ETC CM Report 2022/02

Greenhouse gas intensities of transport fuels in the EU in 2020

Monitoring under the Fuel Quality Directive

Authors:
George Vourliotakis (EXERGIA S.A.), Odysseas Platsakis (EXERGIA S.A.)

European Environment Agency
European Topic Centre
Climate change mitigation

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European Topic Centre on
Climate change mitigation
https://www.eionet.europa.eu/etcs/etc-cm
etccm@vito.be

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Executive summary

About this report

This report provides a summary of the information on the greenhouse gas (GHG) emission intensity of fuels supplied for road transport and non-road mobile machinery in the European Union (EU) in 2020, as reported by EU Member States, UK ( ), Iceland and Norway ( ) under Art. 7a of Directive 98/70/EC ( ) relating to the quality of petrol and diesel fuels (the Fuel Quality Directive, FQD).

Article 7a of the Fuel Quality Directive sets out reporting requirements concerning the volume and type of fuels (including fossil fuels, other non-biofuels and biofuels) supplied for road transport and non-road mobile machinery as well as their life cycle greenhouse gas (GHG) emissions (taking into account their extraction, processing and distribution). This approach also considers the emissions resulting from indirect land use change (ILUC) for biofuels. The FQD sets a reduction target for fuel suppliers to reduce the GHG intensity of transport fuels (life cycle GHG emissions per unit of energy from fuel and energy supplied) by a minimum of 6 % by 2020 as compared to 2010 levels. Member States must also analyse the share of biofuels in the total amount of fuels consumed for the purposes falling within the scope of the FQD.

The EEA supports the European Commission in the compilation, quality checking and dissemination of information reported under Article 7a of the FQD.

Main findings

Fuel suppliers are not sufficiently reducing the GHG intensity of fuels supplied in the EU

According to the data reported in 2021 by the 27 Member States, the average GHG intensity of the fuels[1] supplied in these countries in 2020 (excluding the ILUC emissions intensity for biofuels) was 89 g carbon dioxide equivalent (CO_2e), 5.5 % lower than the 2010 levels. This corresponds to a saving of 51 Mt CO_2e for the year 2020. It also represents an additional reduction of 1.2 percentage points compared to 2019 (4.3 % reduction compared to 2010, for 28 EU Member States) and of 1.8 percentage points compared to 2018 (3.7 % reduction compared to 2010, for 28 EU Member States). Therefore, in 2020, EU fuel suppliers in the 27 reporting Member States were, on average, behind their objective of reducing by 6 % the GHG intensity of transport fuels compared to 2010 (see Figure S.1) (2). In order to reach the obligatory 6 %, target, an additional 0.5 % reduction in the GHG intensity of all fossil fuels, biofuels and electricity supplied would have been needed.

The progress achieved by fuel suppliers varies greatly across Member States. Fuel suppliers from eleven countries already exceeded the 6 % reduction target for 2020 (up to 13.1 percentage points for Sweden, without considering ILUC emissions). Slovakia made significant progress within a year and is close to achieving the target with a 5.8 % reduction. The Netherlands are also on track to meet the 6 % target having already achieved a 5.4 % reduction. Eight more Member States have reported reductions greater than 4 %, and in seven Member States the reductions remain lower than 4 %.

Direct land-use change (DLUC) emissions result from the conversion of non-agricultural land, such as forests, into agricultural land to grow biofuels or to displace food production (grazing land) resulting from biofuel production. Indirect land-use change (ILUC) emissions result from the expansion of cropland for production of displaced agricultural (food/feed) products induced by feedstock growth for biofuel

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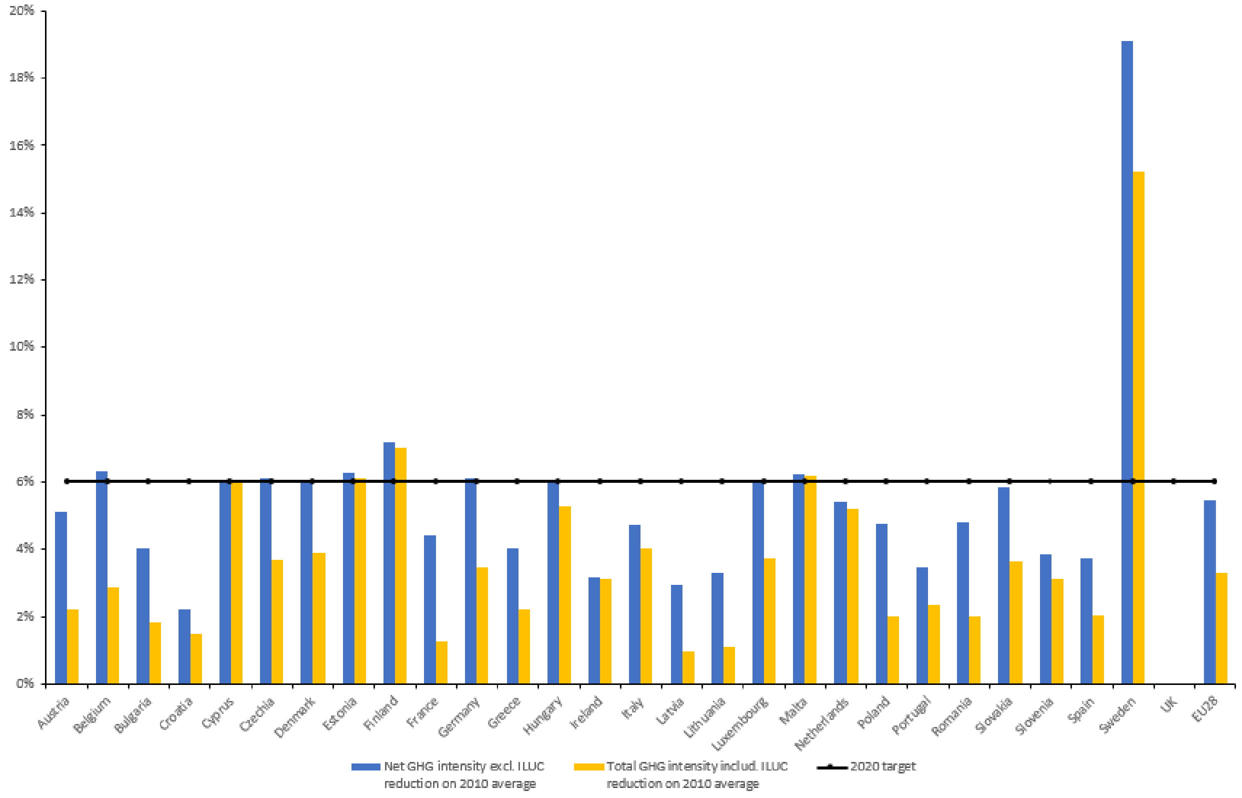
(1) Considering the electricity consumed that was voluntarily reported by 15 Member States.

(2) In 2020, upstream emission reductions were reported by eleven Member States, which are expected to contribute to the 6 % reduction target in the year 2020.

production. As biofuels production increased since 2010, taking these ILUC emissions into account results in lower reductions of the GHG intensity of fuels. The average GHG intensity of the fuels consumed in 2020 was only 3.3 % lower than the 2010 levels – this corresponds to a saving of 30 Mt CO_2e in the year 2020. When ILUC emissions are considered, it should be noted that there is wide disparity per Member State to the type of feedstocks used to produce biofuels that are consumed in their national territories; this constitutes a key factor in the performance of each Member State towards meeting the target, see Figure S.1.

Figure S.1 **Reductions in GHG intensity of fuels achieved by EU fuel suppliers in Member States, 2010-2020.**



Source: EEA

Note: The 2020 target of 6 % refers to GHG intensity reduction excluding ILUC

Diesel and biodiesel dominate fossil fuel and biofuel supply

The total fuel supply of road transport in 2020 for the 27 MS was 10 585 petajoules of which 93.2 % came from fossil fuels and 6.8 % from biofuels. The fuel supply was dominated by diesel (56.1 %) and petrol (22.2 %), followed by gas oil (12.6 %), biodiesel (FAME) (4.2 %), HVO (1.4 %) and bioethanol (0.9 %).

Regarding the main feedstock and pathways used to produce biofuels, biodiesel is produced mainly from rapeseed, used cooking oil and palm oil; bioethanol is produced mainly from corn, wheat and sugar beet; and HVO is produced mainly from palm oil, tallow and palm fatty acid distillate (PFAD).

In addition to the reporting on fossil fuels and biofuels, fuel suppliers may also voluntarily report on the quantity of electricity consumed by electric vehicles and motorcycles. In 2020, this quantity accounted for 0.02 % the total energy supply, as reported by 15 Member States.

ILUC and effects of substitution by biofuels on GHG intensities

The biofuel feedstock is important when assessing the GHG reduction potential of biofuels, especially when including the ILUC effect.

For biodiesel, a substantial part (above 68 % of the total quantities reported) is produced from oil crops, which have a high GHG intensity compared to other feedstocks, particularly when ILUC default reporting values are included (3). Also, when considering ILUC, biodiesel appears to be only marginally better in terms of life cycle GHG emission than fossil diesel fuel (86.4 vs 95.1 g CO2e/MJ).

In the case of HVO, the majority (56%) is produced from other feedstocks, such as tallow, PFAD, waste oils and fats, which generally have lower GHG intensity. The quantities of HVO produced from oil crops (featuring therefore a significantly higher GHG intensity), are lower (around 44 %).

