Concawe
Environmental Science for European Refining

Report

Report no. 2/21A

Concawe's Transport and Fuel Outlook towards EU 2030 Climate Targets - Appendix

ISBN 978-2-87567-139-4

Concawe's Transport and Fuel Outlook towards EU 2030 Climate Targets - Appendix

This report was prepared by:

Marta Yugo, Ehsan Shafiei, Linda Ager-Wick Ellingsen, John Rogerson

Under the supervision of:

M. Yugo (Concawe Science Executive)

Transport_LowCarbonPathways@concawe.eu

At the request of:

Concawe Fuels Quality and Emissions Management Group

Thanks for their contribution to the members of the Concawe STF-14 Task Force

Reproduction permitted with due acknowledgement

© Concawe
Brussels
April 2021

This report consists of the Appendix of the main Concawe report 2/21.

ABSTRACT (CONCAWE 2/21 REPORT)

This Concawe report aims at providing an outlook on the European transport sector by modelling elements such as the evolution of the different powertrains and the availability of different alternative fuels over the period 2018-2030.

An analytical fleet-based model has been used, projecting the evolution of the fleet composition as well as the corresponding fuel demand towards 2030. The analytical tool is used to simulate different parameter combinations of vehicle and fuel (and thereof renewable fuel) technologies to assess fuel demand scenarios looking at vehicle fleet mix, fossil fuel demand, total renewable energy demand, and RED-II target. The composition of 2030 new vehicle sales has been defined based on market trends and experts' view, in compliance with the current 2030 CO_2 intensity targets for new sales in road transport. Besides this, a current and future estimate on both the total energy requirements and alternative fuel penetration have been included for other transport modes including aviation, rail and maritime sectors. The analytical tools evaluate fuel supply availability based on an updated market-based outlook on production plants currently in operation as well as the planned capacities for biofuels.

This study finally explores the compliance with RED II regulation and 2030 targets in a baseline scenario considering the impact of two different interpretations of using renewable electricity in the transport sector. Complementing the baseline, additional sensitivities on key individual parameters have been explored, mainly around the uptake of electric vehicles, bio-kerosene, biomethane, liquid biofuels, and gasoline fuel grades. The sensitivity analysis was conducted to show their individual impact on reaching the RED II targets, to inform the currently on-going process on future RED II targets for road transport (to be agreed in 2021).

KEYWORDS

Transport, Energy Demand, CO_2 Emissions, RED II Target, Well-To-Tank, Well-To-Wheels, Alternative Fuels

INTERNET

This report is available as an Adobe pdf file on the Concawe website (www.concawe.org).

Note. The main Concawe report 2/21 can be found with the following link: report no. 2/21

NOTE
Considerable efforts have been made to assure the accuracy and reliability of the information contained in this publication. However, neither Concawe nor any company participating in Concawe can accept liability for any loss, damage or injury whatsoever resulting from the use of this information.

This report does not necessarily represent the views of any company participating in Concawe.

CONTENTS (Appendix of Concawe report 2/21)

1. FUEL GRADES

With regard to biofuel blending in the model, it was assumed that ethanol and FAME are blended to the maximum volume allowed by the specification. To reflect laboratory test accuracies and other tolerances, 0.1% by volume was subtracted from the blending limit for each blending grade, i.e. an E5-blend would effectively mean a 4.9% (by volume) blending of ethanol into gasoline for all E5 sold in Europe. In addition, a ramp-up of market introduction and market acceptance of new blends has been implemented based on the E10 introduction in Germany, France and Finland. The market uptake of new grades across the EU requires the market introduction in the Member States and it strongly depends on the customer acceptance.

The fleet model allows up to 3 different gasoline grades (a "protection grade", a main grade, and an E85) and up to 2 different diesel grades (a "protection grade" and a main grade). Additionally, for the main diesel grade, market uptake can be set differently for the HDV fleet and Light-Commercial Vehicles compared to the diesel passenger car fleet. For passenger cars, the compatibility between fuels and vehicles of a specific model year can be independently defined in the model.

The fleet model allows setting compatibility between vehicle vintage (model year) and fuel grade. HVO and BTL are included in the diesel pool assuming full backward compatibility. Advanced ethanol (lignocellulose-based) is added to gasoline in the same way as conventional ethanol and is therefore limited by the same blending grade limits as conventional ethanol in the model. Other oxygenates (e.g. Ethyl tert-butyl ether, ETBE) were not modelled separately but would be allowed up to the maximum oxygen specification[1].

[1] As defined in FQD, Annex I

2. MAIN ASSUMPTIONS AND 2030 MODEL OUTPUTS – PASSENGER CARS

Table 1. Passenger car baseline assumptions

Passenger Cars	Unit	2015	2018	2030	Reference
New sales	million units	14.20	15.62	16.0	ACEA statistics
Stock	million units	261.8	276.5	281.5	ACEA statistics, Expert's view
Vehicle mileage	km/yr	11800	12000	11250	Roland Berger, Expert's view
Share of BEV in (BEV+PHEV)	%	40%	56%	67%	Expert's view based on (IEA, 2020) and (Deloitte, 2020)
PHEV e-driving	%	50%	61%	90%	Expert's view derived from JEC TTW v5 data

