IEA-Advanced Motor Fuels
ANNUAL REPORT 2015

GERMANY

Germany

Introduction

The discussion, figures, and tables that follow show fuel consumption in Germany and the number of registered vehicles separated by fuel type. The assumptions about fuel consumption for 2015 are based on real data from 2014 and on trends-based assessments for January until November 2015.

Figure 1 shows Germany's 2014 consumption, with the following ranking from most to least consumed fuel: diesel (61%), gasoline (32%), and renewable fuels (5%).

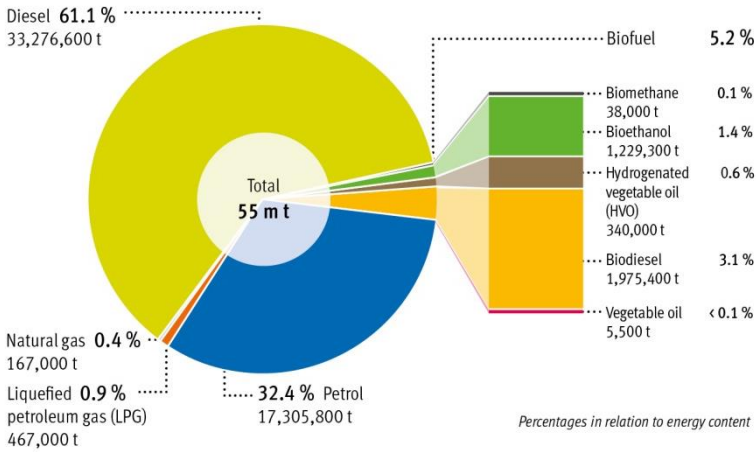

Fig. 1 Fuel Consumption in the Transport Sector in Germany in 2014
(Source: BAFA [Bundesamt für Wirtschaft und Ausfuhrkontrolle] et al. 2015a)
©FNR 2015

In 2014, German fuel consumption for use in road transportation amounted to 55.0 million metric tonnes (Mt), including biofuels. Of this amount, 17.3 Mt of gasoline and 33.3 Mt of diesel were consumed. The consumption of biofuels amounted to 3.6 Mt, with the majority being low-level blends of biodiesel and hydrotreated vegetable oil (2.3 Mt) and bioethanol (1.2 Mt). Quantities of other biofuels consumed in 2014 were (a) pure biodiesel at 5 kilotons (kt); (b) ethanol with 1.1 Mt, (c) ethyl tertiary-butyl ether or ETBE, the additive for motor gasoline, at 139 kt; (d) pure vegetable oil at 5.5 kt; and (d) E85 at 8 kt. The consumption of biofuels in 2014 was a little bit higher than it was in 2013, at 3.4 Mt.

Tables 1 and 2 show the 2015 trends for biofuels and biofuel supplements, respectively. The decrease in all biofuel sales and its blends is expected to be the result of the new 2015 regulations on the greenhouse gas (GHG) quota system introduced in January 2015 (see Policies and Legislation).

Table 1 Trends in German Biodiesel Sales, 2009–2015

Sale (kt)	2009	2010	2011	2012	2013	2014	2015 [a]
Blend	2,191	2,236	2,116	1,928	1,741	1,970	1,847
Pure biodiesel	241	293	97	131	30	5	4
Total	2,431	2,529	2,213	2,059	1,772	1,975	1,851

[a] Data available for Jan–Nov 2015; extrapolated for Dec 2015.

Source: FNR on basis of BAFA et al. (2015)

Table 2 Trends in German Bioethanol Sales, 2009–2015

Sale (kt)	2009	2010	2011	2012	2013	2014	2015 [b]
E85 [a] (ethanol share)	9(7)	18(15)	19(16)	21(17)	14(11)	10(8)	7(6)
Ethanol	687	1,028	1,054	1,090	1,041	1,082	1,047
ETBE [c]	198	122	162	142	154	139	116
Total	892	1,165	1,233	1,249	1,206	1,229	1,163

[a] Including only share of ethanol.

[b] Data available for Jan–Nov 2015; extrapolated for Dec 2015.

[c] Ethyl tertiary-butyl ether; percentage by volume share of bioethanol in ETBE = 47%.

