IEA-Advanced Motor Fuels
ANNUAL REPORT 2015

SWEDEN

Sweden

Introduction

Total energy use in the transport sector, including foreign transport, amounted to 113 terawatt-hours (TWh) in 2013. The shares of energy use for the different transport modes are shown in Figure 1. Bunkering for foreign maritime traffic amounted to 19 TWh, and fuel for nondomestic aviation accounted for slightly less than 9 TWh. Swedish domestic transport used 85 TWh, representing almost one quarter of the country's total energy use in 2013. Petrol and diesel oil, including low blending, met 83% of the country's energy requirements for domestic transport.

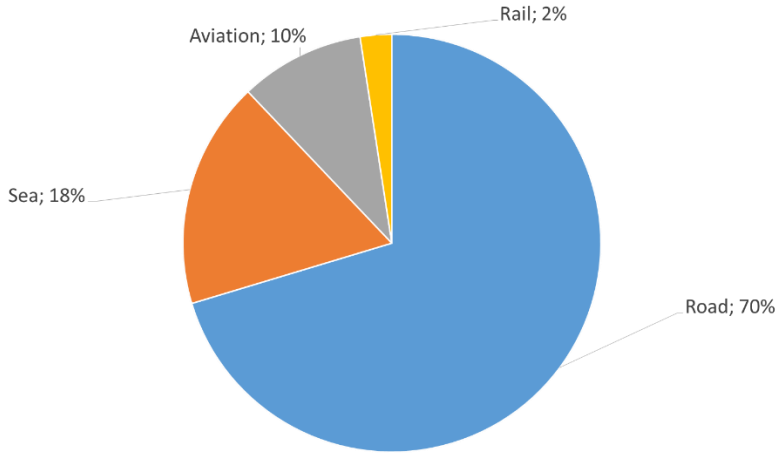

Fig. 1 Share of Energy Use among Different Transport Modes in 2013, both Domestic and Foreign

Sweden imported just less than 20 million tonnes (equivalent to about 200 TWh) of crude oil in 2014 and net-exported 32 TWh of refinery products. Around 50% of Sweden's total crude oil imports came from the North Sea, mainly from Denmark and Norway. Imports from Russia have increased significantly in the last 3 years and now amount to 42% of total imports.

Between 2004 and 2014, the use of diesel fuel increased by about 40%, while the use of petrol fell by 40% over the same period. One reason for this was the change in the mix of different types of vehicles on the road. In 1995, less than 5% of newly registered passenger cars were diesel fuelled. Twenty years later, that figure has changed to almost 60%.

The proportion of renewable motor fuels used by road vehicles continues to rise and accounts for almost 13% of energy use today. The main biofuels currently used by vehicles are ethanol, biogas, fatty acid methyl ester (FAME), and hydrotreated vegetable oil (HVO), both as admixtures and in pure form. Figure 2 shows the percentages for various alternative fuels.

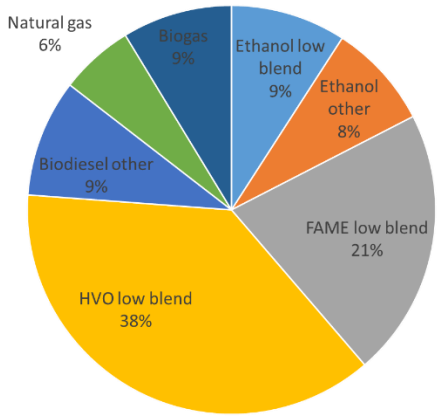

Fig. 2 Share of Alternative Motor Fuels in Road Transport in 2014

Ethanol is blended with gasoline, and it is also the main constituent in fuels such as E85 and the ethanol-diesel mix, ED95, used in public transport. FAME is blended with regular diesel fuel and is also used (to a limited extent) as 100% FAME. HVO was introduced on the domestic market, in measurable amounts, a few years ago and has fast become the main alternative fuel in Sweden. The use of biogas has also increased rapidly during the last couple of years. Currently, the content of almost all petrol is 5% ethanol, while about 85% of diesel fuel contains a 5% blend of FAME. For road use, almost all diesel fuel contains a 5% blend of FAME, and a high share of the diesel fuel also contains a varying degree of HVO.