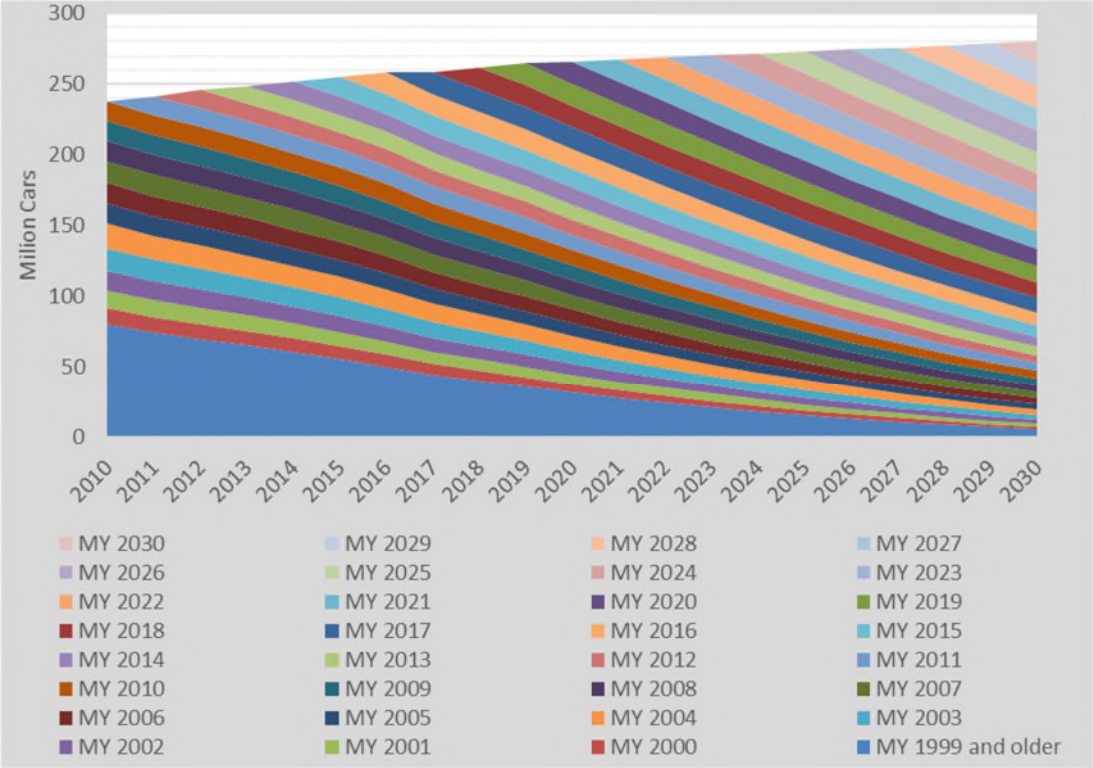
Table 2. Estimated energy consumption (MJ/km) and emission intensity (TTW gCO_2/km) for new passenger car fleet (in NEDC terms)

Powertrain	Energy Consumption (MJ/km)			Emission Intensity (g CO_2/km)		
	2015	2018	2030	2015	2018	2030
Gasoline	1.67	1.69	1.05	122.5	123.5	77.0
Diesel	1.63	1.66	0.98	119.2	121.8	71.6
CNG	1.84	1.83	1.04	103.2	102.7	58.5
LPG	1.84	1.86	1.23	121.0	122.0	80.8
FFV	1.84	1.63	1.16	132.3	117.0	83.1
PHEV	0.92	0.89	0.56	37.0	37.0	7.7
BEV	0.45	0.45	0.35	0.0	0.0	0.0
FCEV	0.75	0.75	0.53	0.0	0.0	0.0
Average new car fleet	**1.64**	**1.66**	**0.90**	**119.6**	**120.8**	**59.7**

2.1. SCRAPPAGE FUNCTION

In the fleet model, the road fleet composition is modified by old vehicles being removed from the fleet and new vehicles entering the fleet based on historical new vehicle registrations per geographical coverage: the new vehicle sales information is an input parameter while scrappage is a function of sales and stock size. The scrappage function therefore effectively reflects the number of vehicles in the fleet which – due to vintage (i.e. model year (MY)) – are affected by a loss of fuel 'protection grade' (e.g. replacement of E5 by E10). In updating F&F version 2018, the scrappage functions have been tuned to obtain an average fleet age in line with the data available from ACEA. The survival rates for each model year are shown in the figure below.

Figure 1. Passenger car model year fleet survival rates per model year



3. MAIN ASSUMPTIONS AND 2030 MODEL OUTPUTS - LIGHT COMMERCIAL VEHICLES

Table 3. Baseline assumptions for gasoline vans

Gasoline vans	Unit	2015	2018	2030	Reference
New sales	Million units	0.059	0.086	0.129	Historical data: Transport in Figures 2020 Future growth rate: 2.85%/yr during 2021-2030 (Based on Ronald Berger)
Stock	Million units	2.43	2.61	2.92	Historical data: ACEA statistics, Transport in Figures 2020 Future growth rate: 0.93%/yr during 2021-2030 (Based on Ronald Berger)
Vehicle mileage	km/yr	9873	9873	9873	JRC IDEES database 2015
PHEV e-driving	%	65%	65%	90%	Expert's view derived from JEC TTW v5

Table 4. Assumptions for diesel vans <2.5t

Diesel vans <2.5t	Unit	2015	2018	2030	Reference
New sales	Million units	0.766	0.908	0.926	Historical data: ACEA statistics Future growth rate: -0.1%/yr during 2021-2030 (Based on Ronald Berger)
Stock	Million units	12.90	13.83	13.05	Historical data: ACEA statistics Future growth rate: -0.48%/yr during 2021-2030 (Based on Ronald Berger)
Vehicle mileage	km/yr	16000	16000	16000	JRC IDEES database 2015
PHEV e-driving	%	65%	65%	90%	Expert's view derived from JEC TTW v5

Note: Diesel <2.5t assumed at 44% of the total sales of diesel vans (<2.5t+>2.5t)

Table 5. Assumptions for diesel vans >2.5t

Diesel vans >2.5t	Unit	2015	2018	2030	Reference
New sales	Million units	0.975	1.156	1.178	Historical data: ACEA statistics Future growth rate: -0.1%/yr during 2021-2030 (Based on Ronald Berger)
Stock	Million units	16.42	17.61	19.12	Historical data: ACEA statistics Future growth rate: 0.93%/yr during 2021-2030 (Based on Ronald Berger)
Vehicle mileage	km/yr	16000	16000	16000	JRC IDEES database 2015
PHEV e-driving	%	65%	65%	90%	Expert's view derived from JEC TTW v5

Table 6. Energy consumption (MJ/km) and emission intensity (TTW gCO_2/km) for new van fleet (in NEDC terms)

Powertrain	Energy Consumption (MJ/km)			Emission Intensity (g CO_2/km)		
	2015	2018	2030	2015	2018	2030
Gasoline	2.38	2.27	1.55	152.0	144.5	98.9
CNG	2.43	2.31	1.58	129.2	122.8	84.0
LPG	2.43	2.31	1.58	150.5	143.1	97.9
E85	2.38	2.27	1.55	164.1	156.1	106.8
PHEV	1.42	1.35	0.72	45.6	43.4	14.8
BEV	0.95	0.91	0.62	0.0	0.0	0.0
FCEV	0.97	0.92	0.63	0.0	0.0	0.0
Diesel	2.67	2.51	1.70	170.0	160.0	108.4
Average new fleet	**2.65**	**2.49**	**1.63**	**168.2**	**157.6**	**101.6**