Bioethanol is mainly produced from cereals and other starch-rich crops (above 78 % of the total quantities reported) and sugars (around 11 %), which both have a moderate GHG reduction potential compared to other feedstocks (mainly non-food/feed crop-based feedstocks such as starch slurry, industrial/municipal waste, bio-waste etc.). When including ILUC, the average GHG intensity of bioethanol increases, however it still remains significantly lower than fossil petrol (31.6 vs 93.3 g CO_2e/MJ).

Substitution of diesel with biodiesel and HVO results in GHG emission reductions of approximately 40 %, including ILUC, and nearly 76 %, excluding ILUC. On the other hand, substitution of petrol with bioethanol and bio-ethyl tert-butyl ether (bio-ETBE) leads to reductions of around 65 % and 75 % respectively.

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(3) Annex V, Part A. Provisional estimated ILUC emissions from biofuels of Directive (EU) 2015/1513 of the European Parliament and of the council of 9 September 2015.

1 Introduction

The role of fuels and their contribution to decreasing air pollution and GHG emissions has been recognized in EU legislation, which has stipulated minimum quality requirements and GHG intensity reduction targets for a range of petroleum and bio-based fuels. The reduction targets are likely to be achieved with the use of sustainable biofuels, electricity consumed by electric vehicles, fossil fuels with lower carbon-intensity, renewable fuels of non-biological origin (RFNBOs), while the reduction of upstream GHGs emitted during the crude oil production phase can also potentially play an important role.

EU Member States report annually information on the volumes, energy content and life cycle GHG emissions of fuels used in road transport and non-road mobile machinery[4], in line with their obligations under the Fuel Quality Directive 98/70/EC (FQD) Article 7a.

The reporting on data pursuant to Article 7a applied for the first time in 2018 in relation to the year 2017, following the application and transposition of Council Directive (EU) 2015/652.

The key documents that lay out the official requirements for the quality and GHG intensity of fuels sold in the EU, as well as the monitoring and reporting obligations for Article 7a, are the following:

- Directive 98/70/EC of 13 October 1998 relating to the quality of petrol and diesel fuels and amending Council Directive 93/12/EEC;
- Directive 2015/652 of 20 April 2015 laying down calculation methods and reporting requirements pursuant to Directive 98/70/EC of the European Parliament and of the Council relating to the quality of petrol and diesel fuels;
- Directive 2009/30/EC of 23 April 2009 amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions and amending Council Directive 1999/32/EC as regards the specification of fuel used by inland waterway vessels and repealing Directive 93/12/EEC; the Directive introduces Article 7a on GHG emission reductions;
- Directive 2009/28/EC of 23 April 2009 on the promotion of the use of energy from renewable sources (Renewable Energy Directive RED) defines, like the FQD, the sustainability criteria for biofuels (Article 17); in addition, it defines the lower calorific values to be used for biofuels (Annex III) and the default GHG emissions for biofuels not fulfilling the sustainability criteria (Annex V D). The RED has been later amended by Directive (EU) 2018/2001 (RED II), detailing the respective provisions for the 2020 – 2030 period.

This report summarises the information reported by the EU Member States and subsequently collected, checked and compiled by the EEA on the volume, energy consumption, and GHG intensity of fossil fuels and biofuels.

Chapter 2 describes the reporting requirements and the summary format for each Member State's submission under FQD Article 7a.

Chapter 3 provides an overview of the Article 7a reported information aggregated at EU level.

Chapter 4 summarises the progress to 2020 targets under the Fuel Quality Directive, whereas Chapter 0 discusses the effects of ILUC on GHG intensities.

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(4) Emissions from inland shipping, which belong to non-road mobile machinery according to Article 1 of Directive (EU) 2015/652, have not been included in the figures reported by the Netherlands.

Chapter 6 compares the information provided under Article 7a with other sources.

2 Reporting by European Union Member States

2.1 Reporting requirements

The information provided by the Member States under Article 7a comprises the following aspects:

1. fossil fuels and other non-biofuels information: possible data confidentiality issues, fuel or energy type, raw material source and process, fuel quantity supplied, energy quantity supplied and greenhouse gas (GHG) intensity;

2. biofuels information: possible data confidentiality issues, biofuel or energy type, sustainability of biofuel, feedstock used, biofuel production pathway, biofuel quantity supplied, energy quantity supplied, GHG intensity and indirect land use change (ILUC) feedstock category and emissions intensity;

3. information on electricity consumed by electric vehicles and motorcycles, on a voluntary basis: energy quantity, including and excluding the powertrain efficiency and the GHG intensity.

An Excel template is used by EU Member States for their reporting obligations under Article 7a of the FQD (5). Its purpose is to provide the necessary information and guidance for the preparation of national reports and to ensure that all the required information has been provided.

The information provided by the Member States over the years is partly (6) accessible in the EEA's Central Data Repository https://cdr.eionet.europa.eu/recent_etc?RA_ID=757&mindate=2018-01-01.

2.2 Quality of Member States' reporting in 2020

The EEA is responsible for the collection, quality assurance/quality control (QA/QC) and compilation of the data submitted at EU level and is assisted in these tasks by the European Topic Centre on Climate change mitigation (ETC CM) (7).

In 2021, in relation to reference year 2020, 27 EU Member States plus UK (8), Iceland and Norway submitted their fuel quality reports in accordance with the requirements of the FQD. During the QA/QC procedure, the ETC CM reviewers posed clarifying questions to the reporting countries, relating to the completeness and consistency of their submitted data sets. The most common findings communicated to the countries following the quality checks performed on the information reported were:

- data reported not corresponding to the data lists provided in the template;
- wrong entries inserted in the report;
- missing information, mainly on feedstock and/or production pathway;
- data reported in aggregated form.

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(5) http://cdr.eionet.europa.eu/help/fqd

(6) Due to the confidentiality of the data, some MS chose not to give public access to the data.

(7) The ETC CM is a consortium of 11 European organizations contracted by the EEA to carry out specific tasks identified in the EEA strategy in the area of climate change mitigation and energy.

(8) In case of the UK only data for Northern Ireland should have been reported according to the Northern Ireland Withdrawal Agreement to be found here https://eur-lex.europa.eu/legalcontent/EN/TXT/PDF/?uri=CELEX:02020W/TXT-20201218&from=EN. The dataset provided covered the whole of the UK. As it is not possible to separate the Northern Ireland data from the rest of the UK, this data was not taken into account.

Most of these issues could be solved directly with the Member States in the communication process, by completing missing information, correcting erroneous values or providing the necessary clarifications. Following the QA/QC procedure, 13 Member States submitted revised data sets. The last resubmission was received on the 18.03.2022.

3 Supplied quantities of road transport fuels in 2020

3.1 Fossil fuel and biofuel quantities supplied

Fuel suppliers must report annually to the authority designated by the Member State on the greenhouse gas (GHG) intensity of fuel and energy supplied within each Member State by providing as a minimum the total volume or quantity of each type of fuel or energy supplied and the associated life cycle GHG emissions per unit of energy.

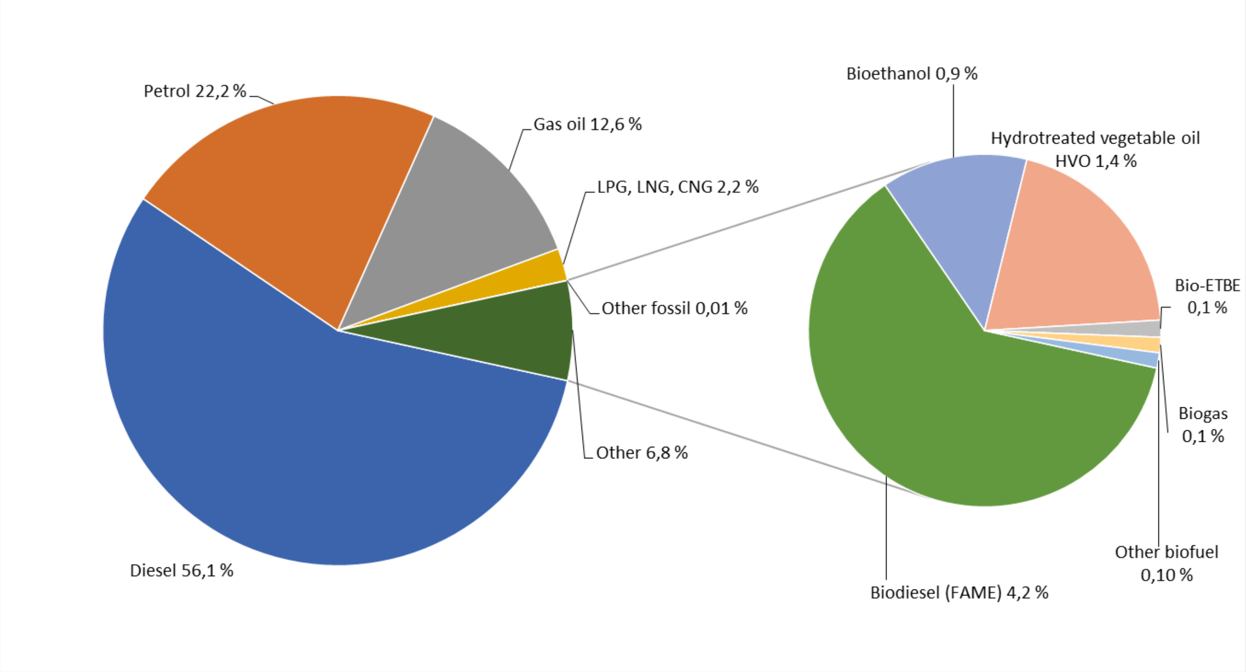
The total energy quantities supplied by suppliers are presented in Table 3.1 for the different fossil fuels and biofuels marketed in the 27 Member States.

