# IEA-Advanced Motor Fuels ANNUAL REPORT 2021

# Switzerland

Technology Collaboration Programme
by iea

## Switzerland

### *Drivers and Policies*

In September 2020, Swiss Parliament passed a revised $CO_2$-Act as a measure to achieve the climate targets of the Paris Agreement and to meet the goal of the Federal Council to reduce Switzerland's net carbon emissions to zero by 2050. An optional referendum came to pass, and the voters rejected it in June 2021. It was rejected because it caused too many costly measures, such as an increase in $CO_2$-tax on fossil fuel for heating up to EUR 200 per ton $CO_2$ (USD 217), a ban of fossil-fueled heating systems in new buildings, additional tax on fuel price, an air-ticket levy and more. Now, the parliament will elaborate a more moderate revision of the $CO_2$-Act. However, in alignment with the European Union Commission, in Switzerland step-by-step reduced $CO_2$ emission regulations apply for new passenger cars and for light and heavy-duty vehicles. Importers of fuels have to compensate for an increasing share of $CO_2$ emissions. One can observe a strong increase in sales of electric vehicles and heat pumps and a rise in electricity demand. This challenges the aims of the energy law in force since 2017[1], which stipulates a gradual phase-out of nuclear energy and which today covers about 35% of electricity demand in Switzerland. The increase of electricity demand can therefore only be achieved by reducing electricity demand in other areas, and through an expansion of hydropower and new, renewable energy sources like photovoltaics and wind. Increasing imports of renewable chemical energy sources, such as hydrogen or synthetic fuels, are being discussed politically. A procedure for importing certain biogenic aviation fuels into Switzerland has been established since July 2021. An initial delivery of 460 metric tons has been imported in the same month and blended with fossil kerosene in existing tank farms.

#### $CO_2$ Emission Regulations for Cars

In 2020, a new $CO_2$ emissions regulation came into force for new cars. The new limit is 95 g $CO_2$/km for passenger cars (previously 130 g $CO_2$/km) and 147 g $CO_2$/km for light commercial vehicles (vans up to 3.5 metric tons). The limit values are measured with the new World Harmonized Light-Duty Vehicles Test Procedure (WLTP). As a result of the tightening of the target value in 2020, average $CO_2$ emissions fell by 10.5%, from 138.1 g $CO_2$/km in 2019 to 123.6 g $CO_2$/km in 2020. However, the average emissions were well above the new target value of 95 g $CO_2$/km. Swiss car importers must pay a penalty if their average emissions exceed the limit value. Eased provisions after the introduction of the new limits apply until 2022. Nevertheless, the penalty rose from EUR 81.4 million (USD 95.5 million) in 2020 to EUR 122.6 million (USD 144.0 million) in 2021.[2]

#### $CO_2$ Emissions Compensation: Motor Fuels

Since 2014, importers of fossil motor fuels must use domestic measures to compensate for $CO_2$ emissions generated by the entire transportation sector.[3] The compensation rate was established at 2% in 2014, and was raised to 12% in 2021. 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. This has led to a sharp increase in sales of liquid biofuels.

#### 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 up to EUR 0.69 (USD 0.82) per liter (L) in comparison with fossil fuels. The mineral oil tax reduction was initially valid until 2020 and has now been extended until 2023.[4] To offset the loss of tax revenue from this tax cut, the fossil fuel tax will be gradually increased until 2028.

1 The Federal Council, 2017, "730.0 Energiegesetz (EnG)"
2 SFOE, 2020, "Vollzug der $CO_2$-Emissionsvorschriften 2020"
3 FOEN, 2012, "$CO_2$ emission compensation: motor fuels"
4 Mineralölsteuergesetz (MinöStG), Stand: July 1, 2020

## *Advanced Motor Fuels Statistics*

The following numbers and statements are all based on 2020 statistics. This therefore represents the impact of the Covid-19 pandemic in 2020.