4. MAIN ASSUMPTIONS AND 2030 MODEL OUTPUTS - HEAVY-DUTY VEHICLES

The main sources utilised to update the fleet model are reported in the table below:

Table 7. Source of data for HDVs

Source	Information provided	Link - Reference
ACEA	Stock and new registrations	(ACEA, 2018)
EU 2050-long term strategy	Activity trends	(EC, 2018)
ICCT Pocketbook 2016/17	Stock, new registrations	(ICCT, 2017)
EUROSTAT	Activity	(Eurostat, 2017)
IDEES database	Activity data	(EC, 2017)
IEA – The Future of Trucks	Payloads and activities	(IEA, 2017)
ITF Transport Outlook 2017	Activity trends	(ITF, 2017)
Roland Berger	Stock, new registrations, alternative powertrains forecast	(Roland Berger, 2016)
NGVA	Stock and forecasts for CNG and LNG vehicles.	(NGVA, 2018)

4.1. HDV TRUCKS 3.5-7.5 T

Table 8. Assumptions for HDV 3.5-7.5t (baseline based on ACEA statistics and expert's view)

HDV 3.5 - 7.5t	Unit	2015	2018	2030
Sales	Million units	0.036	0.033	0.041
Stock	Million units	1.66	1.77	1.99
Vehicle mileage	km/yr	38000	39850	48200
Load factor	tkm/vkm	0.829	0.833	0.847
Share of BEV in (BEV+PHEV)	%	33%	33%	33%
PHEV e-driving	%	59%	69%	75%

Table 9. Composition of new registrations for HDV 3.5-7.5t (Expert's view for the baseline)

POWERTRAIN	2015	2018	2030
DIESEL	97.9%	97.8%	92.0%
CNG	2.1%	2.2%	4.0%
LNG	0.0%	0.0%	0.0%
PHEV	0.0%	0.0%	2.7%
BEV	0.0%	0.0%	1.3%
FCEV	0.0%	0.0%	0.0%

Table 10. Estimated energy consumption and emission intensity for HDV trucks 3.5-7.5t

Powertrain	Energy Consumption (MJ/km)			Emission Intensity (g CO_2/km)			Emission Intensity (g CO_2/tkm)		
	2015	2018	2030	2015	2018	2030	2015	2018	2030
Diesel	4.6	4.5	4.0	334	331	290	403	398	342
CNG	5.6	5.6	4.9	315	313	274	380	375	323
LNG	5.6	5.6	4.9	316	314	275	382	377	324
PHEV	3.3	3.0	2.4	136	103	72	164	124	86
BEV	2.4	2.4	1.9	0	0	0	0	0	0
FCEV	3.4	3.3	2.7	0	0	0	0	0	0
Average new fleet	**4.6**	**4.5**	**3.9**	**333**	**331**	**280**	**402**	**397**	**330**

4.2. HDV TRUCKS 7.5-16 T

Table 11. Assumptions for HDV 7.5-16 t (baseline based on statistics and expert's view)

HDV 7.5 - 16t	Unit	2015	2018	2030
Sales	Million units	0.0316	0.0286	0.0361
Stock	Million units	1.417	1.507	1.698
Vehicle mileage	km/yr	43000	45100	54500
Load factor	tkm/vkm	1.856	1.864	1.898
Share of BEV in (BEV+PHEV)	%	33%	33%	33%
PHEV e-driving	%	59%	69%	75%

Table 12. Composition of new registrations for HDV 7.5-16t (baseline based on statistics and expert's view)

POWERTRAIN	2015	2018	2030
DIESEL	97.9%	97.8%	92.0%
CNG	2.1%	2.2%	4.0%
LNG	0.0%	0.0%	0.0%
PHEV	0.0%	0.0%	2.7%
BEV	0.0%	0.0%	1.3%
FCEV	0.0%	0.0%	0.0%

Table 13. Estimated energy consumption and emission intensity for HDV trucks 7.5-16t

Powertrain	Energy Consumption (MJ/km)			Emission Intensity (g CO2/km)			Emission Intensity (g CO2/tkm)		
	2015	2018	2030	2015	2018	2030	2015	2018	2030
Diesel	6.6	6.5	5.7	481	476	416	259	255	219
CNG	8.1	8.0	7.0	454	449	393	245	241	207
LNG	8.1	8.0	7.0	456	451	395	246	242	208
PHEV	4.7	4.4	3.5	195	149	104	105	80	55
BEV	3.5	3.4	2.7	0	0	0	0	0	0
FCEV	4.9	4.8	3.9	0	0	0	0	0	0
Average new fleet	**6.6**	**6.5**	**5.6**	**480**	**475**	**402**	**259**	**255**	**212**

4.3. HDV TRUCKS 16-32 T

Table 14. Assumptions for HDV 16-32 t (baseline based on statistics and expert's view)

HDV 16-32t	Unit	2015	2018	2030
Sales	Million units	0.1442	0.1444	0.1286
Stock	Million units	1.489	1.584	1.491
Vehicle mileage	km/yr	47500	49800	60300
Load factor	tkm/vkm	6.192	6.213	6.295
Share of BEV in (BEV+PHEV)	%	0%	0%	0%
PHEV e-driving	%	59%	69%	75%

Table 15. Composition of new registrations for HDV 16-32t [(baseline based on statistics and expert's view)

POWERTRAIN	2015	2018	2030
DIESEL	99.8%	99.5%	71.1%
CNG	0.0%	0.0%	0.0%
LNG	0.2%	0.5%	9.6%
PHEV	0.0%	0.0%	9.6%
BEV	0.0%	0.0%	0.0%
FCEV	0.0%	0.0%	9.6%

Table 16. Estimated energy consumption and emission intensity for HDV trucks 16-32t