Source: FNR on basis of BAFA et al. (2015)

Roughly 97% of the crude oil used in Germany in 2015 (for fuel, among other uses) had to be imported. German sources of imported crude oil are relatively well diversified. The Russian Federation accounts for 35% of imports; 14% comes from Norway; 11% comes from Great Britain; between 6% and 7% each comes from Nigeria, Kazakhstan, and Azerbaijan; and 20% comes from 25 other countries worldwide (BAFA 2015b).

Table 3 shows the number of passenger cars on the road in Germany by fuel type for 2006 through 2015.

Table 3 Number of Passenger Cars in Germany by Fuel Type on January 1 of Given Year[a]

Year	Gasoline	Diesel	LPG	NG	EV	Hybrid
2006	35,918,697	10,091,290	40,585	30,554	1,931	5,971
2007	35,594,333	10,819,760	98,370	42,759	1,790	11,275
2008	30,905,204	10,045,903	162,041	50,614	1,436	17,307
2009	30,639,015	10,290,288	306,402	60,744	1,452	22,330
2010	30,449,617	10,817,769	369,430	68,515	1,588	28,862
2011	30,487,578	11,266,644	418,659	71,519	2,307	37,256
2012	30,452,019	11,891,375	456,252	74,853	4,541	47,642
2013	30,206,472	12,578,950	494,777	76,284	7,114	64,995
2014	29,956,296	13,215,190	500,867	79,065	12,156	85,575
2015	29,837,614	13,861,404	494,148	81,423	18,948	107.754

[a] LPG = liquefied petroleum gas according to European fuel quality standard EN 589. NG = natural gas according to German fuel quality standard DIN 51624. EV = electric vehicles.

Source: Kraftfahrt-Bundesamt, the Federal Motor Transport Authority (KBA 2015a)

A total of 53.7 million vehicles were registered in Germany as of January 1, 2015, with 44.4 million of them (82.7%) being passenger cars. Of the registered vehicles, 4.1 million (7.7 %) were motorcycles and 2.7 million (5.0 %) were trucks. The rest were buses, tractors, and other vehicles. Of the passenger cars, 13.9 million (30.0%) were diesel-fuelled and 29.8 million (68.3%) were petrol-fuelled (see Table 1). Vehicles with alternative powertrains numbered 620,931 (1.5%). This total included 12,156 electric vehicles (EVs), 85,575 hybrid vehicles, 500,867 vehicles using liquefied petroleum gas (LPG), and 79,065 vehicles using natural gas (KBA 2015b).

Policies and Legislation

Since January 2015, the benchmark for biofuel quotas has been converted from energy content to a net GHG reduction. This net quota will increase in three steps: from 3.5% in 2015, to 4% in 2017, and to 6% in 2020. Biomethane of natural-gas-quality mixed with natural gas can also be used to fill the quota. This aspired-to quota will be 1% lower by 2020 than the quota previously proposed in 2013. Furthermore, the amendment to the German Emission Control Act (December 2014's Bundes-Immissionsschutzgesetz-BImSchG) bans all double-counting and excludes animal fats and bio-based oils that are co-refined with fossil-based oils from the quota eligibility. Biofuels are currently the only way to fulfill the target. It is expected that there will be provisions for electricity use in road transport in the law in the future.

The sustainability criteria for biofuels agreed to at the European level under the Renewable Energy Directive (RED, 2009/28/EC [European Commission]) and under the Fuel Quality Directive (FQD, 98/70/EC) became German law in 2009. The December 2014 amendment also reflects concerns about the sustainability and GHG-reduction benefits of some biofuels. The new law strives to consider the upcoming European Union (EU) legislation and aligns with the EU Energy Council's political agreement on a draft amendment to the RED and the FQD from June 2014.

In December 2014, the German Agency for Renewable Energy (Deutsche Energie-Agentur GmbH [DENA]), which is strongly aligned with the Federal Ministry of Economic Affairs and Energy, presented a policy paper for sustainable mobility in the EU to the EC. DENA considers the "use of renewable liquid and gaseous fuels of non-biological origin [as] essential for

achieving the EU's climate protection objectives in the transport sector." It recommended:

- The minimum quota for advanced biofuels is 2.5% in 2020.
- Renewable liquid and gaseous fuels of non-biological origin shall be considered to be four times their energy content.
- Fuels produced from carbon-rich (carbon monoxide [CO] or carbon dioxide [CO_2]) gas streams from agricultural residues, waste, and residues of nonrenewable energy sources shall be considered to be four times their energy content.
- The use of renewable hydrogen in refineries is to be considered as a possible method of reducing the GHG emissions of fossil fuels (DENA 2014).