Final total energy consumption in Switzerland in 2020 amounted to 747,400 terajoules. This represents a reduction of 10.6% compared to the previous year. The impact of the pandemic on energy consumption is particularly evident in transport fuels. Gasoline and diesel consumption fell by a total of 8.1% (gasoline -11.4%, diesel -5.2%). Sales of aviation fuels slumped by -62.2%. Overall, fuel consumption was thus 22.6 % lower than in 2019, which represents a historic slump. Transport fuels account for 22% of total Swiss energy consumption. All fossil fuels were imported. See Figure 1.[5]

In 2020, 336,841 motor vehicles were newly registered in Switzerland, which is the lowest level in 24 years and a decrease of 17.8% compared with 2019. New registrations of passenger cars fell by as much as 23.7%. Despite this record drop, the number of hybrid (+78.9%) and electric cars (+49.8%) that were newly registered rose again. Sales of gasoline cars dropped by 38.1% and sales of diesel cars dropped by 34.7%.

The fall in new registrations due to COVID-19 did not prevent the overall vehicle stock from growing by 1.3% to 6,241,141 engine driven vehicles. Despite the steep rise in sales of electric and hybrid vehicles, their share of the total is still very small. Figure 2 shows this, using passenger cars as an example. Hybrid vehicles have a share of 3% of the total passenger car fleet whereas the share of electric vehicles amounts to 1%. Most of the electricity used in the transport sector is for railroad transportation.

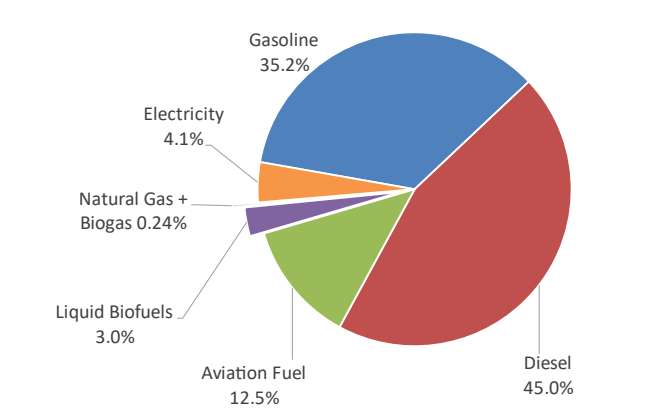


Fig. 1. Shares of Energy Sources in Energy Consumption for the Transportation Sector in Switzerland, 2020[6]

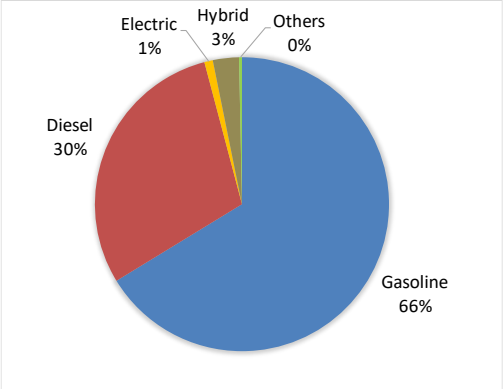


Fig. 2. Passenger car share by fuel, 2020. Total amount is 4,658,335[76]

As mentioned, importers of fossil motor fuels started blending fossil fuels with biofuels in 2014, due to the obligation to reduce $CO_2$ emissions. In the last five years, the use of liquid biofuels rose from 72.5 million L to 243.7 million L. In 2020, 163.1 million L biodiesel and 63.2 million L bioethanol were used. See Figure 3. Hydrotreated vegetable oil has only been used in Switzerland since 2016 (2020: 17.4 million L). Pure vegetable oil fuel is almost negligible (0.040 million L). Upgraded biogas as a transport fuel remained at a low level of 3.1 million kg.[7]

[5] SFOE, 2020, "Gesamtenergiestatistik 2019"
[6] Swiss Federal Statistical Office (BFS), 2020, "Mobility and Traffic"
[7] SFOE, 2020, "Schweizerische Statistik erneuerbarer Energien 2020"

