Switzerland

Drivers and Policies

Since 2017, a fundamentally revised new Energy Act has been in force [1]. The core measure is to withdraw step by step from the use of nuclear energy without increasing carbon dioxide (CO_2) emissions. This goal can be achieved by increased energy savings (energy efficiency); expansion of hydropower and new renewable energy sources; and, if necessary, imports of electricity and fossil-fuel-based electricity production. By the end of 2017, the Federal Council launched a revised CO_2 Act, and the parliament started the debate in spring 2018 [2]. By the end of 2018, no agreement was achieved, and the debate will continue in 2019. The target is to reduce CO_2 emissions at least 50% from their 1990 levels by 2030. Measures to reduce CO_2 emissions from traffic should be tightened, as these emissions cause one-third of Swiss greenhouse gas emissions. Two groups must contribute: the automobile industry and the fossil fuel industry.

CO_2 Emission Regulations for Cars

Since 2015, Swiss car importers must pay a penalty if the average new passenger car fleet exceeds 130 grams (g) of CO_2 per kilometer (km). In 2017, the average was 134 g CO_2/km, and the penalty amounted to €2.4 million or $2.9 million US [3]. In alignment with the European Union Commission, the Federal Council aims to reduce average CO_2 emissions from passenger cars from 2021 to 2024 to 95 g CO_2/km and from light commercial vehicles (vans up to 3.5 metric tons [t]) to 147 g CO_2/km [2]. Further reductions are foreseen for the period 2025–2029. The use of synthetic CO_2-neutral fuels should be taken into account.

CO_2 Emissions Compensation: Motor Fuels

Since 2014, importers of fossil motor fuels must use domestic measures to compensate CO_2 emissions generated by the entire transportation sector [4]. The compensation rate started in 2014 at 2% and will be raised to 10% in 2020. Importers of fossil motor fuels may carry out their own projects or acquire certificates. 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. Blending causes a substantial increase of biofuels. Compared to 2013, the use of biofuels in 2017 was 10 times higher. The draft new CO_2 Act foresees that at least 5% of CO_2 emissions caused by traffic must be compensated with renewable fuels instead of an obligation for blending fossil fuels with biofuels at a fixed rate.

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 standards are completely or partially exempt from the mineral oil tax. As a result, the tax reduction for biofuels is up to €0.64 ($0.72 US) per liter (L) in comparison with fossil fuels. The mineral oil tax reduction is only valid until 2020 [5].

Advanced Motor Fuels Statistics

Final total energy consumption in Switzerland in 2017[1] amounted to 849,790 terajoules (TJ), of which 35% was transport fuels (Figure 1) [6]. Compared to 2016, fuel consumption remains the same. In the same period, the total amount of engine-driven vehicles increased by 1.2%, in the sum of 6,053,258. Fuel consumption by vehicle dropped by 2.8%. Some changes in specific applications were made in 2017: diesel, −0.3%; gasoline, −3.1%; and aviation fuels, +2.4%. All fossil fuels were imported.

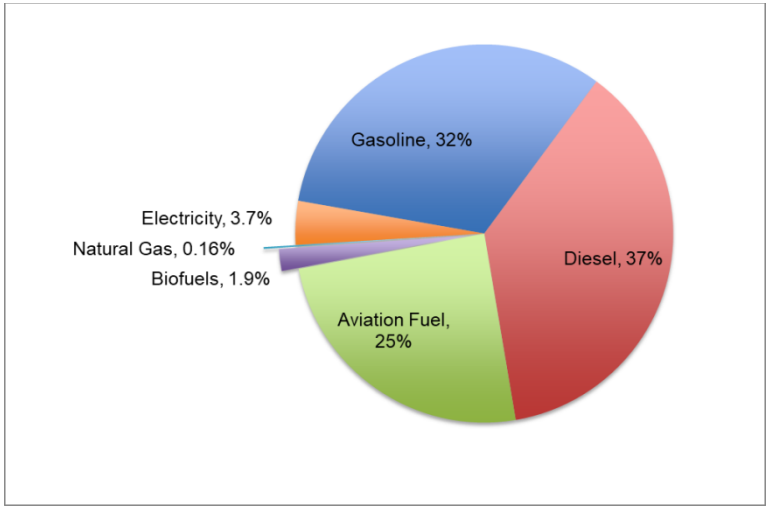

Fig. 1 Shares of Energy Sources in Energy Consumption for the Transportation Sector in Switzerland in 2017 [6]