Table 3.1 Total quantities of fossil fuels and biofuels.

	Total quantity (PJ)
Fossil fuels	**9 862**
Diesel	5 934
Petrol	2 354
Gas oil	1 337
Liquid petroleum gas (LPG)	189
Compressed natural gas (CNG)	32
Liquefied natural gas (LNG)	15
Other	1
Biofuels	**723**
Biodiesel	449
Hydrotreated vegetable oil (HVO)	146
Bioethanol	97
Bio-ETBE	11
Biogas	10
Other	10

Total fuel supply reported was 10 585 petajoules (PJ), of which 93.2 % was from fossil fuels, and 6.8 % was from biofuels (Figure 3.1). No renewable fuels of non-biological origin were reported in 2020.

Figure 3.1 Fuel energy supply shares per fuel type in 2020



Notes: In category "other biofuel" the following types are included: bio-methane, cracked HVO, bio-naphtha, bio-petrol, bio-methanol, bio-LPG (liquid petroleum gas), bio-propane, bio-MTBE (methyl tert-butyl ether), FAEE (fatty acid ethyl esters), pure vegetable oil, synthetic hydrocarbons, bioethanol diesel, bio-TAEE (bio-tert amyl ethyl ether), bio-LNG (liquid natural gas), bio pyro oil.

The fossil fuel supply in 2020 was dominated by diesel (56.1 %; 5 934 PJ (9)), followed by petrol (22.2 %; 2 354 PJ) and gas oil (12.6 %; 1 337 PJ). Liquified petroleum gas (LPG), liquified natural gas (LNG) and compressed natural gas (CNG) had a total share of 2.2 % (236 PJ).

The biofuels energy consumption in the 27 EU Member States is dominated by biodiesel (Fatty acid methyl esters – FAME) (4.2 %; 449 PJ), followed by hydrotreated vegetable oil (HVO; 1.4 %; 146 PJ) and bioethanol (0.9 %; 97 PJ). (Bio-ETBE and biogas account for 0.2 % (21 PJ). All other biofuels used in road transport and non-road mobile machinery in 2020 present a share of 0.1 % (10 PJ) (Figure 3.1).

3.2 Biofuel production pathways and feedstocks used

Member States must report on the feedstock and the biofuel production pathway used for each of the biofuels consumed in their territories. Feedstock is relevant for estimating the potential indirect land use change (ILUC), whereas the biofuel production pathways are relevant for calculating the GHG intensity of the produced fuels and the potential emissions savings from their use.

Feedstocks used for biofuel production may be derived from plants grown directly for the purpose of energy production, or from plant parts, processing wastes, residues and materials from human and animal activities. In relation to the feedstock used, different production pathways may be followed to develop the final biofuels that are available in the market. Hence, feedstocks refer to the origin and to the raw material source of the biofuel while production pathways refer to the different processes used for the production of the biofuel always relevant to the respective feedstock.

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(9) A petajoule (PJ) is equal to one thousand terajoules (TJ) or one million gigajoules (GJ) or one billion megajoules (MJ).

The main feedstocks and production pathways for the three main categories of biofuels, as these have been reported by the 27 Member States, are summarised in Table 3.2 below. The share of undefined production pathways (N/A) largely explains the differences in the shares of the different feedstocks and pathways. Any remaining differences are due to the shares reported as “Other” by the Member States.

Table 3.2 Summary of main feedstock and production pathways by biofuel.

Biodiesel	**Feedstock**	**Pathway**
Rapeseed	45.2 %	38.9 %
Used cooking oil / waste vegetable oil or animal fat	15.0 %	16.6 %
Palm oil	11.3 %	4.8 %
Other	28.5 %	18.1 %
N/A	0.01 %	21.5 %
Bioethanol	**Feedstock**	**Pathway**
Corn (maize)	56.1 %	27.1 %
Wheat	16.0 %	14.5 %
Sugar beet	6.1 %	5.6 %
Other	21.8 %	18.4 %
N/A	0.01 %	34.4 %
Hydrotreated vegetable oil	**Feedstock**	**Pathway**
Palm oil	39.4 %	13.1 %
Tallow / Used cooking oil / waste vegetable oil or animal fat	31.9 %	27.8 %
Palm fatty acid distillate (PFAD)	7.1 %	9.1 %
Other	21.5 %	14.6 %
N/A	0.03 %	35.4 %

Feedstocks

- The main types of feedstock used to produce **biodiesel** (4.2 % of total fuel consumption) are rapeseed (45.2 %), used cooking oil and waste vegetable oil or animal fat (15.0 %) and palm oil (11.3 %). These three feedstocks account for about 71.5 % of the total biodiesel quantities supplied to the 27 Member States.
- **Bioethanol** (0.9 % of total fuel consumption) is mainly produced from corn (maize, 56.1 %), wheat (16.0 %) and sugar beet (6.1 %). These three feedstocks account for about 78.2 % of the total bioethanol quantities supplied to the 27 Member States.
- For **HVO** (1.4 % of total fuel consumption) production, palm oil accounts for 39.4 %, tallow, used cooking oil and waste vegetable oil or animal fat for 31.9 % and palm fatty acid distillate (PFAD) for 7.1 %. These three feedstocks account for about 78.4 % of the total HVO quantities supplied to the 27 Member States.

Production pathways

- **Biodiesel** is derived mainly from four production pathways: pathways utilising rapeseed (38.9 %), used cooking oil and waste vegetable oil or animal fat biodiesel (16.6 %), palm oil biodiesel (4.8 %) and soybean biodiesel (9.9 %). These four pathways account for the production of about 70.2 % of the total biodiesel quantities supplied to the 27 Member States. There is also a substantial share of 21.5 % for which the production pathway of biodiesel has not been defined by the reporting Member States. This incomplete reporting also explains the lower shares of the different production pathways compared to the respective values of the considered feedstocks indicated above.

- For the production of **bioethanol**, pathways utilising corn ethanol (27.1 %) is the most common pathway, followed by pathways utilising wheat (14.5 %, of which 13.1 % comes from non-specified processes), and sugar beet (5.6 %). These three pathways account for the production of about 47.2 % of the total bioethanol quantities supplied to the 27 Member States. There is also a substantial share of 34.4 % of the supplied bioethanol quantities for which the production pathway has not been defined by the reporting Member States. Similar to biodiesel, this share explains the differences between feedstocks used and production pathways.
- **HVO** originates mainly from pathways utilising tallow, used cooking oil, waste vegetable oil or animal fat (27.8 %), palm oil (13.1 %), and PFAD (9.1 %). These pathways account for the production of about 50 % of the total HVO quantities supplied to the 27 Member States. There is also a substantial share of 35.4 % for which the production pathway of HVO has not been defined by the reporting Member States. Similar to the above cases, this share explains the differences between feedstocks used and production pathways. Comparing these values to the respective values of 2019, where the share of unknown pathways was very low (8 %) and palm oil was responsible for 32.1 % of the HVO production, it can be assumed that most pathways that were not defined in the reporting of 2020 correspond to palm oil.

3.3 Electricity consumption

The reporting of the quantity of electricity consumed by electric vehicles and motorcycles by fuel suppliers is voluntary, despite the fact that it can be considered for the 6 % reduction target by 2020. Fifteen Member States reported the electricity consumed by electric vehicles and motorcycles. As per the Art. 7a requirements, reported consumed electricity is also accompanied by the associated electricity GHG intensity. One of them (Romania), however, did not report the associated GHG intensities of the electricity consumed.

In Table 4.3 the energy quantities consumed by electric vehicles, excluding and including powertrain efficiency, are summarized for the fifteen Member States which provided this information. An adjustment factor of 0.4 for powertrain efficiency is assigned to the battery electric powertrain (10). This includes all electric powertrains, without distinguishing between battery electric vehicles and plug-in hybrid electric vehicles.

Actual electricity consumption in the different Member States may be larger since it is not a compulsory field under Article 7(a) and is not actually considered towards the target by most of the Member States albeit it could be taken into account for achieving the 6% target (11). GHG intensities reported by Member States under Article 7a are presented in Table 4.3, together with data provided by the Joint Research Centre (JRC) of the European Commission (12) on the average carbon intensity of the electricity consumed at low voltage in the EU in 2015 for comparison purposes.

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(10) Based on Annex I (f) of Council Directive (EU) 2015/652 of 20 April 2015.

(11) Reasons for this unused possibility to reduce GHG intensity are not known. It could be that the GHG intensity of the electricity mix so far does not result to a carbon intensity sufficiently low to reduce GHG emissions of road transport fuels significantly; this however would have to be further investigated in order to be confirmed.

(12) Improved calculation of carbon intensity of electricity consumed in the EU Member States in 2015 including upstream emissions and trade, Ispra, 7 February 2018.