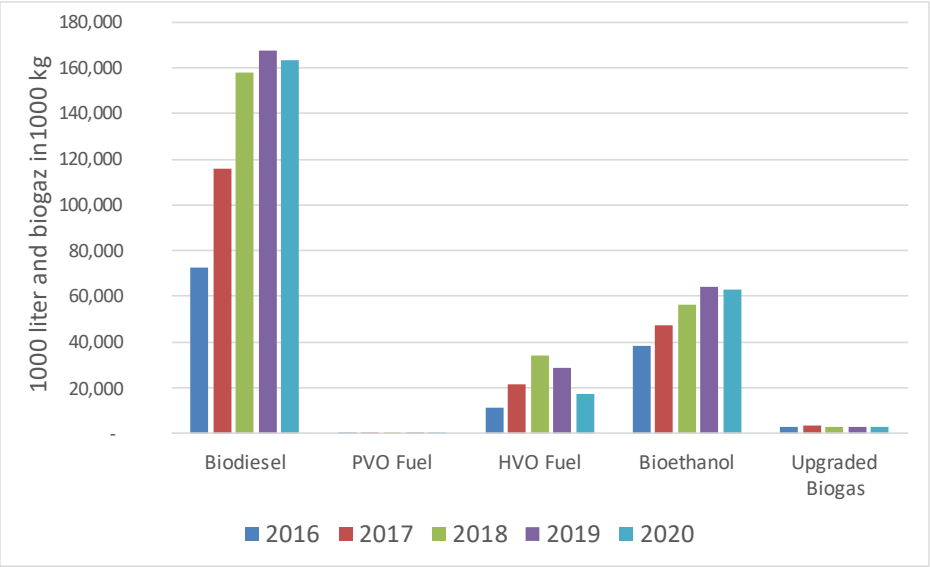


Fig. 3. Development of the Use of Biofuels as Motor Fuels in Switzerland, 2016–2020

Only 13.0 million L of biodiesel were produced in Switzerland. The other 154.5 million L were imported (Germany, 37.9%; Japan, 32.3%; France, 17.1%; China 9.9%). All bioethanol is imported (Poland, 30.7%; Sweden, 22.2%; Norway, 17.3%; Germany, 12.1%; Italy, 7.0%; and the rest from three other countries).[8] Hydrotreated vegetable oil is imported from the United States, 98.4%; and China, 0.2%.

The total amount of biogas produced and used in Switzerland in 2020 was 113 million kg. Only 29 million kg has been upgraded and fed into the natural gas grid. From this, a small amount (3.1 million kg) has been sold as biogas for cars, and the rest for heating. All 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 4 shows the development of the use of biogas and natural gas as motor fuels in cars. Despite an increasing amount of biogas fed into the natural grid, the demand for it as a motor fuel remains at a low level while 89% of biogas is used for residential heating.[9]

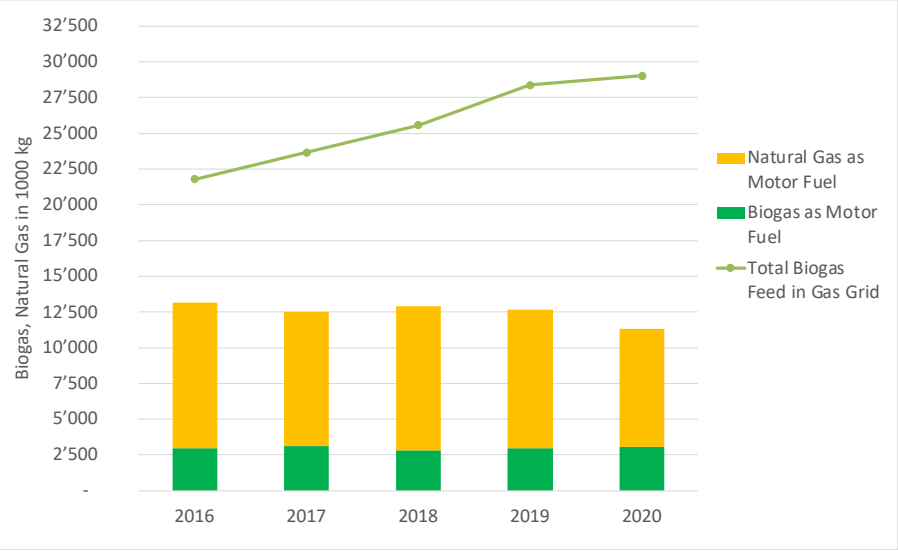


Fig. 4. Development of the Use of Natural Gas and Biogas as Motor Fuel for Cars and Total Upgraded Biogas Fed into the Natural Gas Grid (green line)