In addition to the promotion of an appropriate, consistent tax and regulatory business environment, the promotion of research and development (R&D) is also occurring across the various biofuel sectors to create conditions conducive to boosting biofuel use. In this context, the German Federal Government supports projects that will further develop existing biofuel technologies and develop new ones from scratch. This support encompasses the full value chain, including the provision of raw materials (e.g., growing of crops), biomass conversion, quality assurance, and the use of biofuels in vehicles (e.g., emissions, material compatibility).

Under the Renewable Resources Funding Scheme of the Federal Ministry of Food and Agriculture (BMEL), a reasonable decrease in funded projects related to biofuels can be seen. Forty R&D projects received funding in 2015 of €14 million ($15.6 million US) (in 2014, 70 projects received funding of €23 million/$25.7 million US). This support includes funding for projects related to bioethanol, biodiesel, vegetable oil, biomethane, and advanced biofuels, as well as to areas like biofuel sustainability. The aid is granted through the BMEL's project sponsor, the Agency of Renewable Resources (Fachagentur Nachwachsende Rohstoffe e.V., or FNR).

With regard to advanced biofuels, project support was focused on biomass-to-liquid (BTL) fuels, which have not been introduced to the market yet but are considered a promising option because of their broad raw material base and chemical composition. In addition, the production of hydrocarbons from biochemical pathways is playing an increasingly important role with regard to funding activities. Another funding focus is on developing ways to deploy energy from renewable resources, such as algae.

Since 2013, the project AUFWIND (with 12 partners) has been receiving financial support. The aim of the project is to produce kerosene made of algae. To identify the sustainable biomass potential of biofuel and to prevent some kind of impact related to indirect land use change (ILUC), the Federal Ministry for Environment, Nature Conservation, Building, and Nuclear Safety (BMUB) and BMEL funded four projects having a common priority — conducting "studies on aspects of the sustainability of biofuels." Results will be published in 2016.

The Federal Ministry of Transport and Digital Infrastructure (BMVI) launched the "Mobility and Fuel Strategy" in 2011 aimed at creating environment- and climate-friendly, socially responsible, and economically efficient modes of future transportation. It is based on a strategy launched in 2004 that was completed in 2013. The recent strategy does not favor a specific technology but includes all important transportation modes (road, aviation, railway, and waterborne) and all relevant drivetrains and energy sources (fossil-based fuels, biofuels, electric mobility, and fuel cells). In 2015, BMVI and other stakeholders announced the effort to push the implementation and usage of liquefied natural gas (LNG), especially for heavy-duty transport (HDT). The Mobility and Fuel Strategy is organized as a consistent and adaptive process, and stakeholders from government, industry, academia, society, and nongovernmental organizations (NGOs) participate. The main goals of its dialogue process are to find medium- and long-term prospects for the substitution of fossil fuels, to develop fuels based on renewable sources of energy, and to identify promising drivetrain technologies and the supply infrastructure required to support them. The process continued in 2014 and 2015; first recommendations can be reviewed in German on the BMVI website.

With respect to electrified transportation, the goal of the German Government is to have at least 1 million EVs on German roads by 2020. Electrification of transport is the main governmental strategy for reducing GHG emissions in this sector. In May 2010, the National Platform for Electro Mobility (Nationale Plattform Elektromobilität [NPE]) was founded. In the NPE, all relevant car manufacturers, suppliers, and research facilities are represented; they are organized into seven working groups who discuss specific issues and identify measures for dealing with them. Nevertheless, in 2014, only 24,000 EVs were sold instead of the planned 100,000. By the end of 2015, 31,311 EVs and 141,384 hybrids were registered. Thus, Germany is at risk of missing its climate targets for road transportation. Leading politicians from the German Government and the NPE are demanding stronger support of the sector, which would amount to €3 billion for the coming years (Focus Online 2014). Industry and politics are calling for