Powertrain	Energy Consumption (MJ/km)			Emission Intensity (g CO2/km)			Emission Intensity (g CO2/tkm)		
	2015	2018	2030	2015	2018	2030	2015	2018	2030
Diesel	9.3	9.3	7.8	682	679	574	110	109	91
CNG	11.5	11.4	10.0	644	641	562	104	103	89
LNG	11.5	11.4	10.0	647	644	564	104	104	90
PHEV	6.7	6.2	4.9	277	212	143	45	34	23
BEV	4.9	4.9	3.9	0	0	0	0	0	0
FCEV	6.9	6.8	5.6	0	0	0	0	0	0
Average new fleet	**9.3**	**9.3**	**7.5**	**682**	**679**	**476**	**110**	**109**	**76**

4.4. HDV TRUCKS > 32 T

Table 17. Assumptions for HDV >32 t (baseline based on statistics and expert's view)

HDV >32t	Unit	2015	2018	2030
Sales	Million units	0.1242	0.1244	0.1108
Stock	Million units	1.798	1.913	1.801
Vehicle mileage	km/yr	72000	75500	91400
Load factor	tkm/vkm	9.551	9.591	9.753
Share of BEV in (BEV+PHEV)	%	0%	0%	0%
PHEV e-driving	%	59%	69%	75%

Table 18. Composition of new registrations for HDV > 32 t (baseline based on statistics and expert's view)

POWERTRAIN	2015	2018	2030
DIESEL	99.8%	99.5%	71.1%
CNG	0.0%	0.0%	0.0%
LNG	0.2%	0.5%	9.6%
PHEV	0.0%	0.0%	9.6%
BEV	0.0%	0.0%	0.0%
FCEV	0.0%	0.0%	9.6%

Table 19. Estimated energy consumption and emission intensity for HDV trucks >32t

Powertrain	Energy Consumption (MJ/km)			Emission Intensity (g CO_2/km)			Emission Intensity (g CO_2/tkm)		
	2015	2018	2030	2015	2018	2030	2015	2018	2030
Diesel	11.0	10.9	9.2	802	798	675	84	83	69
CNG	13.5	13.4	11.7	758	754	660	79	79	68
LNG	13.5	13.4	11.7	761	757	663	80	79	68
PHEV	7.9	7.3	5.7	326	249	169	34	26	17
BEV	5.8	5.7	4.6	0	0	0	0	0	0
FCEV	8.1	8.0	6.6	0	0	0	0	0	0
Average new fleet	**11.0**	**10.9**	**8.9**	**802**	**798**	**560**	**84**	**83**	**57**

4.5. BUSES AND COACHES

Table 20. Assumptions for Buses and Coaches (baseline based on statistics and expert's view)

Buses & Coaches	Unit	2015	2018	2030
Sales	Million units	0.0326	0.0325	0.0359
Stock	Million units	0.767	0.80	0.80
Vehicle mileage	km/yr	38000	38140	38700
Load factor	pkm/vkm	16.548	16.549	16.588
Share of BEV in (BEV+PHEV)	%	25%	98%	67%
PHEV e-driving	%	56%	62%	75%

Table 21. Composition of new registrations for Buses and Coaches (Baseline based on statistics and expert's view)

POWERTRAIN	2015	2018	2030
DIESEL	93.5%	95.3%	77.5%
CNG	6.1%	2.6%	14.0%
LNG	0.0%	0.0%	0.0%
PHEV	0.3%	0.0%	2.2%
BEV	0.1%	2.0%	4.3%
FCEV	0.0%	0.1%	2.0%

Table 22. Estimated energy consumption and emission intensity for Buses and Coaches

Powertrain	Energy Consumption (MJ/km)			Emission Intensity (g CO_2/km)			Emission Intensity (g CO_2/pkm)		
	2015	2018	2030	2015	2018	2030	2015	2018	2030
Diesel	19.6	18.9	16.6	1433	1386	1213	87	84	73
CNG	24.1	23.3	20.4	1353	1309	1146	82	79	69
LNG	24.1	23.3	20.4	1359	1314	1150	82	79	69
PHEV	14.4	13.3	10.1	631	527	303	38	32	18
BEV	10.4	9.9	8.0	0	0	0	0	0	0
FCEV	14.5	13.9	11.4	0	0	0	0	0	0
Average new fleet	**19.8**	**18.9**	**16.5**	**1424**	**1355**	**1107**	**86**	**82**	**67**

5. BIOFUEL AVAILABILITY

This chapter details the assumptions in modelling the biofuel availability.

5.1. DATA SOURCES AND ASSUMPTIONS

While the 2017 STRATAS database provides much data, various assumptions had to be made to estimate the biofuel capacity. These assumptions are detailed in the text below.

5.1.1. Inclusion of plants in capacity estimation

The STRATAS database distinguishes between five plant statuses: *operating*, *under construction*, *proposed*, *not operating*, and *cancelled*. In mapping the biofuel availability in Europe, plants with status as *operating*, *under construction*, and *proposed* were included. Plants that have status as *not operating* or *cancelled* were omitted. This inherently assumes that plants that are *not operating* will not become operational again, and that *cancelled* plants will not become operational. It was further assumed that plants that are *operating* will remain operational through 2030. It was also assumed that plants that are *under construction* or *proposed* will be operational from the (stated or assumed) onstream year through 2030.

5.1.2. Onstream date

The STRATAS database specify the onstream month and year for the production plants. However, for a few plants there was no information about onstream month and/or year. Assumptions about how the lack of information was dealt with is detailed below.

It was assumed that plants with status as *operating* with no specified onstream month or year had been onstream since before 2015. It was further assumed that plants with status as *under construction* or *proposed* with no stated onstream month or year would go onstream as of January 2025.

In the database, three plants had status as *under construction* or *proposed* with recoded onstream years as 2015 and 2016. As these were *not operating* as of 2017, it was assumed that these went onstream in 2018.

Where the month for going onstream was not specified, it was assumed that the onstream month for these plants was January. According to this assumption, the plant was onstream for the entire year of the onstream year. This assumption was applied to both past and prospective production capacities.

5.1.3. Utilization rates

Production capacity can be reported in terms of *installed* and *utilized* capacity. To estimate the supply of biofuels, the *utilized* production capacity was used. However, the STRATAS database reports the *installed* production capacities, rather than the *utilized* production capacities. To estimate the biofuels available on the market, the *utilized* production capacities must be estimated.

The *utilized* production capacities are based on utilization rates and the *installed* production capacity. The used utilizations rates for 2015 – 2018 is summarized in **Table 23**. The utilization rates are based on the USDA report (Flach, Lieberz, & Bolla, EU Biofuels Annual 2019, 2019).

