.3%; China, 11.7%; France, 9.6%; Austria, 4.8%). All bioethanol is imported (Poland, 43.9%; Germany, 13.7%; Norway, 13.2%; Sweden, 11.6%; Italy, 11.4%; United States, 6.2%).[10] Hydrotreated vegetable oil is mostly imported from the United States (99.8%), with the rest from Sweden and Finland.

The total amount of biogas produced and used in Switzerland in 2021 was 116 million kg. Only 29.1 million kg has been upgraded and fed into the natural gas grid. Of this, 3.1 million kg has been sold as biogas for cars, and the rest for heating. Almost all biogas used as motor fuel in cars is upgraded biogas fed into the natural gas grid. Figure 4 shows the development of the use of biogas and natural

7 SFOE, 2022, "Gesamtenergiestatistik 2021."
8 Swiss Federal Statistical Office (BFS), 2022, "Mobility and Traffic."
9 SFOE, 2022, "Schweizerische Statistik erneuerbarer Energien 2021."
10 Swiss Custom Administration, 2022, "T2.8 Biogene Treibstoffe 2021."

gas as motor fuels in cars. Despite an increasing amount of biogas fed into the natural gas grid, the demand for it as a motor fuel remains low: 89.4% of biogas is used for residential heating.[11]

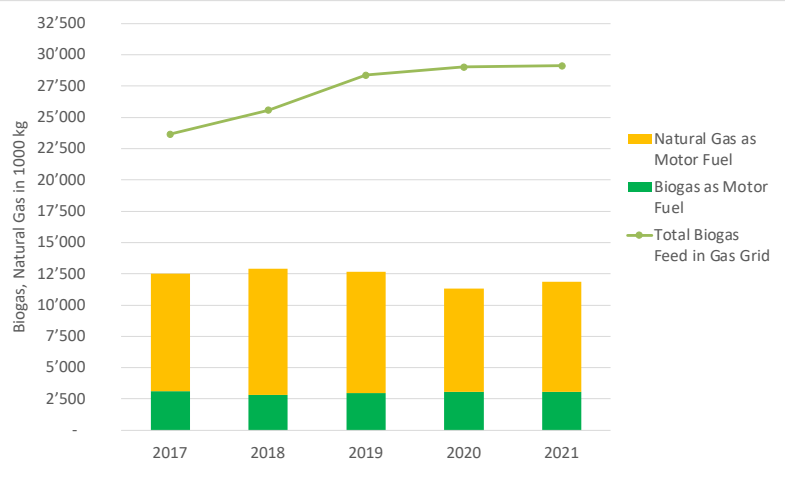

Fig. 4. Development of the Use of Natural Gas and Biogas as Motor Fuel for Cars and Total Upgraded Biogas Fed into the Natural Gas Grid (green line)

Research and Demonstration Focus

The Swiss Federal Office of Energy (SFOE) has three funding schemes for subsidiary support of energy-related projects.

- The main focus of the Energy Research Programme is on development and application.
- The Pilot and Demonstration Programme promotes the testing and implementation of new technologies, solutions, and concepts.
- The purpose of the programme SWEET – "**SW**iss **E**nergy research for the **E**nergy **T**ransition" – is to accelerate innovations that are key to implementing Switzerland's Energy Strategy 2050 and achieving the country's climate targets.[12]

The overarching goals of all funded projects are to foster energy security, energy efficiency, decarbonization, and renewable energies.

According to scenario ZERO Basis of the Swiss Energy Perspectives 2050+ until 2050 the transport sector should be operated without fossil fuel. That means a reduction from 200 petajoules (PJ) gasoline, diesel, and natural gas plus 7 PJ biofuels and 10.6 PJ electricity in 2021 to 71.9 PJ renewable fuels and 60.7 PJ electricity in 2050 (data without fuels for aviation). Figure 5 displays final energy demand.