[8] Swiss Custom Administration, 2020, "T2.8 Biogene Treibstoffe 2020"
[9] Association of the Swiss Gas Industry, 2021, "VSG-Jahresstatistik"

## *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.[10] In the transport sector, the bioenergy and combustion programs almost exclusively fund alternative fuels projects in the industry and at universities. The combustion and engine-relevant properties of biogas, hydrogen ($H_2$), dimethyl ether (DME), polyoxymethylene dimethyl ether (OME) and ammonia ($NH_3$) are investigated. The mobility program has its research focus on electromobility. Demonstration projects with fuel cells in commercial vehicles are also funded. The following are examples of ongoing projects:

### Carbon reduced Dual-fuel combustion in marine engines[11]

The adoption of LNG as marine fuel is a very important step to reduce GHG-Emission. In this project, a next step in the direction of sustainable fuels generated through synthesis on the basis of renewable energy is investigated. Synthetic fuels are associated with a price penalty that is clearly depending on the level of refinement, i.e. the number and complexity of processing steps involved. In consequence, gaseous synfuels must be expected to be the most realistic option for marine applications. These include specifically $H_2$, $NH_3$ and synthetic methane. The latter can be considered a classical drop-in fuel whereas the physical and combustion properties of $H_2$ and $NH_3$ are clearly distinct from the LNG used today on Dual Fuel engines. Therefore, the combustion relevant properties of pure and blended synfuels are investigated at a novel “optical engine” test facility (see Figure 5) in order to predict their impact on large Dual Fuel engines. This is specifically important for the initial phase of the introduction of such fuels, when they will not be available worldwide and in large quantities, such that engines will need to be able to operate on multiple fuels and also mixtures of them.

Fig. 5. The Flex-OeCoS – a novel optically accessible test rig for the investigation of advanced combustion processes under engine-like conditions
*Source: ITFE FHNW, WIN-GD, CFS 2020-2023; contributes to AMF Task 60*

### Hydrogen Direct Injection Combustion Process[12]

This project focuses on hydrogen internal combustion engines (ICE) for heavy-duty, off-road applications, which have advantages over PEM fuel cells concerning service life, investment costs, thermal management and fuel flexibility (H2/CH4 admixtures). The aim is fuel conversion predominantly in a stratified, jet-guided mode; enabling combustion at $\lambda=1$ with nearly zero emissions and without the knock limitations of conventional combustion processes, especially at high loads.[13]

### New combustion process for hydrogen engine in heavy duty and off road application[14]

In contrast to the aforementioned project, very lean hydrogen combustion will be investigated here. For this purpose, a special injection and ignition system is being developed that enables very lean hydrogen

[10] www.bfe.admin.ch
[11] https://www.aramis.admin.ch/Grunddaten/?ProjectID=47512
[12] https://www.aramis.admin.ch/Grunddaten/?ProjectID=48410
[13] Empa, ETHZ, IFS Uni Stuttgart, 2021 – 2023
[14] https://www.aramis.admin.ch/Grunddaten/?ProjectID=44967

mixtures up to $\lambda = 3$ to be ignited. The goal is to achieve very low engine-out $NO_x$ emissions that meet EURO 7 standards without exhaust after-treatment system. See Figure 6.