Table 23. Assumed utilization rates for different biofuel types

Biofuel	2015	2016	2017	2018
Ethanol - 1st gen.	72 %	66 %	70 %	70 %
Ethanol - advanced	50 %	50 %	60 %	60 %
FAME	55 %	55 %	62 %	55 %
HVO	73 %	77 %	81 %	82 %
Biogas	63 %	62 %	68 %	67 %
Other	63 %	62 %	68 %	67 %

It was assumed that the utilization rate increases linearly from the 2018 utilization rates to reach full *installed* capacity in 2030.

5.1.4. Feedstocks

To a large degree, the STRATAS database distinguishes between the different feedstocks used to produce the biofuels at various refineries. However, feedstock information was not provided for all refineries. Thus, where the feedstock was not provided, assumptions were made. The assumptions were based primarily on biofuel conversion technology (as noted in the STRATAS database) and the location of the refinery. Location-based assumptions were based on general information provided by the USDA report (Flach, Lieberz, & Bolla, EU Biofuels Annual 2018, 2018). In some cases, information about a refinery's specific feedstock was found on the websites.

Note that for ethanol, it was assumed *sugars* referred to sugar beet and sugar cane. It was assumed that the distribution of feedstocks from sugar beet and sugar cane was 90% and 10%, respectively. This is in agreement with the USDA report that states that sugar beet derivatives are commonly used to produce ethanol in the EU (Flach, Lieberz, & Bolla, EU Biofuels Annual 2018, 2018).

The biofuels were categorized into three types: 1st generation food crop, advanced as defined in Annex IX part A, and advanced as defined in Annex IX part B. The feedstock types that the STRATAS database provided as feedstocks for European production were categorized according these feedstock types. **Table 24** provides an overview of how the feedstocks were categorized.

Note:

In the modelling, only the primary inputs were considered when mapping the feedstocks of the different biofuels. Secondary feedstocks that are not listed includes: bovine manure (which is more or less the same as cow manure), confectionary by products, green waste, safflower oil, yellow grease. Note that plants using these secondary feedstocks all contribute to negligible biofuel production volumes. Tertiary feedstocks not listed includes: Arundo Donax and yellow grease. These are only used in two plants.

Table 24. Categorization of feedstock types as described in the STRATAS database

1st generation food crop	Advanced - Annex IX Part A	Advanced - Annex IX Part B
Barley	Agricultural waste	Animal fat
Canola oil	Animal waste	Used cooking oil
Corn	Bagasse	Waste oil
Fish oil	Biowaste	
Jatropha oil	Black liquor	
Molasses	Bracken	
Palm	Cellulose	
Rapeseed oil	Cow manure	
Rice	Energy crops	
Rye	Food waste	
Soy oil	Forest products	
Sugars	Industrial and agricultural biowaste	
Sunflower oil	Landfill	
Wheat	Lignin from trees	
Whey	Municipal and industrial biowaste	
	Municipal solid waste	
	Municipal waste	
	Sewage sludge	
	Straw	
	Tall oil	
	Tallow	
	Waste beverage	
	Waste grape skin	
	Wheat straw	
	Wood waste	

5.1.5. Modifications

For HVO, a modification was performed to the feedstock of two plants. For the two plants, animal fat was listed as the primary feedstock and vegetable oils were listed as alternative feedstocks. As the USDA report states that animal fat requires changes to the technical equipment (Flach, Lieberz, & Bolla, EU Biofuels Annual 2018, 2018), it was assumed that these plants did not use animal fat but rather used cooking oil in addition to vegetable oils. It was further assumed that used cooking oil and rapeseed oil were used in equal shares in these two plants.

Furthermore, additional data sources were also used to estimate production capacities of HVO for 2017 and onward. The rationale for including supplementing data sources is that for HVO there has been much development in the past couple of years. For instance, one of the larger plants that had status as *cancelled* in the 2017 STRATAS database is currently operating.

5.1.6. Conversion factors

The production capacity of the individual plants is reported in various units and in the STRATAS database these are all converted to million litres. Because the calculations in the Fleet & Fuel model are made in million tonnes oil equivalents (Mtoe), the production volumes were converted to Mtoe. The factors used in the conversion are listed in **Table 25**.

Table 25. Conversion factors

Fuels	Density (kg/l)	LHV (MJ/kg)
Ethanol	0.794	26.8
FAME	0.890	37.2
HVO	0.780	44.0
Biomethane	0.752	46.1
ETBE	0.750	36.3
ED95	0.820	25.4
DME	0.670	28.4
Biomethanol	0.793	19.9
Aviation biofuel	0.720	43.7
Biogasoline (FT)	0.745	43.2

5.2. FEEDSTOCKS

To validate the estimated production capacities, the results from the STRATAS database were compared to other data sources. Distribution of feedstocks based on the STRATAS database is also compared to the external sources.

For ethanol, STRATAS results were compared to data reported from the European ethanol association ePURE. For FAME and HVO, the STRATAS results are compared to data reported from the European Biodiesel Board (EBB), which is based on data from Eurostat.