There are about 300,000 passenger cars running on alternative fuels, and around 200,000 of these are flex-fuel vehicles (E85). There are more than 3,000 buses running on renewable fuels, of which more than 600 are ED95 buses, and there are around 9,700 trucks running on renewable fuels.

Policies and Legislation

The Swedish Government has a long-term priority that by 2030, the country shall have a vehicle fleet that is independent of fossil fuel. It also has a vision that by 2050, the country will have a sustainable and resource-efficient energy supply, with no net emissions of greenhouse gases (GHGs) in the atmosphere.

Sweden is using a relatively high proportion of biofuels in relation to most other countries in the European Union (EU). The main driver behind biofuel policy is to decrease the amount of carbon dioxide (CO_2) emissions from the transport sector. Another policy aim, not directly related to biofuels, is to increase overall energy efficiency in the transport system.

The fuel tax consists of two parts: an energy tax and a CO_2 tax. Bio-based motor fuels are fully exempted from CO_2 tax both for low blending (i.e., up to 7% biodiesel and 10% ethanol) and high blending (i.e., more than 85%). The reduction in energy tax is related to both the type of bio-based motor fuel and the blending ratio. Only bio-based motor fuels that fulfill the EU sustainability criteria are eligible for tax reduction.

Since 2004, all fuel stations of a certain size, in terms of volume of fuel sold, are required by law to also offer at least one renewable fuel. Most fuel stations have fulfilled this requirement by offering E85.

In October 2006, the motor vehicle tax was changed to be based on a vehicle's CO_2 emissions instead of its weight. The purpose of this change was to encourage the sale of more low-carbon vehicles. Some other tax relief is provided for vehicles that are capable of running on bio-based motor fuels. Starting in 2011, the vehicle tax for newly registered light goods vehicles, buses, and motor caravans was also subject to the CO_2 tax charge. The vehicle tax for heavy goods vehicles does not include a CO_2 element but depends on the vehicle's weight and level of regulated emissions.

Starting on July 1, 2009, new "clean vehicles" have been exempted from the vehicle tax for 5 years. The definition of a clean vehicle was revised in 2013 as follows:

- A vehicle with a mass in running order[1] of 1,372 kilograms (kg) is allowed to emit 95 grams (g) of CO_2 per kilometer (km) if it runs on petrol or diesel fuel. Vehicles capable of running on alternative fuels (i.e., all other fuels than diesel and gasoline/petrol) are allowed to emit 150 g CO_2/km.

1 *Mass in running order is the term to be used according to CO_2 legislation on passenger cars in the EU.*

- Heavier vehicles can emit more, while lighter vehicles must emit less (the slope corresponds to 4.57 g CO_2/100 kg).
- The electricity consumption of electric vehicles, including plug-in hybrid vehicles, must be less than 37 kilowatt-hours (kWh)/100 km.

Implementation: Use of Advanced Motor Fuels

The sustainability criteria for biofuels and bioliquids aim to reduce GHG emissions and ensure that no areas with "high biological values," according to the definition in Directive 2009/28/EC, have been damaged as a consequence of the production of renewable fuels. Starting in the spring of 2012, those operators in the Swedish economy that must report on their biofuel and bioliquid use have had to submit annual reports. The reports describe the quantities of sustainable biofuels and bioliquids used in Sweden in the previous year.

Emission Reduction of More Than 2 Million Tonnes of CO_2

Biofuels used in 2014 included ethanol, FAME, biogas, HVO, ethyl tertiary-butyl ether (ETBE), and dimethyl ether (DME) (Table 1). The total amount of sustainable biofuels was equivalent to more than 11.5 TWh. Of the biofuels used, HVO showed the highest increase, from 1.3 to 4.6 TWh. Most of the feedstock for the biofuel used in Sweden originated from Europe. For ethanol, some of the feedstock came from Russia or Ukraine, while the non-European feedstock for HVO came from Indonesia and Malaysia.