Table 3.3 **Electricity consumed by electric vehicles and motorcycles in 2020 as a reported contribution by fuel suppliers to their GHG reduction target.**

Member State	Quantity of energy (GJ)		GHG intensity (g CO_2e/MJ)		
	excluding powertrain efficiency	including powertrain efficiency	reported by Member State	reported by Member State	JRC data
Austria	69 971	27 988	21.8	78	309
Bulgaria	129 600	51 840	522.0	1 879	637
Chechia	1 085	434	177.0	637	637
Estonia	62 091	24 836	114.5	412	847
France	1 526 400	610 560	16.6	60	80
Germany	2 394 000	957 600	153.0	551	541
Hungary	17 387	6 955	56.3	203	415
Ireland	176 276	70 511	110.1	396	569
Italy	234 015	93 606	110.3	397	426
Netherlands	766 091	306 437	141.0	508	594
Portugal	37 350	14 940	65.7	237	483
Romania	645 225	258 090	-	-	478
Slovakia	155 950	62 380	46.4	167	421
Slovenia	2 447	979	97.5	351	361
Sweden	308	123	13.0	47	24

Note: Member States data are for 2020 whereas JRC data refer to 2015 (shown for comparison purposes).

Hungary reported several GHG intensities, accompanied by the respective electricity consumption. The value presented in this Table corresponds to the weighted average of the reported values.

The above data on GHG intensity are not directly comparable as individual Member States may have used a calculation methodology different from that used by the JRC (13). For example, electricity consumed versus electricity generated and/or applied corrections for the effect of cross-border electricity trade may have an impact on the calculated intensities. JRC's data refer to electricity production before cross-border trading and therefore do not refer to the electricity actually available for consumption for end uses in each Member State. In addition, JRC data refer to the year 2015 whereas Member States data are for 2020.

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(13) As foreseen by Directive 2015/652, Annex I Part 2, Point 6.

4 Progress to 2020 targets under the Fuel Quality Directive

4.1 Average GHG emissions intensity of transport fuels in 2020

The Fuel Quality Directive (FQD) requires a reduction in the GHG intensity of transport fuels by a minimum of 6 % by 2020 compared with 2010 levels via the suppliers' monitoring mechanism ([14]) and by an additional optional 4 % via reduction technologies and the Clean Development Mechanism of the Kyoto Protocol. The baseline for this reduction is the average GHG intensity of the EU's fuel mix in 2010, which was 94.1 g CO_2/MJ ([15]). The fuel baseline standard is calculated based on EU average fossil fuel consumption of petrol, diesel, (non-road) gasoil, LPG and CNG.

For each Member State, Table 4.1 shows the GHG emissions from the consumption of all fuels (fossil fuels and biofuels) and electricity used in road transport. The average GHG intensity has been calculated for each Member State as well as the relative reduction over the 2010 default baseline value is also shown in the same table.

The average GHG intensity of the fuels supplied in the 27 EU Member States (excluding ILUC for biofuels) was 89.0 g carbon dioxide equivalent (CO_2e) in 2020. Thus, a reduction of 5.5 % was achieved in 2020 compared to 2010. This corresponds to a saving of 51 Mt CO_2e compared to the 2010 levels in the year 2020. It also corresponds to an additional reduction of 1.2 percentage points, compared to 2019 (4.3 % reduction compared to 2010, for 28 EU Member States) and 1.8 percentage points compared to 2018 (3.7 % reduction compared to 2010, for 28 EU Member States). In order to reach the obligatory 6 % target, an additional reduction of 0.5 percentage points in the GHG intensity of all fossil fuels and biofuels supplied will be needed on average in the EU ([16]). Consequently, additional efforts are necessary to meet the 6 % target. In 2020, upstream emission reductions (UERs) were reported by eleven countries (see details in section 4.2), contributing to a further reduction of the GHG intensity of about 0.3 % to reach 5.5 % in total. It is noted that in 2019, only two countries had reported upstream emission reductions, reducing the GHG intensity by about 0.2 %.

The average GHG intensity, and hence also the relative distance to meet the set target, depends on the share and type of fossil fuels and biofuels in the total fuel mix. The highest GHG intensities of all fuels correspond to petrol (95.3 g CO_2e/MJ), diesel and gas oil (95.1 g CO_2e/MJ), whereas substitution with bioethanol (20.7 g CO_2e/MJ, excluding ILUC), HVO (15.3 g CO_2e/MJ, excluding ILUC) and biodiesel (25.2 g CO_2e/MJ, excluding ILUC) reduces significantly the overall GHG intensity, providing thus the highest GHG benefits.

The distance to meet the set target varies across Member States from 3.8 % (for Croatia) to 0.2 % (for Slovakia). The two Member States with the lowest achievements in reducing their GHG intensities over the 2010 – 2020 period (lower than 3 %) are Croatia and Latvia (achieving a reduction of only 2.2 % and 2.9 respectively). The main reason for these low performances is the low share of biofuels (3.2 % in Croatia and 4.0 % in Latvia). In addition to this, Latvia has a high GHG intensity for biofuels (26.9 g CO_2eq/MJ) as well. In comparison, the GHG intensity for biofuels in Croatia is significantly lower (17.3 g CO_2eq/MJ), but still due to the low quantities the relevant contribution remains limited.

On the other hand, Finland and Sweden have achieved the highest reductions in the average GHG intensity of their fuels with 7.2 % and 19.1 % respectively (excluding ILUC). These two countries, which have

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([14]) For the purposes of Article 7a of the FQD, Member States shall ensure that suppliers use the calculation method set out in Annex I of Directive 2015/652 to determine the GHG intensity of the fuels they supply.

([15]) Baseline value for 2010, according to Annex II of the Council Directive (EU) 2015/652.

([16]) Determined across the 27 Member States that reported data.

exceeded the target of 6 % in both 2018 and 2019, have also exceeded the target for 2020. Nine more Member States also exceeded the target in 2020 and Slovakia is close to achieving the target, having reported a 5.8 % reduction. Finland has a biofuel share of 8.7 % (62.16 % of which is HVO that has the lowest GHG intensity among biofuels, 18.53 % is bioethanol and 11.7 % is biodiesel) while diesel, petrol and gas oil represent 48 %, 25 % and 17 % of the mix respectively. Sweden has the highest biofuel share among all Member States amounting to 23.2 % (65 % of which is HVO, 21 % is biodiesel 7 % is biogas) and diesel and petrol share in the total fuel mix is 50 % and 26 % respectively. The reductions achieved by these two Member States are attributed to the high biofuels share, as well as the low GHG intensity of biofuels used (12.1 g CO_2eq/MJ in Finland and 15.4 g CO_2eq/MJ in Sweden).

Table 4.1 shows wide disparity of performances across Member States when ILUC is accounted for, due to the different type of feedstocks used for the biofuels consumed in each country. Whereas for many Member States the difference with and without ILUC is relatively small (in the order of 1 percentage units), for some other Member States these differences are significant. France’s performance without ILUC is 4.4 %, while when ILUC effects are considered, the overall reduction target it is 1.3 % due to the extensive consumption of oil crops (71 % of its biofuels feedstock, mainly produced from rapeseed and soybeans) that have the highest GHG intensities among feedstock categories. Belgium’s performance also largely deteriorates when ILUC emissions are considered (from 6.3 % excl. ILUC down to 2.9 %) due to the extensive use of oil crops (ca. 62 % of its biofuels feedstock), mainly produced from rapeseed and palm oil. Austria presents another example of noticeable discrepancy in the reduction achieved with and without ILUC (5.1 % without ILUC vs 2.2 % with ILUC). This is due to the prevalence of rapeseed in the feedstock used (accounting for approximately 77 % of its biofuels feedstock).

Table 4.1 Average GHG emissions intensity reported by fuel suppliers by Member State in 2020 and reductions compared with 2010.

Member State	Fossil fuels		Biofuels		Electricity (incl. powertrain efficiency)		Average fuel GHG intensity (g CO_2e/MJ) (excl. ILUC)	2010-2020 GHG intensity reduction (excl. ILUC) (%)	Average fuel GHG intensity (g CO_2e/MJ) (incl. ILUC)	2010-2020 GHG intensity reduction (incl. ILUC) (%)
	Energy consumption (TJ)	GHG emissions (kt)	Energy consumption (TJ)	GHG emissions (kt)	Energy consumption (TJ)	GHG emissions (kt)				
Austria	299 303	27 789	18 051	548	28	0.61	89.3	5.1 %	92.0	2.2 %
Belgium	291 463	27 557	28 815	675	-	-	88.1	6.3 %	91.4	2.9 %
Bulgaria	111 873	10 363	5 632	232	52	27.06	90.3	4.0 %	92.4	1.8 %
Croatia	84 266	7 960	2 746	47	-	-	92.0	2.2 %	92.7	1.5 %
Cyprus	24 590	2 259	1 102	13	-	-	88.4	6.0 %	88.4	6.0 %
Czechia	233 347	21 755	15 828	261	0.4	0.08	88.4	6.1 %	90.6	3.7 %
Denmark	172 690	15 934	10 929	309	-	-	88.5	6.0 %	90.4	3.9 %
Estonia	33 315	3 088	1 958	25	25	2.84	88.2	6.3 %	88.4	6.1 %
Finland	179 997	17 018	17 212	209	-	-	87.4	7.2 %	87.5	7.0 %
France	1 583 095	149 845	123 799	3 833	611	10.14	90.0	4.4 %	92.9	1.3 %
Germany	2 041 040	192 476	168 223	2 767	958	146.51	88.3	6.1 %	90.8	3.5 %
Greece	180 775	16 880	9 263	281	-	-	90.3	4.0 %	92.0	2.2 %
Hungary	200 674	18 588	11 771	194	7	0.39	88.4	6.1 %	89.1	5.3 %
Ireland	156 971	14 884	7 415	100	71	7.76	91.1	3.2 %	91.1	3.1 %
Italy	1 167 117	108 663	57 149	1 101	94	10.32	89.6	4.7 %	90.3	4.0 %
Latvia	46 740	4 395	1 966	53	-	-	91.3	2.9 %	93.2	0.9 %
Lithuania	79 590	7 482	4 053	129	-	-	91.0	3.3 %	93.1	1.1 %
Luxembourg	68 843	6 502	6 005	116	-	-	88.4	6.0 %	90.6	3.7 %
Malta	7 443	702	562	4	-	-	88.2	6.2 %	88.3	6.2 %
Netherlands	381 091	35 819	26 126	444	306	43.21	89.0	5.4 %	89.2	5.2 %
Poland	934 737	86 799	52 818	1 719	-	-	89.6	4.7 %	92.2	2.0 %
Portugal	195 708	18 498	10 413	231	15	0.98	90.9	3.4 %	91.9	2.4 %
Romania	286 899	26 747	17 162	493	-	-	89.6	4.8 %	92.2	2.0 %
Slovakia	97 477	9 068	6 544	161	62	2.89	88.6	5.8 %	90.7	3.7 %
Slovenia	67 916	6 430	3 776	57	1	0.10	90.5	3.8 %	91.2	3.1 %
Spain	694 832	65 632	41 270	1 051	-	-	90.6	3.7 %	92.2	2.0 %
Sweden	239 768	22 650	72 532	1 119	-	-	76.1	19.1 %	79.8	15.2 %
EU27	**9 861 563**	**925 782**	**723 119**	**16 176**	**2 229**	**253**	**89.0**	**5.5 %**	**91.0**	**3.3 %**