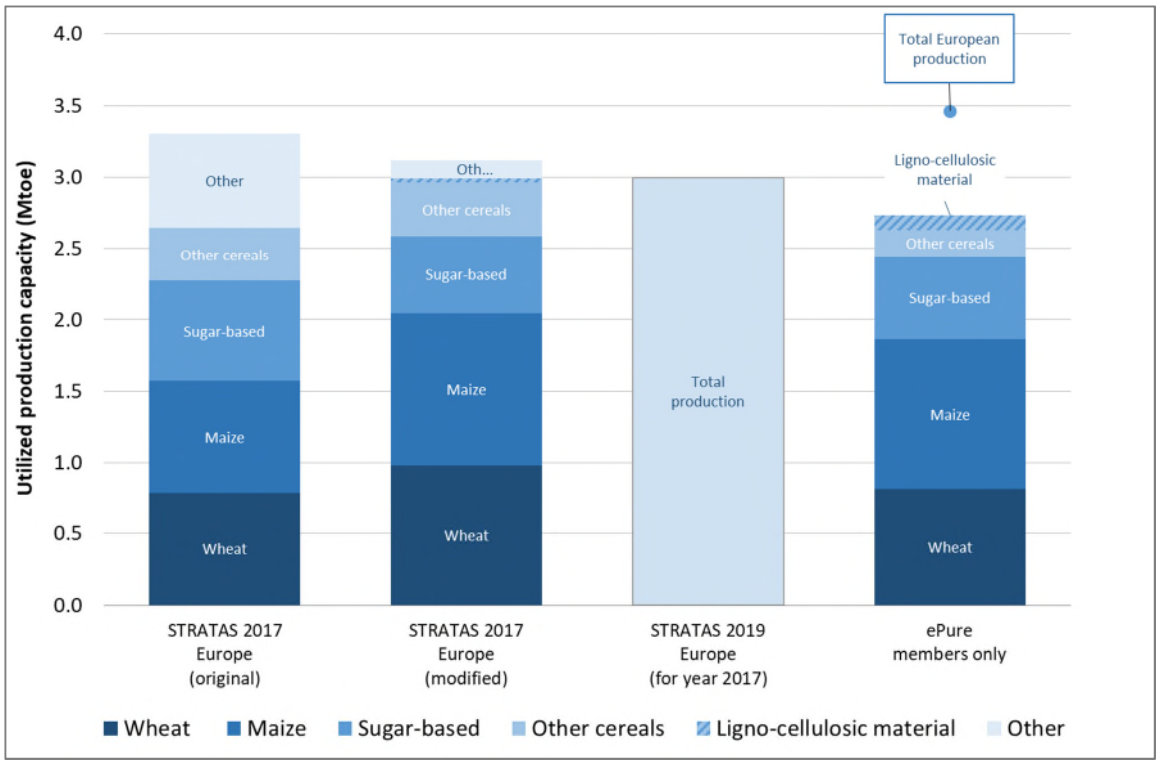
Two results based on the STRATAS database are reported. Results based on the original 2017 database includes no assumptions regarding feedstocks, while the modified 2017 database includes assumptions regarding the feedstocks as well as updates regarding HVO production.

The comparison of estimated utilized production capacities for ethanol, FAME and HVO are presented in the sections below. The figures report the biofuel feedstocks used to produce the biofuels as well as the total production volume. Note that in all three figures 1st generation fuels have a solid coloured background, while advanced biofuels (from both Annex IX Part A and B) have a striped background.

5.2.1. Ethanol feedstocks and comparisons

Figure 2 presents the comparison for ethanol. The total production capacity estimates range around 3 Mtoe. The results are discussed below the figure.

Figure 2. Comparison of ethanol production capacity and feedstock distribution between STRATAS and other data sources



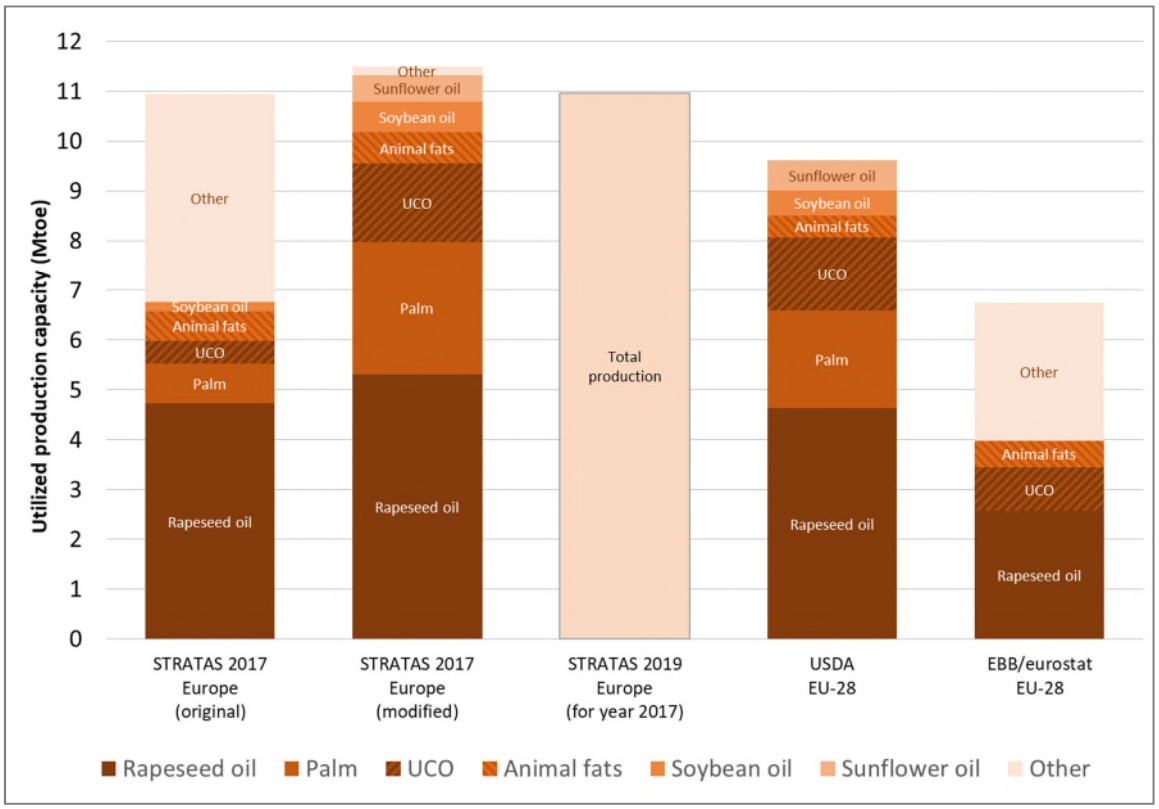
For ethanol, the 2017 STRATAS database used in our estimate reports higher total production capacity than ePURE (European renewable ethanol, 2018) and the 2019 STRATAS database. Note that the STRATAS database and ePURE operate with different system boundaries. While STRATAS considers all production in Europe, ePURE only considers production from their members. A document released by ePURE reports that the total installed production capacity in all of Europe including non-members was 9 262 Ml, which is comparable with the installed production capacity of 9 112 Ml reported by the 2017 STRATAS database (note that these values have been converted to Mtoe *utilized* capacity in **Figure 2**). As such, our estimate for total ethanol production is in good agreement with the estimate presented by ePURE.

The modified version of the 2017 STRATAS database has similar distribution among ethanol feedstocks as ePURE.