Electricity is used for railroad transportation, and a negligible amount is used for electric cars. Despite an impressive annual increase of electric vehicles (2014, +65%; 2015, +70%; 2016, +42%; and 2017, +36%), the total amount is still very small (14,539 passenger cars) [7]. In 2000, the

[1] At the time this report was prepared, only data from 2017 were available.

share of diesel of the total amount of fuels (without aviation) amounted to 26%. With a share of 52% in 2017, the consumption of diesel was higher than the use of gasoline (45%) and biofuels (2.6%).

As mentioned, importers of fossil motor fuels started blending fossil fuels with biofuels in 2014, due to the obligation to reduce CO_2 emissions. Within 5 years, the use of liquid biofuels rose from 16.035 million to 189.650 million L. In 2017, 116.370 million L biodiesel and 51.668 million L bioethanol were used (Figure 2). Hydrotreated vegetable oil has only been used in Switzerland since 2016 (2017: 21.523 million L). Pure vegetable oil fuel is almost negligible (0.089 million L). Upgraded biogas as a transport fuel remained at a low level of 3.116 million kg [8].

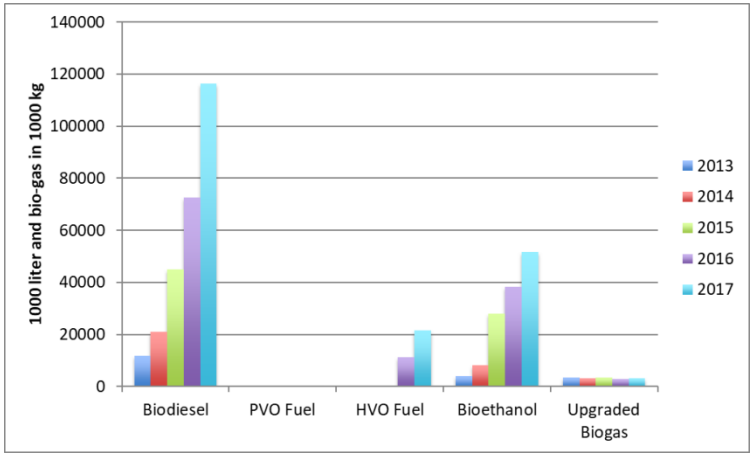

Fig. 2 Development of the Use of Biofuels as Motor Fuels in Switzerland, 2011–2015

Only 8.688 million L of biodiesel was produced in Switzerland. The other 107.682 million L was imported (Germany 75% and the rest from six other countries). All bioethanol is imported (Holland, 40.6%; Sweden, 21.3%; Poland, 13.6%; Norway, 12.5%; Italy, 11.5%; and Germany, 0.5%) [9].

The total amount of biogas produced and used in Switzerland in 2017 was 109,425 t. Only 23,667 t has been upgraded and fed into the natural gas grid. From this, a small amount (3,116 t) has been sold as biogas for cars, and the rest for heating [8]. Most biogas used as motor fuel in cars is upgraded biogas fed into the natural gas grid. Therefore, cars need no special requirements for biogas as a fuel. Figure 3 shows the development of the use of biogas and natural gas as motor fuels in cars. The demand for biogas is stable, but the demand for natural gas is decreasing year by year. Figure 3

shows that the amount of upgraded biogas fed into the natural gas grid has more than doubled in the last 5 years due to an increased demand for biogas for residential heating but not for automotive applications [10].