4.2 Upstream emission reductions

Upstream emissions refer to the GHG emissions produced during the extraction, processing, handling and transport of raw material from their original state to the refinery or processing plant gate where the fuel was produced. Upstream emission reductions (UER) are the GHG emissions reductions that can occur prior to the crude oil entering the refinery, during extraction, processing, handling and transport, including reductions of flaring and venting emissions. The UER claimed by a supplier have to be quantified and reported in accordance with the requirements set out in Directive (EU) 2015/652. There are several options for suppliers to reduce the GHG intensity of fuels towards the 2020 reduction target. More detailed information on approaches to quantify, monitor and report on UER can be found in the relevant guidance note ([17]). It is noted however, that there is no obligation to use UER as a compliance option for the FQD Article 7a reduction target.

Eleven out of 27 Member States that have submitted data under Article 7a have claimed UER. These are: Austria (573.1 kt CO_2e), Cyprus (56.7 kt CO_2e), Chechia (165.8 kt CO_2e), Denmark (400.8 kt CO_2e), Estonia (45.8 kt CO_2e), Hungary (368 kt CO_2e), Italy (300 kt CO_2e), Luxembourg (25.4 kt CO_2e), Poland (339.3 kt CO_2e), Romania (220.6 kt CO_2e) and Slovakia (129.2 kt CO_2e).

Overall, the total reported UER was 2 625 kt CO_2e in 2020, contributing an additional 0.3 % reduction of the overall fuel GHG intensity from 5.2 % to 5.5 %.

([17]) https://ec.europa.eu/clima/sites/default/files/guidance_note_on_uer_en.pdf

5 Effects of indirect land use change on GHG intensities

5.1 Greenhouse gas emission intensities of crop types

According to Article 23 paragraph 5(f) of the RED ([18]), fuel suppliers have to report the life cycle greenhouse gas emissions per unit of energy, including the provisional mean ([19]) values of the estimated ILUC emissions from biofuels to the Member States. ILUC emissions may significantly reduce the GHG benefits from the use of the different biofuels. Depending on the land types converted to cropland because of biofuels production, these GHG savings may be completely cancelled out. Hence, in an encompassing life cycle analysis, the ILUC-related GHG emissions intensity should be added to the GHG intensity directly attributed to the production and transport of biofuels. For the reporting of ILUC emissions, the mean values included in Annex VIII of the RED II are used. ILUC emissions are not taken into account for assessing compliance with the obligatory 6 % reduction target.

Table 5.1 provides an overview of the energy supplied by the different crops from which biofuels are produced. The default GHG intensities for each crop type are also reported. ILUC emissions related to biofuel consumed were around 22 Mt CO_2e in 2020, an amount almost equivalent to the annual total emissions (excluding ILUC) of Czech Republic. Oil crops were responsible for 94.4 % of these ILUC emissions.

Table 5.1 ILUC summary table

Feedstock category	Cereals and other starch-rich crops	Sugars	Oil crops	Other
Quantity of energy supplied (TJ)	87 300	12 267	371 663	251 938
Default ILUC intensity provisional mean ([20]) values of the estimated ILUC emissions (g CO_2e/MJ)	12	13	55	0
Total ILUC GHG emissions (kt CO_2e)	**1 048**	**159**	**20 441**	**-**

Based on the mean values of the estimated indirect land-use change emissions provided in the RED (see Annex VIII, Directive 2018/2001), and the 2020 data, an average value of 2.0 g CO_2e/MJ is added to the overall GHG intensity of the transport fuel mix that is reported under Article 7a. Adding this value to the average GHG intensity of 89 g CO_2e/MJ (without ILUC) of the fuels consumed in the 27 EU Member States as calculated above (Table 5.1), results in an eventual value of 91 g CO_2e/MJ (with ILUC). It is noted that the GHG intensity including ILUC decreased in 2020 in comparison to 2019 (91.6 g CO2e/MJ in 2019) due to a small reduction in the energy provided from biofuels (723 PJ in 2020 compared to 771 PJ in 2019), which also induced a reduction in the use of all feedstocks. Nonetheless, if ILUC was included in the calculation of the GHG intensity, the relevant reduction from the baseline (in the year 2010) would be 3.3 % as opposed to the 5.5 % reduction when excluding ILUC, see Table 4.1.

The overall GHG intensity reduction including ILUC is below 2 % for 5 Member States and the highest performances are noted in three Member States (Sweden, Finland and Malta). Estonia has the most

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([18]) Directive 2009/28/EC of the European Parliament and of the council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.

([19]) For the purposes of Article 7a of the FQD, Member States shall ensure that suppliers use the calculation method set out in Annex I of Directive 2015/652 to determine the GHG intensity of the fuels they supply.

([20]) The mean values included here represent a weighted average of the individually modelled feedstock values (Annex VIII, Directive 2018/2001 of the European Parliament and of the council of 11 December 2018 on the promotion of the use of energy from renewable sources).

significant improvement on its performance compared to 2019 (1.3 % in 2019) with a reduction of 6.1 % for 2020. This is due to the reduction of use of oil crops (4 % in 2020 and 25 % in 2019) to produce biofuels, and in particular biodiesel, as the GHG intensity of oil crops is only marginally better than fossil fuel diesel when ILUC is included (87 vs 95.1 g CO_2e/MJ).

5.2 Greenhouse gas emission savings by substituting fossil fuels with biofuels

In order to estimate the decarbonization potential of biofuels, i.e. the GHG savings that can be achieved from the substitution of their fossil fuel counterparts, data on the actual biofuel use and the respective GHG intensities, as reported by the different EU Member States, are used.

To this aim, GHG emissions from the use of biofuels differentiated for the biofuel feedstock have been calculated with and without ILUC, by using the reported GHG intensities. These emissions are then compared with the calculated GHG emissions from the use of equal quantities — in terms of energy content — of conventional fuels.

The most relevant biofuels for this analysis are biodiesel, bioethanol and HVO, which account for 95.6 % of the total biofuel energy consumption in the 27 EU Member States. The relevant data for this comparison is summarised in Table 5.2. The average GHG intensity and corresponding GHG emissions with and without ILUC are presented for the different feedstocks for each of the selected biofuels.

Table 5.2 GHG emissions from the use of biofuels and different feedstocks

	Energy quantity (TJ)			Average GHG intensity (g CO_2e/MJ)						GHG emissions (kt CO_2e)					
				Excluding ILUC emissions			Including ILUC emissions			Excluding ILUC emissions			Including ILUC emissions		
	2018	2019	2020	2018	2019	2020	2018	2019	2020	2018	2019	2020	2018	2019	2020
Cereals and other starch-rich crops	1	24	134	15.33	34.21	24.65	27.33	46.21	36.65	0	1	3	0	1	5
Sugars	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oil crops	331 808	329 376	305 585	33.92	32.22	31.47	88.92	86.99	86.4	11 256	10 612	9 618	29 506	28 652	26 415
Other	167 404	197 406	142 945	11.61	12.00	11.68	11.61	12.00	11.68	1 943	2 369	1 670	1 943	2 369	1 670
Biodiesel	**504 122**	**526 806**	**448 671**	**26.44**	**24.64**	**25.17**	**62.64**	**58.89**	**62.61**	**13 328**	**12 982**	**11 292**	**31 577**	**31 023**	**28 091**
Cereals and other starch-rich crops	1 898	48	-	10.94	7.57	-	22.94	19.57	-	21	0.4	-	44	1	-
Sugars	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oil crops	30 761	33 795	63 892	30.20	26.39	23.49	85.24	81.39	78.5	930	892	1 501	2 622	2 751	5 015
Other	60 240	62 455	82 084	8.27	7.30	8.82	8.27	7.30	8.82	498	456	724	498	456	724
HVO	**92 899**	**96 298**	**146 018**	**15.60**	**14.00**	**15.27**	**34.05**	**33.31**	**39.33**	**1 449**	**1 348**	**2 229**	**3 164**	**3 207**	**5 743**
Cereals and other starch-rich crops	89 742	87 010	76 536	23.63	22.51	20.51	35.63	34.51	32.50	2 120	1 959	1 569	3 197	3 003	2 488
Sugars	15 439	15 417	10 724	31.91	26.81	25.01	44.91	39.79	37.98	493	413	268	693	613	407
Oil crops	1	5	52	34.18	24.60	46.85	89.18	79.60	101.85	0.04	0.1	2	0.09	0.4	5
Other	5 296	8 435	9 775	12.74	16.39	17.08	12.74	16.39	17.08	67	138	167	67	138	167
Bioethanol	**110 523**	**110 866**	**97 089**	**24.27**	**22.64**	**20.67**	**35.83**	**33.87**	**31.6**	**2 682**	**2 511**	**2 007**	**3 960**	**3 755**	**3 067**

Note: Estimated ILUC emissions considering the average GHG intensity values of RED and the reported biofuel energy quantities

The above table shows that the biofuel feedstock is important when assessing the GHG reduction potential of biofuels, especially when ILUC effects are considered.