strong incentives like tax exemptions for commercial vehicles, public programs to build 15,000 charging stations, publicly funded buyers' premiums in the range of €5,000 ($5,410 US),[1] and public campaigns to foster a shift in public behavior and buying decision. These recommendations were in discussion since the beginning of 2014, but no decision was taken until the end of 2015. The BMVI established grants for public procurement incentives for EV fleets in summer 2015. Experts claim that if not all measures are enacted soon, achieving the government's goal of 1 million EVs by 2020 and the targeted GHG savings will be at considerable risk. However, different propositions to approach this shortfall have been on several political agendas lately.

The program called the "Initiative for Natural Gas-Based Mobility – CNG and Biomethane as Fuels" supports the German Government's goal of encouraging greater use of natural gas vehicles (NGVs). Currently, natural gas is only 0.4% of the fuel mix. Compressed natural gas (CNG) and biomethane have the potential to reach 4% by 2020 in Germany, which would represent a greater-than tenfold increase. The members of the initiative are consumer organizations and well-known energy and transportation sector companies along the entire value chain. The initiative is coordinated by DENA, the German Energy Agency. The NGV fleet in Germany in 2015 increased again by 2,500 vehicles, similar to 2014; however, the share of registered CNG vehicles is still rather low, with 0.18%. In 2014, the methane mixture achieved a higher share of biomethane (23%) than the year before, thus reducing GHG emissions and dependency on fossil-based natural gas (DENA 2015; KBA 2015a).

After the federal election in September 2013, the coalition agreement among the three parties forming the German Government — CDU (Christian Democratic Union), CSU (Christian Social Union), and SPD (Social Democratic Party) — was published in November 2013. The agreement supports the development of new powertrains and fuels. The German Government wants to develop a biofuels strategy oriented toward the potential of sustainable biomass. It was proposed to extend the tax relief for natural gas beyond 2018, but this was not decided in 2015.

At the end of January 2016, the international conference "Fuels of the Future 2016" took place in Berlin, with more than 500 visitors.

1 Main federal ministers (for economy, transport, and environment) decided in February 2016 to implement the buyers' premiums starting mid-2016. Private buyers should receive €5,000 and commercial buyers €3,000. Forty percent of the expected costs of €1.3 billon should be covered by the car manufactures. Further public investments should be spent for 15,000 charging stations, battery research, and for public procurement for the public fleet (Spiegel Online 2016).

Implementation: Use of Advanced Motor Fuels

Incentives for using advanced motor fuels include a full tax exemption for specific biofuels (i.e., BTL, bioethanol from lignocellulose, biomethane, and E85 [E70–E90]), which expired the end of 2015, and a partial tax exemption for natural gas (CNG and LNG) and LPG as transport fuel until the end of 2018. The switch in the beginning of 2015 in the biofuels quota legislation from quantitative quotas (energy content) to GHG-reduction quotas (3.5% from 2015 on, 4% from 2017 on, and 6% from 2020 on) has provided a further impetus for using advanced biofuels. Biofuels performing better than the minimum GHG-reduction requirements of the RED and FQD (which are reductions of 35% until 2017, 50% from 2017 on, and 60% from 2018 on for new production facilities) should be rewarded by higher market prices.

German car manufacturers Audi and Mercedes-Benz are already testing advanced motor fuels. Under the leadership of Audi in Werlte, Lower Saxony, the world's first power-to-gas plant was built on an industrial scale to produce synthetic natural gas (Figure 2).

Fig. 2 Power-to-Gas Plant to Produce E-Gas
(Source: Audi AG)

The plant opened in June 2013. The Audi e-gas plant in Werlte produces hydrogen and synthetic methane from renewable energy surpluses, which will permit mobility that is almost CO_2-neutral. The Audi e-gas plant uses renewable electricity in the first stage for electrolysis — splitting water into oxygen and hydrogen (Audi e-hydrogen), which could power fuel cell vehicles someday. Because there is not a widespread hydrogen infrastructure, however, the hydrogen is then reacted with CO_2 in a methanation plant to produce renewable synthetic methane, or Audi e-gas.