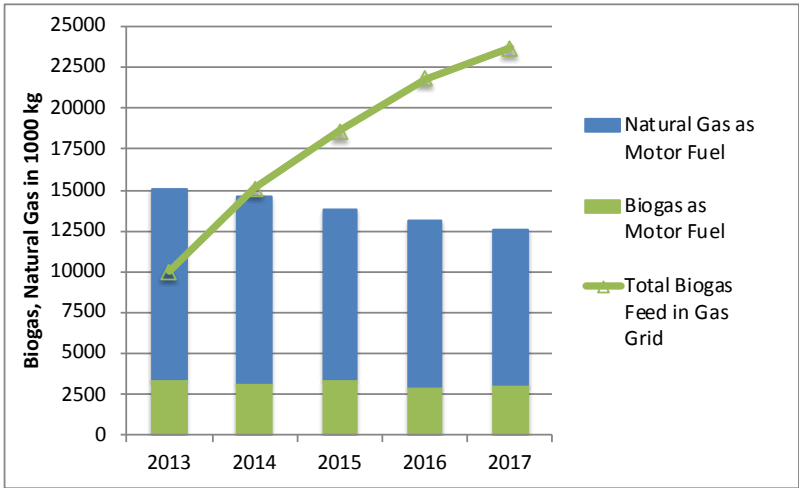

Fig. 3 Development of the Use of Natural Gas and Biogas as Motor Fuel for Cars and Total Upgraded Biogas Fed into the Natural Gas Grid (green line)

Research and Demonstration Focus

In the research, development, and demonstration funding framework of the Swiss Federal Office of Energy, three programs — bioenergy, combustion, and mobility — support AMF research activities [11]. In addition, Swiss Competence Centers for Energy Research support coordination, improve collaboration, and increase capacity building. One is dedicated to mobility [12] and another to bioenergy [13], including liquid and gaseous biofuels. Examples of ongoing research projects are detailed below.

Adapted fuels for dual-fuel and diesel combustion. A novel optically accessible test facility is used to examine combustion processes at engine-relevant flow, temperature, and pressure conditions. Of particular interest are investigations of lean gas/air-premixed dual-fuel combustion with adapted pilot fuels as well as optimization of diesel-combustion with respect to emissions and particulate matter by tailored alternative liquid fuels.

Investigations of the suitability of DME as an alternative fuel in heavy-duty vehicles. Methanol/dimethyl-ether (DME) is a well-suited fuel for compression ignition engines, which can be produced from several

renewable sources. To use DME, the fueling system needs to be adapted. Because DME contains oxygen, an interesting NO_x-soot-efficiency trade-off can be expected, especially if exhaust gas recirculation is used. Within this project, a modern heavy-duty engine will be optimized for the use of DME.

Diesel engine with neat OME_{3-6}. Polyoxymethylene-dimethylether (OME) fuel has a high potential for reducing CO_2. The combustion characteristics of OME increase efficiency and simplify the exhaust after-treatment system, which increases the market chances of the more expensive fuel. This project's goal is to lay out an optimum OME engine and after-treatment configuration. This procedure includes detailed optical investigations, modelling of the combustion process, and testing of bench experiments.

Outlook

The main driver to increase the use of biofuels is the government's requirement that the petrol industry compensate 10% of CO_2 emissions via domestic measures. The target to reduce average CO_2 emissions from passenger cars by 2020 from 130 to 95 g CO_2/km will increase sales of hybrid, electric, and gas-driven vehicles. With the drafted new CO_2 Act, these drivers will be amplified. The Swiss gas industry aims to achieve a share of 30% of renewable gas in the heating market by 2030. To achieve this target, different sources of renewable gas are needed, including power-to-gas technologies. Gas is mainly used for heating purposes. Only a negligible amount is used as motor fuel. Despite this, several new research projects focus on the improvement of the gas engine technology. Perhaps the request to reduce CO_2 emissions will boost gas as a relevant motor fuel.

Additional Information Sources

[1] The Federal Council, 2017, "730.0 Energiegesetz (EnG)."
[2] Federal Office for Environment (FOEN), "Totalrevision CO_2 Gesetz."
[3] SFOE, 2018, "CO2-Emissionen von Neuwagen …im Jahr 2017."
[4] FOEN, 2012, "CO_2 emission compensation: motor fuels."
[5] Mineralölsteuergesetz (MinöStG), Stand: Jan. 1, 2012.
[6 SFOE, 2018, "Gesamtenergiestatistik 2017."
[7] Swiss Federal Statistical Office (BFS), 2018, "Mobility and Traffic."
[8] SFOE, 2016, "Schweizerische Statistik erneuerbarer Energien 2016."
[9] Swiss Custom Administration, 2017, "Mineralölstatistik."
[10] Association of the Swiss Gas Industry, 2018, "Mineralölsteuer …"
[11] www.bfe.admin.ch
[12] www.sccer-mobility.ch
[13] www.sccer-biosweet.ch