For biodiesel, a substantial part (above 68 % of its total quantities) is produced from oil crops, which have a high GHG intensity compared to other feedstocks suitable for biodiesel production. When considering ILUC, oil crop based biodiesel is only marginally better in terms of life cycle GHG emissions than fossil fuel diesel (86.4 vs 95.1 g CO2e/MJ).

In the case of HVO, the majority is produced from feedstocks with no ILUC value associated (such as tallow, waste oils and fats, around 56.2 %) and with a low GHG intensity, whereas the HVO quantities produced from oil crops, which have a much higher GHG intensity (23.5 g CO2e/MJ without ILUC and 78.5 g CO2e/MJ with ILUC), are much lower (around 44 %).

Bioethanol is mainly produced from cereals and other starch-rich crops (around 79 %) and sugars (around 11 %) which have a moderate GHG reduction potential compared to other feedstocks. When including ILUC, the average GHG intensity of bioethanol increases; however, it still remains significantly lower than fossil petrol (31.6 vs 93.3 g CO_2e/MJ).

Table 5.3 shows the calculated GHG emissions saved by replacing fossil fuels with corresponding biofuels for all 27 MS. Substitution of diesel by biodiesel and HVO results in GHG emission reductions as compared to the baseline in the order of 76 % when ILUC is excluded, whereas these reductions are in the order of 40 % when including ILUC. The respective reductions for petrol substituted by bioethanol and ETBE are somewhat lower without ILUC but in the same order of magnitude, while they become higher when ILUC effects are considered (77 %). Overall, this higher reduction in petrol-fuels compared to diesel ones is due to the high GHG ILUC values of oil crops from which mainly biodiesel is produced, and the much lower GHG ILUC values of cereals from which ethanol is produced. In the case of the Netherlands the situation is the opposite however, since the substitution of diesel leads to a higher GHG emission reduction than the substitution of petrol (87.5 % and 87.3 % excluding and including ILUC for diesel, compared to the respective values of 71.5 % and 61.4 % for petrol). This is due to the lower use of food/feed crops and a much higher use of waste/residues as raw material for diesel substitutes compared to the other EU countries.

The percentage of GHG emission reductions for natural gas for the 27 MS are of the same order of magnitude with petrol, but the overall effect is rather small due to the small quantities of CNG supplied.

Table 5.3 GHG emissions savings from the use of biofuels.

Fossil fuel	Substituting biofuel	Excluding/including provisional mean values of the estimated ILUC emissions	GHG emissions from fossil fuels (kt CO_2e)	Emissions savings (kt CO_2e)	GHG emission reduction from substitution (%)
Diesel	Biodiesel + HVO	Excluding	56 555	43 034	76.1
		Including	56 555	22 721	40.2
Petrol	Bioethanol + ETBE	Excluding	10 115	7 799	77.1
		Including	10 115	6 601	65.3
CNG	Biogas	Excluding	708	565	79.7
		Including	708	555	78.4

6 Consistency between fuel volumes reported under Article 7a and Article 8

To ensure consistency, the reported fuel volumes under Article 7a are compared with those reported under Article 8 of the Fuel Quality Directive (FQD). The comparison is carried out for petrol and diesel only, both fossil and bio-based substitutes, as no other fuels are reported under Article 8.

The total volumes of petrol and diesel reported under Article 8 already includes blended biofuels, i.e. mainly bioethanol in petrol and biodiesel (and HVO) in diesel. To enable the comparison, all volumes of bioethanol, bio-ETBE and other petrol substitutes were added to the petrol volumes as reported by Member States under Article 7a. Similarly, all volumes of biodiesel, HVO and other diesel substitutes were added to the diesel volumes. Table 6.1 shows the results of the comparison for the 27 Member States that have reported under both Articles 7a and 8.

Table 6.1 Total quantities of fossil fuels and bio-based substitutes (million litres)

Member State	Petrol		Diesel		Difference (%)	
	Article 7a	Article 8	Article 7a	Article 8	Petrol	Diesel
Austria	1 809	1 827	7 284	7 479	-1.0%	-2.6%
Belgium	2 163	2 176	6 709	6 708	-0.6%	0.0%
Bulgaria	646	598	2 401	2 655	8.1%	-9.6%
Croatia	538	550	1 919	1 944	-2.3%	-1.3%
Cyprus	384	384	373	385	-0.2%	-3.1%
Czechia	1 723	1 966	5 247	5 737	-12.4%	-8.5%
Denmark	1 681	1 683	3 391	3 086	-0.1%	9.9%
Estonia	259	259	724	724	-0.08%	0.01%
Finland	1 741	1 753	3 092	2 893	-0.7%	6.9%
France	10 065	9 917	33 561	33 382	1.5%	0.5%
Germany	22 388	21 679	41 566	41 751	3.3%	-0.4%
Greece	2 530	2 527	2 861	3 069	0.1%	-6.8%
Hungary	1 844	1 849	719	4 290	-0.3%	-83.2%
Ireland	772	1 079	3 203	3 222	-28.5%	-0.6%
Italy	7 531	7 581	1 764	25 462	-0.7%	-93.1%
Latvia	211	218	1 127	1 172	-3.4%	-3.8%
Lithuania	318	319	1 971	2 086	-0.2%	-5.5%
Luxembourg	370	366	1 774	1 511	1.0%	17.4%
Malta	92	94	140	167	-2.0%	-16.1%
Netherlands	5 128	4 938	6 665	6 915	3.8%	-3.6%
Poland	5 883	5 858	20 546	20 113	0.4%	2.2%
Portugal	1 123	1 029	4 699	4 066	9.1%	15.6%
Romania	1 732	1 377	6 708	5 627	25.9%	19.2%
Slovakia	709	709	2 248	2 248	0.0%	0.0%
Slovenia	426	559	1 621	1 934	-23.8%	-16.2%
Spain	3 447	5 642	14 650	23 046	-38.9%	-36.4%
Sweden	2 769	2 721	6 233	5 723	1.8%	8.9%
EU (27 Member States)	**78 282**	**78 433**	**183 195**	**215 518**	**-0.19%**	**-15.00%**

For many Member States, the differences for both petrol and diesel are relatively small, within ±10 %. However, there are also many Member States for which larger differences are observed, where total volumes reported under Article 7a are lower or higher than those reported under Article 8. The main reasons of such discrepancies include fuel quantities purchased and sold in different years, or incomplete reporting by Member States. It is not possible to distinguish to what extent the differences can be attributed to each of these reasons. In some cases, there are indications of incomplete reporting as in the case of Italy where, as in 2018 and 2019, the diesel quantities reported under Article 7a for 2020 are much lower than those reported under Article 8 and also much lower compared to other Member States of similar size. For 2019, Italy had confirmed that the reported quantity of petrol under Article 8 was lower than the quantity reported under Article 7a because it related only to summer and winter period and if the excluded periods of the year were added, the quantity would be the same as in Article 7a. However, relevant information for the 2020 data is not available.

List of abbreviations

Abbreviation	Name
CHP	Combined heat and power
CNG	Compressed natural gas
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
DLUC	Direct land use change
EEA	European Environment Agency
EFB	Empty fruit bunch
Eionet	European Environment Information and Observation Network
ETBE	Ethyl tert-butyl ether
ETC CM	European Topic Centre on Climate change Mitigation
EU	European Union
FAEE	Fatty acid ethyl esters
FAME	Fatty acid methyl esters
FFBS	Fresh fruit brunches
FQD	Fuel Quality Directive
GHG	Greenhouse gas
GJ	Gigajoule
HVO	Hydrotreated vegetable oil
ILUC	Indirect land use change
JRC	Joint Research Centre
LBG	Liquefied biogas
LNG	Liquified natural gas
LPG	Liquid petroleum gas
MJ	Megajoule
MTBE	Methyl tert-butyl ether
PFAD	Palm fatty acid distillate (PFAD)
PJ	Petajoule
POME	Palm oil mill effluent
QA/QC	Quality assurance/quality control
RUCO	Repurpose used cooking oil
SBE	Spent bleaching earth
TAEE	Tert-amyl ethyl ether
TJ	Terajoule
UER	Upstream emission reductions

Annex

Table A1.1 Greenhouse gas (GHG) intensity per fossil fuel type

Fuel or energy type	GHG intensity (g CO_2e/MJ)
Liquified petroleum gas	73.6
Compressed natural gas	69.3
Diesel	95.1
Petrol	93.3
Gas oil	95.1
Liquified natural gas	74.5
Other	93.3