Chemically speaking, this e-gas is identical to fossil-based natural gas. As such, it can be distributed to CNG stations via a natural gas network. The e-gas from Werlte (roughly 1,000 tons per year) can power 1,500 new Audi A3 Sportback g-tron vehicles for a distance of 15,000 km (9,320 mi) every year. To reach higher annual operating times, the plant contributed to the electricity balancing market in Germany in 2015, which benefitted the power grid and the amount of Audi e-gas that was produced.

Since July 2012, Clariant AG in Straubing near Munich has produced cellulosic ethanol on a large scale — 1,000 tons of bioethanol per year — by using its sunliquid20® process. This process converts wheat and barley straw, and corn stover (i.e., the leaves and stalks of maize, rice straw, and the leftovers of sugar cane) into cellulosic ethanol. This process, which extracts and then converts the sugars contained in the plant material almost entirely into ethanol, could make use of about 60% of the 240 million tonnes of residual cereal straw that could be collected from the fields in Europe after harvest every year.

Mercedes-Benz decided to run fleet tests for 1 year with sunliquid20 (Figure 3). German car manufacturers in general see significant benefits from using an E20 fuel, if engines are optimized for this fuel grade. Cellulosic ethanol is mixed with conventional fuel components to create the new fuel. As a benefit, cellulosic ethanol is virtually CO_2-neutral, and there is no competition with food production or for agricultural acreage. According to the tests, sunliquid20 improves engine efficiency so that its 4%-less energy content (compared with that of E10) is more than compensated for. Another notable finding was the 50% improvement in particle count emissions of sunliquid20 over those from using the European Union (EU) reference fuel, EU5. In addition, the fuel blend of cellulosic ethanol sunliquid20 demonstrates GHG emission savings of up to 95% across the entire value chain (well-to-wheel). Today, the latest Mercedes-Benz BlueDIRECT cars can run on sunliquid20 (Clariant AG 2014).

Fig. 3 Mercedes-Benz Cars in Front of the Sunliquid® Demonstration Plant
(Source: Daimler AG)

Outlook

At the end of 2015, it was difficult to provide a reliable outlook for the use of advanced motor fuels over both the short and long term. The EU target for 2020 is still to use 10% renewable energy sources in transportation. In September 2015, however, the EC brought to an end many months of debate about the revision of the RED and FQD. By 2017, these will have to be implemented into national legislation. The impact on advanced biofuels is uncertain. On a national level in Germany, the increasing GHG-reduction quota will guide market developments. Further R&D activities (e.g., reducing the GHG emissions of biofuels to make them compatible with the amended RED and FQD, upscaling advanced biofuel production processes to an industrial scale) are other important challenges.

Additional Sources

- Agentur für Erneuerbare Energien, www.unendlich-viel-energie.de
- Bayerisches Staatsministerium für Ernährung, Landwirtschaft und Forsten, www.tfz.bayern.de
- Biofuels Portal, www.bio-kraftstoffe.info
- Biorefineries Roadmap as part of the German Federal Government action plans for the material and energetic utilization of renewable raw materials, www.bmbf.de/pub/BMBF_Roadmap-Bioraffinerien_en_bf.pdf

- Bundesverband der deutschen Bioethanolwirtschaft, www.bdbe.de
- Bundesverband Regenerative Kraft, www.brm-ev.de/de
- Federal Government's Mobility and Fuels Strategy under the lead responsibility of the BMVI, www.bmvi.de/SharedDocs/EN/Artikel/G/G-MKS/mfs-context.html?nn=86868
- Initiative for natural-gas-based mobility, www.erdgasmobilitaet.info/en/home.html
- Kraftfahrt-Bundesamt, www.kba.de
- National Policy Strategy on Bioeconomy, Renewable Resources, and Biotechnological Processes as a basis for food, industry, and energy, BMEL 2013 www.bmel.de/SharedDocs/Downloads/EN/Publications/NatPolicyStrategyBioeconomy.pdf?__blob=publicationFile
- ProcessNet initiative of Dechema and VDI-GVC: Sustainable Production, Energy and Resources (SuPER) Expert group on alternative fuels, http://www.processnet.org/en/
- Union zur Förderung von Oel–und Proteinpflanzen e.V., www.ufop.de
- Verband der Deutschen Biokraftstoffindustrie e.V., www.biokraftstoffverband.de
- Verband der Ölsaaten-verarbeitenden industrie in Deutschland, www.ovid-verband.de

References

BAFA (Bundesamt für Wirtschaft und Ausfuhrkontrolle, Federal Office for Economic Affairs and Export Control), 2015a, *Amtliche Mineralöeldaten*, http://www.bafa.de/bafa/de/energie/mineraloel_rohoel/amtliche_mineraloeldaten/, accessed March 29, 2016.