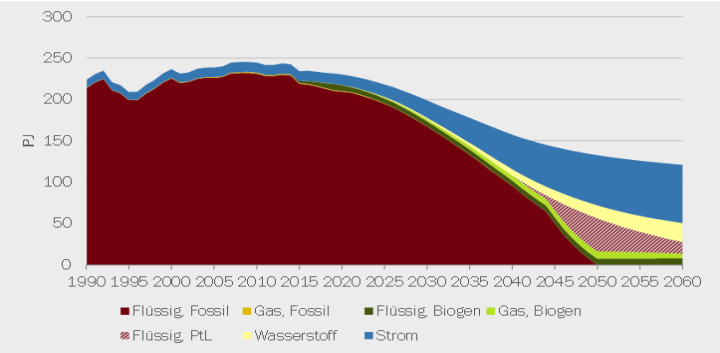

Fig. 5. Final Energy Demand of Domestic Transport (Scenario ZERO Basis, Excluding International Aviation)[13]

[11] Association of the Swiss Gas Industry, 2022, "VSG-Jahresstatistik."
[12] https://www.bfe.admin.ch/bfe/de/home/politik/energiestrategie-2050.html
[13] SFOE, 2022, Energy Perspectives 2050+, Technical Report

Therefore, in the transport sector the priority is electrification of passenger cars and public transport and the use of non-fossil fuels for the rest. The projects mentioned below cover the production, storage, and distribution of the fuels as well as their highly efficient use in internal combustion engines and gas turbines and exhaust gas after-treatment. The combustion and engine-relevant properties of biogas, hydrogen (H2), dimethyl ether (DME), polyoxymethylene dimethyl ether (OME), and ammonia (NH3) are investigated.

The following projects have recently been launched or are successfully active:

Sustainable Chemical Transport Fuels for Switzerland (2021–2024)[14]
The role and perspectives of sustainable chemical transportation fuels within a net-zero Swiss energy system are evaluated. To this end, a techno-economic, environmental, and social life cycle assessment of a comprehensive portfolio of chemical fuels – including hydrogen, biogenic, sun-to-liquid, and power-to-gas/liquid fuels – will be conducted and integrated into a scenario-driven energy system analysis. Due to limited sustainable primary energy resources for such fuel production in Switzerland, the analysis will be performed on a global level to identify plausible sources and locations for fuel production and import pathways.

E-Fuels: International Exchange of Research Findings and Activities (2021–2025)[15]
This project conducts an international exchange on the topic of e-fuels for transportation. Both the needs of the participating countries and their expertise will be gathered. The exchange should enable individual countries to fill the knowledge gaps of other countries with their expertise and, conversely, benefit from the expertise of other countries. One goal of this project for Switzerland is to gain knowledge about e-fuels through the exchange at both the national and international level. This will enable Switzerland to get a picture of the state of development of e-fuels on a global level and to deduce which research gaps still exist. The content of this project is a compilation of previous findings from Switzerland and the coordination of the international exchange of information. The project contributes to IEA AMF Task 64.

SWEET: Sustainable Fuels and Platform Chemicals (2023-2030)[16]
At the end of 2022, the SWEET Call 2-2022, "Sustainable Fuels and Platform Chemicals," was launched and is expected to start in 2023. Researchers are to investigate how Switzerland can meet its future needs for sustainable fuels and platform chemicals. Technologies for production, transport, distribution, storage, and use are to be further developed. Researchers also are to show how the additional potential of Swiss farmyard manure can be profitably used for the production of sustainable fuels and platform chemicals.

N_2O Exhaust Gas Treatment in Ammonia Engines (2022–2025)[17]
NH_3 is considered a promising fuel for large engines and, in particular, for international shipping applications, as no CO_2 is produced from its combustion. However, high concentrations of the pollutants NO_x, NH_3, and N_2O can be released. This project aims to develop recommendations for exhaust after-treatment systems that reduce pollutant emissions from NH_3-fueled engines. Catalytic experiments will be performed in a wide range of concentrations of pollutants and other feed components (O_2, H_2O, etc.) as well as temperature in order to provide recommendations for after-treatment setups and catalyst compositions depending on these operating conditions. The project will include a general screening of suitable catalysts, but currently Fe-exchanged zeolites seem most promising to remove N_2O and NO_x from exhaust gases with the help of NH_3.