Table A1.2 Average reported greenhouse gas (GHG) intensity per biofuel type (excluding ILUC)

Fuel or energy type	GHG intensity (g CO_2e/MJ)
Biodiesel	25.2
Bioethanol	20.7
Hydrotreated vegetable oil HVO	15.3
Bio-ETBE	26.6
Biogas	16.7
Biomethanol	33.8
Bio-MTBE	35.3
Bio-TAEE	7.8
Pure vegetable oil	19.7
Other (Bio pyro oil)	26.4
Other (Bioethanol-diesel)	25.6
Other (Bio-LNG)	10.2
Other (Bio-LPG)	23.1
Other (Biomethane)	18.7
Other (Bio-Naphtha)	17.8
Other (Bio-petrol)	9.9
Other (Biopropane)	6.8
Other (cracked HVO to petrol)	19.0
Other (FAEE)	1.6
Other (Synthetic hydrocarbons)	33.1

Table A1.3 Feedstocks used for biofuels

- Acid oil from used cooking oil
- Animal fats classified as categories 1 and 2
- Animal manure and sewage sludge
- Bagasse
- Barley
- Biomass fraction of industrial waste
- Biomass fraction of mixed municipal waste
- Biomass fraction of wastes and residues from forestry and forest-based industries
- Bio-waste
- Brown grease
- Cobs cleaned of kernels of corn
- Corn (maize)
- Crude glycerine
- Grape marcs and wine lees
- N/A
- Nut shells
- Other (Agri-food waste)
- Other (alcohol production residues)
- Other (Animal fat category 3)
- Other (Animal manure, triticale)
- Other (Animal manure, triticale, sorghum, corn stalks, straw, chaff of rice)
- Other (Animal manure, triticale, straw)
- Other (Bacteria)
- Other (beer production residues)
- Other (Biomass fraction of mixed industrial and municipal solid waste and sewage sludge)
- Other (Biowaste class 3)
- Other (Brown liquor)
- Other (Cottonseed)
- Other (Ethanol waste liquids)
- Other (Ethiopian mustard seed)
- Other (FFBS)
- Other (Fish oil)
- Other (Fodder beet)
- Other (Food waste)
- Other (Free fatty acids)
- Other (Garden waste)
- Other (Grape marcs and wine lees, agri-food waste)
- Other (Grass silage residues)
- Other (Grass silage)
- Other (Grass)
- Other (Industrial food waste)
- Other (molasses)
- Other (Non-food cellulosic material)
- Other (Palm Fatty Acid Destillate)
- Other (Palm Kernel Oil)
- Other (palmolein)
- Other (residues from the distilling industry)
- Other (Sewage sludge)
- Other (SHEA OLEIN)
- Other (soap acid oil)
- Other (Soapstock acid oil contaminated with sulphur)
- Other (Starch broth)
- Other (Starch slurry)
- Other (Technical corn oil)
- Other (TER)
- Other (Triticale)
- Other (Waste from beverage production)
- Other (Waste from food industry)
- Other (Waste from processing alcohol)
- Other (waste starch slurry)
- Other (wastes and residues)
- Other (Wastewater sediments)
- Other (Wastewater)
- Other (Wetland grass)
- Other (Whey Permeate)
- Other (Whey)
- Other cereals
- Other oil crops
- Other sugar crops
- Palm oil
- Palm oil mill effluent
- Palm oil mill effluent and empty palm fruit bunches
- Rapeseed
- Soapstock acid oil contaminated with sulphur
- Soybeans
- Spent bleached earth
- Starch slurry
- Straw
- Sugar beet
- Sugar cane
- Sunflower seed
- Tall oil pitch
- Tallow - category 3 or unknown
- Used cooking oil
- Waste pressings from production of vegetable oils
- Waste vegetable or animal oils
- Waste wood
- Wheat

Table A1.4 Biofuel production pathways

- Biogas from dry manure as compressed natural gas
- Biogas from municipal organic waste as compressed natural gas
- Biogas from wet manure as compressed natural gas
- Farmed wood ethanol
- Farmed wood methanol
- Hydrotreated vegetable oil from palm oil (process not specified)
- Hydrotreated vegetable oil from palm oil (process with methane capture at oil mill)
- Hydrotreated vegetable oil from rape seed
- Hydrotreated vegetable oil from sunflower
- MTBE renewable component
- N/A
- Other (Biodiesel from vegetable oil)
- Other (Bagasse ethanol)
- Other (Barley ethanol)
- Other (beetroot industrial waste)
- Other (Biodiesel from animal fats catogries 1 and 2)
- Other (Biodiesel from Biomass fraction of industrial waste)
- Other (biodiesel from bio-waste)
- Other (Biodiesel from bleaching clay)
- Other (Biodiesel from canola)
- Other (Biodiesel from Corn)
- Other (Biodiesel from Crude glycerine)
- Other (biodiesel from distillate of fatty acids from palm oil)
- Other (Biodiesel from empty palm fruit bunches)
- Other (biodiesel from ffbs)
- Other (Biodiesel from free fatty acids)
- Other (biodiesel from industrial food waste, process not specified)
- Other (biodiesel from palm fatty acid distillate - PFAD)
- Other (biodiesel from Palm oil mill effluent)
- Other (Biodiesel from POME)
- Other (Biodiesel from process by-product - fatty acid)
- Other (Biodiesel from process waste - butter)
- Other (Biodiesel from process waste - cleaning of tanks)
- Other (Biodiesel from process waste - feed production)
- Other (Biodiesel from process waste - flotation fat)
- Other (Biodiesel from process waste - shut down FAME plant)
- Other (Biodiesel from process waste - special oil)
- Other (Biodiesel from process waste - thistleoil)
- Other (Biodiesel from process waste - vegetable oil)
- Other (Biodiesel from rapeseed/canola)
- Other (Biodiesel from separately collected used cooking oils and fats of vegetable origin)
- Other (Biodiesel from soapstock acid oil)
- Other (Biodiesel from Soy seed)
- Other (Biodiesel from spent bleached earth)
- Other (biodiesel from sulfur contaminated soapy pastes, unspecified process)
- Other (Biodiesel from Tall oil pitch)
- Other (Biodiesel from Tallow-categories 1 and 2)
- Other (Biodiesel from Tallow-category 3 or unknown)
- Other (Biodiesel from TER)
- Other (Biodiesel from the preparation and processing of fruit, vegetables, cereals unsuitable for consumption or processing - vegetable edible oils and fats)
- Other (biodiesel from uco)
- Other (Biodiesel from used cooking oil - origin vegetable oil)
- Other (biodiesel from used cooking oil)
- Other (Biodiesel from used cooking oil-origin animal fat)
- Other (Biodiesel from waste vegetable or animal oil)
- Other (Biodiesel Hydrotreated Tallow)
- Other (Biodiesel produced from biomass fraction of industrial waste)
- Other (Biodiesel produced from used cooking oil - origin animal oil or animal+vegetable oil)
- Other (Biodiesel produced from vegetable mix fatty acid oil)
- Other (Biodiesel)
- Other (Bio-ETBE from Barley)
- Other (Bio-ETBE from Corn)
- Other (Bio-ETBE from Sugar beet)
- Other (Bio-ETBE from Sugar cane
- Other (Bio-ETBE from Wheat)
- Other (bioethanol from bagasse)
- Other (Bioethanol from barley)
- Other (Bioethanol from brown liquor)
- Other (Bioethanol from corn)
- Other (Bioethanol from Grape marcs and wine lees)
- Other (Bioethanol from internal waste)
- Other (Bioethanol from molasses)
- Other (Bio-ethanol from other bio-waste)
- Other (Bioethanol from rye)
- Other (Bioethanol from sorghum)
- Other (Bioethanol from starch slurry)
- Other (Bioethanol from triticale)
- Other (Bioethanol from waste/residue from processing of alcohol)
- Other (Bio-ethanol produced from biomass fraction of industrial waste)
- Other (Bioethanol)
- Other (Biogas from agri-food waste as compressed natural gas)
- Other (biogas from Animal fats classified as categories 1 and 2)