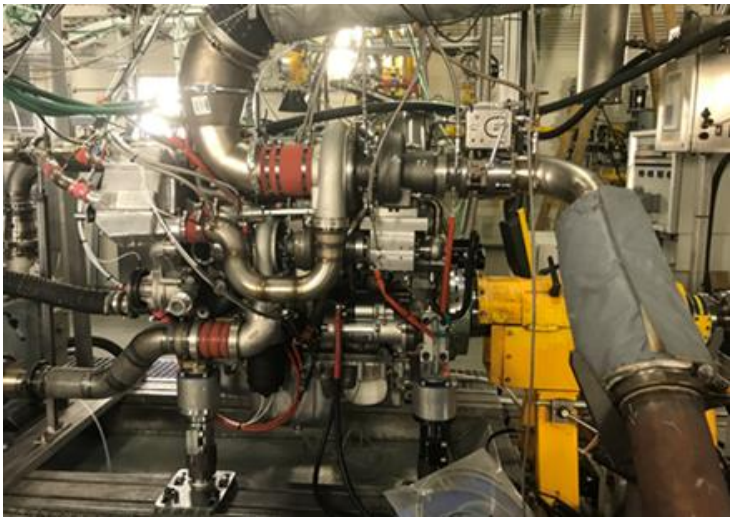

Fig. 6. Hydrogen Fueled Engine in the test bench
*Source: Liebherr Machines Bulles SA*

**Flexible engine platform with new combustion concepts for renewable fuels[15]**
The type of renewable chemical energy sources can vary greatly from region to region (methane/DME or methanol, biodiesel, HVO, etc). The availability of efficient, affordable and flexible energy converters for mobile heavy-duty applications is therefore important in order to be able to react to market conditions and thus promote the use of renewable energy. This project considers a flexible engine platform capable of efficiently converting high- or low-reactivity fuels. This is achieved by a novel fully variable valve train (see Figure 7) that allows flexible control of gas exchange and exhaust gas recirculation in combination with optimized combustion chambers and new combustion modes.

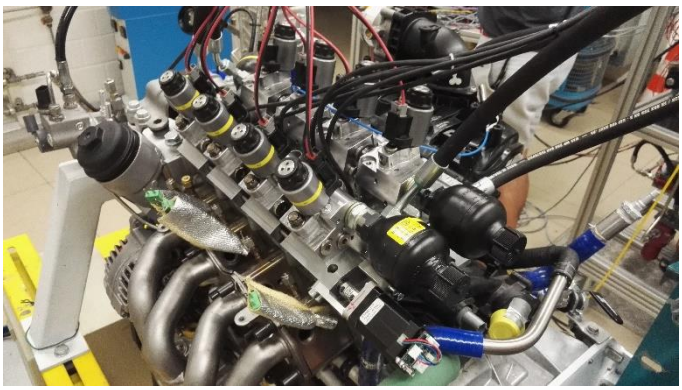

Fig. 7. Novel electro-hydraulic valvetrain on 4-Cylinder Engine
*Source: Empa, FPT Motorenforschung AG, IDSC ETHZ, Etavalve; 2021 - 2023*

## *Outlook*

Sales of passenger cars with electric drive systems will continue to grow strongly. The expanded range of vehicles on the market, the massive expansion of electric charging stations and tax relief all contribute to this. Demand for large electric vehicles will be mainly confined to the municipal sector and to public transport. Trucks with fuel cells are also being tested, and power-to-gas plants are being built to supply them with hydrogen. The engine industry and research institutes are developing and testing combustion and engine concepts for the use of different fuels with a low GHG footprint. The focus is especially on $H_2$, but also on $NH_3$, DME, and OME. The engines developed for these fuels are intended for long-distance transport, marine transport, and different off-road applications.

[15] https://www.aramis.admin.ch/Grunddaten/?ProjectID=49517

**Major changes**
Swiss Parliament passed in September 2020 a revised $CO_2$-Act. It was rejected by an optional referendum in June 2021.

Swiss car importers must pay a penalty if the average new passenger car fleet exceeds 95g $CO_2$/km. With an average of 123.6 g $CO_2$/km in 2020, they had to pay EUR 122.6 million (USD 144.0 million). Total Swiss energy consumption dropped by 10.6%; fuel consumption was 22.6% lower than in 2019. Sales of gasoline and diesel passenger cars dropped and sales of hybrid and electric cars rose.

**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 TCP AMF 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.