Table 1 Biofuel Use 2012 to 2014 in GWh

Fuel Category	2012	2013	2014
HVO	1 300	3 729	4 607
FAME	2 780	3 009	4 156
Ethanol	2 255	2 060	1 902
Gaseous biogas	903	834	972
Liquid biogas	12	36	39
ETBE	43	10	3
DME	3	2	2

Feedstocks and Emission Reductions

The current emission reduction requirement is set at 35% for biofuels (compared to fossil fuels); however, the majority of the biofuels in Sweden that have been reported on already fulfill the 50% reduction requirement that will not come into effect until 2017. On average, the emission reduction was

57% for all biofuels. Only HVO produced from palm oil had a reduction of less than 50%.

The emissions from the cultivation of biomass often constitute a large proportion of the total emissions from biofuels from a life-cycle perspective. Depending on the feedstock, the average emission reduction that results from using ethanol varies between 50% and 85%. HVO is associated with the largest reduction in GHG emissions at 85%, while the use of FAME, based mostly on rapeseed, has achieved a 40% reduction.

The use of alternative fuels has resulted in avoided emissions of CO_2, compared with if fossil fuels had been used, with 2.3 million tonnes CO_2 equivalent. This was an improvement of 19% compared with 2013. As shown in Figure 3, HVO and FAME accounted for almost three-fourths of the total emission reduction.

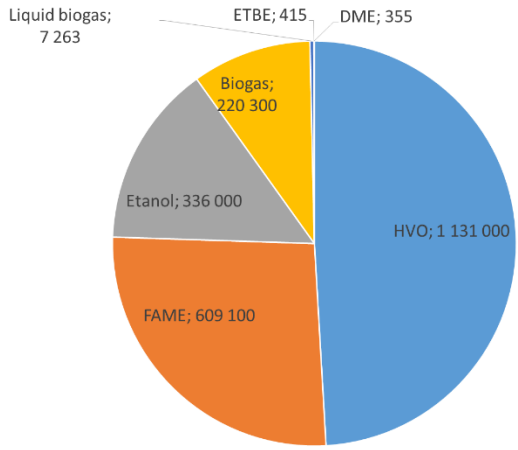

Fig. 3 Avoided Emissions of CO_2 in Tonne CO_2 Equivalent in 2014

The ethanol delivered in 2014 was derived from a high number of different types of feedstock, mostly wheat and corn. About one-fifth of the ethanol was produced from domestic feedstock, a significant reduction compared with 2012.

HVO is based mainly on slaughterhouse wastes, waste oil (of both vegetable and animal origins), and tall oil, which is a residue from the forest industry (Figure 4). The use of different waste oils has increased compared with other feedstocks.

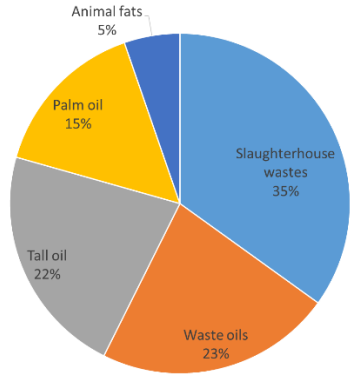

Fig. 4 Feedstock for HVO in 2014

Biogas intended for transport is subject to the sustainability criteria. Swedish feedstock contributed to 94% of the biogas used for transport in 2014. The biogas was produced from various feedstocks, which, in most cases, were waste or residues. The biogas produced from manure yields the best reduction in emissions — more than 80%. Cultivated biomass, such as barley, rye, corn, and ley crops, result in the lowest emission reduction — 40%–60%.

Approximately 34% of the biofuel quantities also meet certain requirements for social and economic sustainability that go beyond the sustainability criteria set by the EU Commission by having been certified under one of the EU Commission's 19 approved voluntary certification schemes.

Outlook

In December 2013, the Swedish Commission on Fossil-Free Road Transport presented possible courses of action and identified measures to reduce the emissions from and dependence on fossil fuels within the transport sector. The suggestions are in line with Sweden's 2050 vision and priority of having a fossil-independent vehicle fleet in 2030. Four different groups of actions were identified:

- Planning and developing attractive, accessible towns and cities with a reduced demand for transport and greater transport efficiency;
- Instituting infrastructure-related measures and changes in modes of transport;
- Using more efficient vehicles and more energy-efficient driving strategies; and

- Using biofuels, including electric-powered road vehicles.

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