5.2.2. FAME feedstocks and comparisons

Figure 3 presents the comparison for FAME. The total production capacity estimates range from just below 7 Mtoe to 11 Mtoe. The results are discussed below the figure.

Figure 3. Comparison of FAME production capacity and feedstock distribution between STRATAS and other data sources



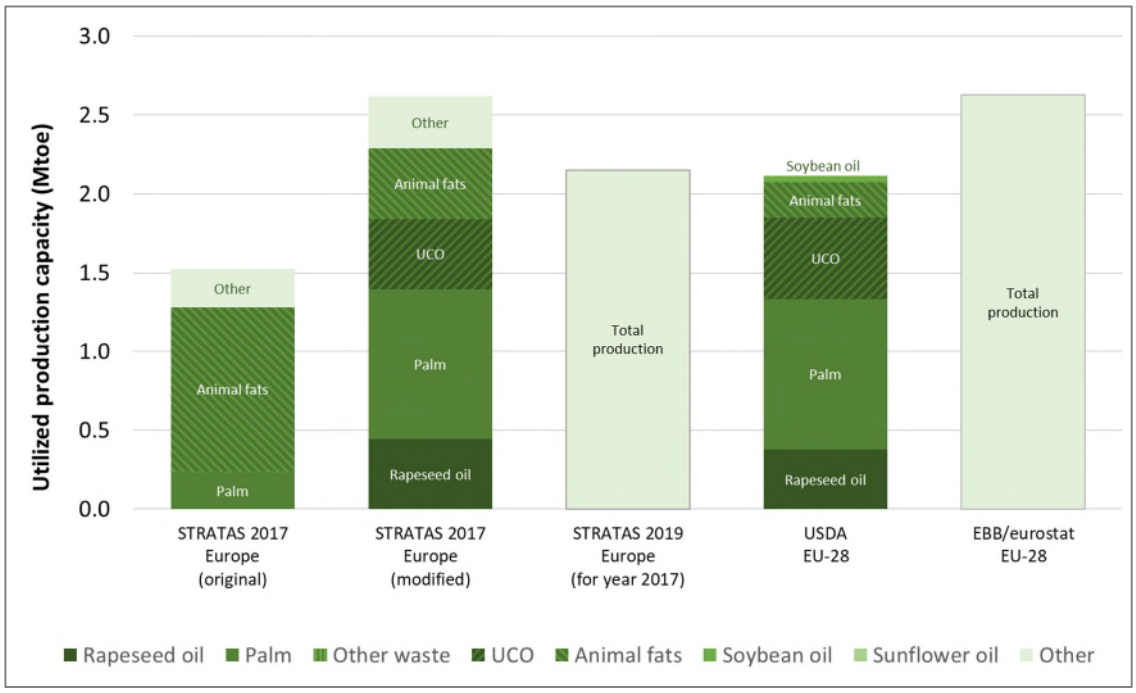
For FAME, both the 2017 and the 2019 STRATAS databases estimate higher production volumes than USDA (Flach, Lieberz, & Bolla, EU Biofuels Annual 2018, 2018) and EBB (European Biodiesel Board, 2019). While the STRATAS estimates considers all of Europe, USDA and EBB only considers EU member states. Note that the USDA estimate is based on statistics from Eurostat and Member State official statistics and adjusted by EU FAS Posts using additional information obtained from national industry organizations and governments. The EBB estimate is only based on Eurostat statistics. The utilization rate used by EBB is unknown, while our estimate applied the utilization rates reported by USDA (Flach, Lieberz, & Bolla, EU Biofuels Annual 2019, 2019). As the difference between our estimate and that by the USDA is relatively small and some of the difference is explained by the system boundary, we deem our estimate to be representative for Europe in 2017.

The modified version of the 2017 STRATAS database shows similar distribution of feedstocks as the USDA.

5.2.3. HVO feedstocks and comparisons

Figure 4 presents the comparison for HVO. The total production estimates range from 1.5 Mtoe to 2.6 Mtoe. The results are discussed below the figure.

Figure 4. Comparison of HVO production capacity and feedstock distribution between STRATAS and other data sources



The estimates based on the original 2017 STRATAS database are significantly lower than the estimates by the USDA (Flach, Lieberz, & Bolla, EU Biofuels Annual 2018, 2018) and EBB (European Biodiesel Board, 2019). Because there has been much activity within HVO production in the last couple of years, the STRATAS database was supplemented with newer information. Consequently, the modified 2017 STRATAS database estimates higher production capacity than the original version. The modified 2017 STRATAS estimate is 24% and 22% higher than that of the 2019 STRATAS database and USDA, respectively, but 0.3% lower than that of EBB.

Compared to the distribution of feedstocks reported by the USDA, the modified 2017 version of the STRATAS database obtained more similar results than the original version. The better alignment with the USDA results for the modified version is partly due to assumptions regarding feedstocks used in two of the largest HVO producing plants.

5.2.4. Summary of comparisons

In summary, the estimates for production of ethanol, biodiesel, and HVO have been compared to external estimates using different data sources. As these three biofuels make up 82% of our estimated *installed* biofuel production capacity, the benchmarking covers a large majority of the estimated biofuel production capacity.

The modified 2017 STRATAS database was used to estimate biofuel production in Europe as it was in good agreement with the external references sources. Even so, there were some differences between the modified 2017 STRATAS estimates and the other data sources. For total production volumes, the differences were largely explained through the difference in system boundaries; while the other estimates only considered the EU, our estimate considered Europe. For the modified version of the 2017 STRATAS database, there was good agreement for the ethanol and FAME feedstocks. However, there was some discrepancy for HVO. The discrepancy was mainly concerning the shares of rapeseed oil, used cooking oil and animal fat.

6. JEC WTT V5 - GHG INTENSITY FACTORS (G CO2-EQ/MJFUEL)

This Chapter presents the chosen pathways and emission factors for the various fuels and energy carriers and the GHG intensity factors extracted from the JEC WTT v5 report.

6.1. WTT GHG INTENSITY FACTORS FOR EUROPEAN PRODUCED BIOFUELS

This sub-chapter provides an overview of assumed pathways and WTT GHG intensity factors for the biofuels produced in Europe.

Table 26 provides an overview of the selected pathways and associated WTT GHG intensity factors used for ethanol feedstocks.