Use of LBG (Liquefied Biogas) for Swiss Heavy-Duty Transport («HelloLBG») (2019-2023)[18]
The central objective of this project was to investigate whether and how LBG can be used in heavy-duty transport in Switzerland in an ecologically and economically sensible way. For this purpose, the energy demand and emissions during the entire value chain, from the production of LBG to transport and storage to its use in the vehicle, were investigated. This well-to-wheel analysis not only determined

[14] https://www.aramis.admin.ch/Texte/?ProjectID=49507
[15] https://www.aramis.admin.ch/Texte/?ProjectID=49314
[16] https://www.bfe.admin.ch/bfe/en/home/research-and-cleantech/funding-program-sweet/calls-for-proposals-overview/sweet-call-2-2022.html
[17] https://www.aramis.admin.ch/Texte/?ProjectID=51133
[18] https://www.aramis.admin.ch/Texte/?ProjectID=44233

the direct CO_2 emissions, but also took into account additional relevant greenhouse gas emissions as CO_2 equivalents. During fuel combustion, further pollutant emissions, for example NO_x and particulate matter, were also measured. For this purpose, two trucks with different engine technologies for LNG as fuel – high pressure direct injection (HPDI) and spark ignition (SI) – and an LNG filling station were purchased and examined specifically for the project. In a tank-to-wheel analysis, measurements have shown a GHG reduction of as much as 17 % (liquefied methane compared to diesel). In the well-to-wheel analysis, a GHG emissions reduction of up to 80% could be determined. An estimation of LBG production costs in possible Swiss plants shows that reasonable production costs are achievable. The biggest impact lies in the costs of biogas production.

Fig. 6. LNG Service Station in Weinfelden, Switzerland
Source: https://www.cng-mobility.ch/beitrag/lidl-weiht-erste-schweizer-lng-tankstelle-ein/

Outlook

The sharp rise in energy prices in 2022, the obvious dependence on energy imports, and the associated risk of an electricity shortage and a gas supply failure in winter: all of these impact implementation of the Swiss Energy Strategy 2050. Along with a strong increase in renewable electricity production, the production and procurement of non-fossil fuels has also become more important. In addition to the transportation sector, a need for secure power supply is also emerging. Sales of electric passenger cars will continue to grow strongly. Demand for large electric vehicles will continue to grow in the municipal sector, the public transport as well as mostly recently experienced in the heavy-duty truck sector.

For the remaining transport systems powered by combustion engines (like long-distance transport, marine transport, and different off-road applications), research institutes and industry are looking for the most suitable solutions. The focus is especially on H_2, but also on NH_3, methanol, and DME. The challenge is that it is not clear which of these fuels are best suited and will become established. Collaboration between research and development of renewable fuels and the use in combustion systems is important.

Major changes
In 2022 the Swiss parliament passed a new Act on Climate Protection Goals, Innovation and Strengthening Energy Security that will be subject to a referendum in 2023.

In 2021, sales of motor vehicles were still significantly lower (-14.6%) than before the 2019 onset of the coronavirus pandemic. Compared to 2019, sales of gasoline- and diesel-fueled cars declined by 50.9%, but 190% more hybrid and 143% more electric passenger cars were sold. The share of gasoline and diesel vehicles sold in 2021 decreased to 55%, while hybrid vehicles accounted for 32% and electric vehicles for 13%. These sales had a positive effect on the average CO_2 emissions from newly registered passenger cars. It exceeded the target value by 11.8 gCO_2/km and was 58.7% lower than in 2020 (28.6 gCO_2/km).

Sales of biofuels dropped slightly and remain at a very low level (3.3%), compared to the consumption of diesel and gasoline.

Benefits of participation in AMF
The future of internal combustion engines depends, among other things, on the successful market introduction of CO_2-reduced fuels. The AMF TCP is a pioneer in researching and describing novel fuels and their application, benefits, and effects in terms of efficiency and emissions. AMF is a unique source of information and a platform for international exchange of experience and cooperation.