- Other (Biogas from animal manure as compressed natural gas)
- Other (Biogas from bacteria as compressed natural gas)
- Other (biogas from Biomass fraction of mixed municipal waste)
- Other (Biogas from biowaste as compressed natural gas)
- Other (Biogas from bio-waste)
- Other (Biogas from cereals)
- Other (Biogas from corn)
- Other (biogas from glycerine)
- Other (Biogas from grass silage residues)
- Other (Biogas from grass silage)
- Other (Biogas from industrila waste)
- Other (Biogas from manure and agri-food waste as compressed natural gas)
- Other (Biogas from manure and sewage sludge)
- Other (Biogas from municipal organic waste and sewage sludge as compressed natural gas)
- Other (Biogas from municipal organic waste as compressed natural gas)
- Other (biogas from nut shells)
- Other (biogas from pit greases and flotation sludge)
- Other (Biogas from sewage sludge as compressed natural gas)
- Other (Biogas from suger cane)
- Other (Biogas from TER)
- Other (biogas from used cooking oil)
- Other (biogas from waste (other))
- Other (Biogas from waste from food industry as compressed natural gas)
- Other (Biogas from waste from food industry)
- Other (Biogas from waste vegetable oils or animal fats)
- Other (Biogas from wastewater and compressed natural gas)
- Other (Biogas from wastewater sediments and compressed natural gas)
- Other (Biogas from wastewater)
- Other (Biogas from whey)
- Other (Biogasoline from animal fat)
- Other (bio-LNG from bio-waste)
- Other (Bio-LNG from sewage sludge)
- Other (Bio-LPG from Biomass fraction of industrial waste)
- Other (Bio-LPG from Palm oil)
- Other (Bio-LPG from POME)
- Other (Bio-LPG from SHEA OLEIN)
- Other (Bio-LPG from Soybeans)
- Other (Bio-LPG from Sunflower seed)
- Other (Bio-LPG from UCO)
- Other (BioLPG from waste wood)
- Other (biomass as process energy in biomass boilers)
- Other (biomethan from waste fats)
- Other (biomethan from waste food)
- Other (Biomethane from crude glycerine)
- Other (Biomethane from Fatty Acids)
- Other (Biomethanol from organic municipal waste)
- Other (Bio-methanol from other bio-waste)
- "Other (Bio-methanol from Sugar beet residues)"
- Other (Biomethanol produced from biomass fraction of industrial waste)
- Other (Biomethanol produced from Straw)
- Other (Bio-methanol produced from sugar beet)
- Other (Bionafta from used cooking oil)
- Other (bionafta from waste (other))
- Other (Bionaphta produced from palm oil)
- Other (Biopetrol from PFAD)
- Other (Biopetrol from tall oil)
- Other (Biopetrol from technical corn oil)
- Other (Biopetrol from waste vegetable oil or animal fat)
- Other (Biopropane from palm oil)
- Other (Brown liquor ethanol)
- Other (by-product in HVO production)
- Other (Cat 3 Animal Fat)
- Other (cereals bioethanol)
- Other (co-processed advanced diesel)
- Other (co-processed advanced gasoline)
- Other (Co-processed oil for replacement of diesel (crude oil(rapseed/canola)))
- Other (Corn (maize) ethanol)
- Other (Corn (maize))
- Other (corn ethanol - natural gas as process fuel in CHP plant)
- Other (Corn Ethanol)
- Other (Corn ethanol, Community produced (natural gas as process fuel in CHP plant))
- Other (Corn ethanol, natural gas as process fuel in CHP plant)
- Other (Corn ethanol, natural gas as process fuel in conventional boiler)
- Other (Corn ethanol, overseas generated (process fuel natural gas in CHP plant))
- Other (corn ethanol, process fuel not specified)
- Other (corn oil biodiesel)
- Other (Corn(maize) ethanol)
- Other (corn)
- Other (Cottonseed oil Biodiesel)
- Other (ETBE renewable component)
- Other (ethanol from barley (lignite as process fuel in CHP plant))
- Other (ethanol from barley (process not specified))
- Other (Ethanol from barley)
- Other (ethanol from beer production residues)
- Other (Ethanol from biomass fraction of industrial waste and residues)
- Other (ethanol from biomass fraction of industrial waste)
- Other (Ethanol from biomass fraction of wastes and residues from forestry and forest-based industries)
- Other (Ethanol from biowaste class 3)
- Other (ethanol from bio-waste)
- Other (ethanol from cobs cleaned of kernels of corn)
- Other (ethanol from corn (maize) (flue gas heat as process fuel))
- Other (ethanol from corn (maize) (natural gas as process fuel in CHP plant))

- Other (ethanol from corn (maize) (natural gas as process fuel in conventional boiler)
- Other (ethanol from corn (maize) (process not specified))
- Other (Ethanol from corn)
- Other (Ethanol from ethanol waste liquids)
- Other (ethanol from molasses (process not specified)
- Other (ethanol from residues from the distilling industry)
- Other (ethanol from rye (flue gas heat as process fuel))
- Other (ethanol from rye (natural gas as process fuel in conventional boiler)
- Other (ethanol from rye (process not specified)
- Other (Ethanol from rye)
- Other (Ethanol from sorghum)
- Other (Ethanol from starch broth)
- Other (ethanol from triticale (flue gas heat as process fuel)
- Other (Ethanol from waste in the food industry)
- Other (Ethanol)
- Other (Ethanoldiesel from biomass fraction of industrial waste and residues)
- Other (Ethyl-tert-butyl-ether (ETBE) - renewable component)
- Other (FAEE from fishy oil ethyl ester)
- Other (FFA UCO)
- Other (FFBS)
- Other (Food waste ethanol)
- Other (food waste from households)
- Other (Food waste)
- Other (Fresh fruit bunches (FFBs))
- Other (grape marcs and lees ethanol)
- Other (HVO from Biomass fraction of industrial waste)
- Other (HVO from food waste)
- Other (HVO from palm oil mill effluent)
- Other (HVO from PFAD)
- Other (HVO from POME)
- Other (HVO from SHEA OLEIN)
- Other (HVO from Soybeans)
- Other (HVO from spent bleached earth)
- Other (HVO from UCO)
- Other (Hydrogenated oil from separately collected waste cooking vegetable oils and fats (100.00%))
- Other (hydrotreated biomass fraction of industrial waste)
- Other (Hydrotreated oil palm fresh fruit bunches (FFBs))
- Other (hydrotreated oil from POME)
- Other (hydrotreated oil from UCO)
- Other (Hydrotreated tallow - category 3 or unknown)
- Other (Hydrotreated UCO)
- Other (Hydrotreated used cooking oil - 100% origin vegetable oil)
- Other (Hydrotreated used cooking oil - origin animal oil or animal+vegetable oil)
- Other (Hydrotreated vegetable oil bionafta from palm oil)
- Other (Hydrotreated vegetable oil from animal fat (process not specified))
- Other (Hydrotreated vegetable oil from Animal Fat (waste/residue))
- Other (Hydrotreated vegetable oil from Animal fat cat. 3)
- Other (Hydrotreated vegetable oil from animal fat)
- Other (Hydrotreated vegetable oil from PFAD (traceable to plantation))
- Other (Hydrotreated vegetable oil from technical corn oil)
- Other (Hydrotreated vegetable oil from used cooking oil - origin 100% vegetable oil)
- Other (Hydrotreated vegetable oil from used cooking oil - origin 100% vegetable oil))
- Other (Hydrotreated vegetable oil from used cooking oil - origin animal or animal+vegetable oil)
- Other (Hydrotreated vegetable oil from waste vegetable oil or animal fat)
- Other (Hydrotreated vegetable oil from waste vegetable oil)
- Other (industrial food waste)
- Other (Maize bioethanol)
- Other (Maize ethanol)
- Other (methanisation)
- Other (Molasses ethanol)
- Other (Natural gas in CHP Plant)
- Other (Non community produced)
- Other (Non-food cellulosic material)
- Other (non-sustainable bioethanol))
- Other (non-sustainable biogas)
- Other (non-sustainable biopetrol))
- Other (non-sustainable ETBE renewable component)
- Other (non-sustainable hydrotreated vegetable oil)
- Other (oil crops biodiesel)
- Other (Oil from palm oil)
- Other (Oil palm fresh fruit bunches (FFBs))
- Other (Other cereals ethanol, process fuel not specified)
- Other (Other cereals)
- Other (Other non-food cellulosic material)
- Other (Palm bunches)
- Other (palm oil mill effluent)
- Other (Palm oil)
- Other (palmolein biodiesel)
- Other (POME)
- Other (Rye ethanol)
- Other (Silage and fodder residues)
- Other (Soap acid oil Biodiesel)
- Other (soapy pastes contaminated with sulfur)
- Other (Sorghum ETBE)
- Other (Sorghum ethanol)
- Other (Spent bleaching earth)
- Other (strach slurry ethanol)
- Other (Sugar beet residues)
- Other (SunHydrotreated vegetable oil from sunflower)
- Other (synthetic hydrocarbons from rapeseed)
- Other (TAEE renewable component)

- Other (Tall oil)
- Other (Tallow - category 1)
- Other (Tallow - category 2)
- Other (Tallow - category 3 or unknown)
- Other (Triticale ethanol (process fuel not specified))
- Other (Triticale)
- Other (UCO)
- Other (Used cooking oil - 100% vegetable origin)
- Other (Used cooking oil - origin vegetable oil (100%))
- Other (used cooking oil biodiesel)
- Other (Used cooking oil- origin animal (or animal and vegetable)fat)
- Other (Used cooking oil -origin animal fat)
- Other (Used cooking oil- origin vegetable fat)
- Other (Used cooking oil -origin vegetable oil)
- Other (Used cooking oil)
- Other (Waste classified wetland grass)
- Other (Waste from beverage production ethanol)
- Other (Waste from the cereal industry)
- Other (waste of processing vegetablefats, lubricants and soaps)
- Other (waste starch slurry Bioethanol)
- Other (Waste starch slurry ethanol)
- Other (waste starch slurry)
- Other (Wet milling of wheat)
- Other (Wheat ethanol (bran as process fuel in CHP plant))
- Other (Wheat ethanol (flue gas heat as process fuel))
- Palm oil biodiesel (process not specified)
- Palm oil biodiesel (process with methane capture at oil mill)
- Pure vegetable oil from rape seed
- Rape seed biodiesel
- Soybean biodiesel
- Sugar beet ethanol
- Sugar cane ethanol
- Sunflower biodiesel
- Waste vegetable oil or animal fat biodiesel
- Waste wood ethanol
- Waste wood methanol
- Wheat ethanol (lignite as process fuel in CHP plant)
- Wheat ethanol (natural gas as process fuel in CHP plant)
- Wheat ethanol (natural gas as process fuel in conventional boiler)
- Wheat ethanol (process fuel not specified)
- Wheat straw ethanol

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