BAFA, 2015b, *EnergieINFO, Rohölimporte November 2015*, www.bafa.de/bafa/de/energie/mineraloel_rohoel/engergieinfo_rohoel/2015/november.pdf, accessed January 11, 2016.

BAFA et al. (erdgasmobil, DVFG, BMF, FNR), 2015, *©FNR 2015*.

Clariant AG, 2014, *Advanced Biofuel from Clariant and Haltermann. Sunliquid® 20 Shows What It Can Do in the Fleet Test with Mercedes-Benz Series Vehicles,* press release, September 4, http://newsroom.clariant.com/wp-content/uploads/2014/09/sunliquid-20-shows-what-it-can-do-in-the-fleet-test-with-mercedes-benz-series-vehicles_en.pdf, accessed March 23, 2016.

DENA (Deutsche Energie-Agentur GmbH), 2014, *DENA Presents Policy Paper for Sustainable Mobility in the EU,* http://www.powertogas.info/fileadmin/user_upload/141204_dena_Policy_paper_RED_FQD_final.pdf, accessed January 20, 2015.

DENA, 2015, *Summary, Initiative for Natural Gas-Based Mobility – Natural Gas and Biomethane as Fuels,* http://www.erdgasmobilitaet.info/en/aims-and-content.html, accessed January 16, 2015.

Focus Online, 2014, *Gerade Mal 24.000 Fahrzeuge, Absatz von Elektroautos kommt nur schleppend voran*, November 11, http://www.focus.de/auto/elektroauto/gerade-mal-24-000-fahrzeuge-absatz-von-elektroautos-kommt-nur-schleppend-voran_id_4302474.html, accessed March 23, 2016.

KBA (Kraftfahrt-Bundesamt), 2015a, *Bestand an Pkw in den Jahren 2005 bis 2015 nach Ausgewählten Kraftstoffarten,* http://www.kba.de/DE/Statistik/Fahrzeuge/Bestand/Umwelt/b_umwelt_z.html?nn=663524, accessed January 6, 2016.

KBA, 2015b, *Fahrzeugzulassungen (FZ) Bestand an Kraftfahrzeugen und Kraftfahrzeuganhängern nach Zulassungsbezirken 1,* January 2015, http://www.kba.de/SharedDocs/Publikationen/DE/Statistik/Fahrzeuge/FZ/2015/fz1_2015_pdf.pdf?__blob=publicationFile&v=2, accessed January 6, 2016.

Nachhaltige Mobilität mit Erdgas und Biomethan: Marktentwicklung 2014/2015, http://www.erdgasmobilitaet.info/service-und-aktuelles/downloads.html?tx_filelinks_pi1%5Bdownload%5D=181&tx_filelinks_pi1%5Bcid%5D=155&cHash=f438fa3158d5866c3e45d54eaf3852dc, accessed January 13, 2016.

Spiegel Online, 2016, *Kaufprämie für Elektroautos: Minister einigen sich auf 5000-Euro-Bonus*. http://www.spiegel.de/auto/aktuell/elektroauto-kaufpraemie-minister-einigen-sich-auf-5000-euro-bonus-a-1079468.html, accessed March 30, 2016.

Major Changes

The move from an energy quota for biofuels to a GHG reduction quota by January 1, 2015, can be judged as the most important change in German legislation. With this change, all double-counting mechanisms have been stopped. The GHG quota is the key instrument as an incentive for biofuels

and has led to significant progress with regard to the reduction of GHG emissions of biofuels.

The current market is strongly based on conventional biofuels. It is expected that they will dominate the market at least until 2020. In the field of advanced biofuels, a series of research, development, and demonstration (RD&D) projects on different technology readiness levels (TRLs) or fuel readiness levels (FRLs) are under way.