Table 26. Assumed data for ethanol feedstocks

Ethanol feedstock	Pathway code	WTT GHG intensity factor (g CO_2-eq/MJ_{fuel})
Sugars (2017)	SBET1a (63 %); SBET1b (27 %); SCET1 (10%)	28.0
Sugars (2030)	SBET1a (27 %); SBET1b (63 %); SCET1 (10%)	22.7
Wheat (2017)	WTET1a (70 %); WTET2a (30 %); WTET4a (0 %)	63.7
Wheat (2030)	WTET1a (0 %); WTET2a (70 %); WTET4a (30 %)	52.7
Barley/Rye	BRET2a	64.9
Corn	CRET2a	57.3
Straw	STET1	17.8
Wood	WWET1a	22.8
Agricultural waste	WWET1a	22.8
Bagasse	STET1	17.8
Cellullose	SCET1	23.5
Food waste	WWET1a	22.8
Lignin from trees	WWET1a	22.8
Molasses	SCET1	23.5
Municipal solid waste	WWET1a	22.8
Rice	BRET2a	64.9
Waste beverage	WWET1a	22.8
Waste grape skin	WWET1a	22.8
Whey	WWET1a	22.8
Black liquor	WWET1a	22.8
Bracken	WWET1a	22.8

Table 27 provides an overview of the selected pathways and associated WTT GHG intensity factors used for FAME feedstocks.

Table 27. Assumed data for FAME feedstocks

FAME feedstock	Pathway code	WTT GHG intensity factor (g CO_2-eq/MJ_{fuel})
Rapeseed (2017)	ROFA1 (50 %); ROFA2 (50 %)	50.7
Rapeseed (2030)	ROFA1 (40 %); ROFA2 (50 %); ROFA3 (10%)	50.9
Soy (2017)	SYFA3a (20 %); SYFA3b (80 %)	58.2
Soy (2030)	SYFA3a (10 %); SYFA3b (90 %)	58.5
Sunflower	SOFA3	42.1
Palm (2017)	POFA3a (20 %); POFA3b (80%)	35.7
Palm (2030)	POFA3a (0 %); POFA3b (100%)	31.8
Animal fat/tallow	TOFA3a	13.8
Food waste	WOFA3a	8.3
Canola oil (2017)	ROFA1 (50 %); ROFA2 (50 %)	50.7
Canola oil (2030)	ROFA1 (40 %); ROFA2 (50 %); ROFA3 (10%)	50.9
Fish oil	TOFA3a	13.8
Jatropha oil	POFA3b	31.8
Used cooking oil	WOFA3a	8.3

Table 28 provides an overview of the selected pathways and associated WTT GHG intensity factors used for HVO feedstocks.

Table 28. Assumed data for HVO feedstocks

HVO feedstock	Pathway code	WTT GHG intensity factor (g CO_2-eq/MJ_{fuel}) (g CO_2/MJ_{fuel})
Rapeseed	ROHY1a; ROHY1b	52.3
Soya (2017)	SYHY1a (20 %); SYHY1b (80 %)	59.6
Soya (2030)	SYHY1a (10 %); SYHY1b (90 %)	59.9
Sunflower	SOHY1a	42.3
Palm (2017)	POHY3b (20%); POHY3a (80 %)	34.8
Palm (2030)	POHY3b (0%); POHY3a (100 %)	30.9
Animal fat/Tallow	TOHY1a	16.1
Used cooking oil	WOHY1a	11.1
Agricultural waste	WWSD1a	10.3
Tall oil	TOHY1a	16.1
Wood/straw	WWSD1a	10.3
e-diesel	RESD2a	0.8

Table 29 provides an overview of the selected pathways and associated WTT GHG intensity factors used for biogas feedstocks.

Table 29. Assumed data for biogas feedstocks

Biogas feedstock	Pathway code	WTT GHG intensity factor ($g\ CO_2$-eq/MJ_{fuel})
Municipal waste	OWCG1	9.5
Manure	OWCG21 (50 %); OWCG22 (50 %)	-68.6
Sludge	OWCG3	22.3
Crops	OWCG4 (50 %); OWCG5 (50 %)	23.7
Biomass (Synthetic)	WFCG2	24.4
Forest products	WFCG2	24.4

Table 30 provides the chosen WTT GHG intensity factors used for bio-kerosene and biogasoline. Note that the STRATAS database offered limited information about production of bio-kerosene and that suitable pathways were unavailable. Therefore, it was assumed that bio-kerosene has the same WTT GHG intensity factor as HVO/HEFA.

Table 30. Assumed data for bio-kerosene and biogasoline

Biofuel type	Pathway code	WTT GHG intensity factor 2017 ($g\ CO_2$-eq/MJ_{fuel})	WTT GHG intensity factor 2030 ($g\ CO_2$-eq/MJ_{fuel})
Bio-kerosene	N/A *	28.0	11.0 - 23.0 **
Biogasoline	WWSD1a	10.7	10.7

(*) Combination of advanced feedstocks and low-ILUC food-crop based as reported in STRATAS database.
(**) Considering a lower value in 2030 to show a potential lower value corresponding only to advanced biofuels/waste based feedstocks.

6.2. WTT GHG INTENSITY FACTORS FOR IMPORTS

The STRATAS database was consulted to obtain information about feedstocks used for production of biofuels in the exporting countries. Selected pathways and, as a proxy, JEC WTT v5 GHG intensity (Europe based) were chosen from the JEC WTT v5 GHG intensity list based on feedstock and depending on the availability and suitability.

6.2.1. WTT GHG intensity factors for ethanol imports

According to the STRATAS database, most of the exporting countries use sugar-based feedstocks, such as sugarcane or molasses, in their ethanol production. Smaller shares of the imports are likely to be derived from corn, forest products, sorghum, and bagasse.

Table 31 provides an overview of the assumed feedstocks, selected pathways, share of import, and WTT GHG intensity factors used for ethanol imports.

Table 31. Assumed data for ethanol imports

Assumed feedstock	Selected pathway code	Share of imports	WTT GHG intensity factor ($g\ CO_2$-eq/MJ_{fuel})
Sugarcane	SCET1	83 %	23.5
Waste residual wood	WWET1b	6.2 %	29.0
Corn	CRET2a	6.7 %	57.3
Corn	CRETus	3.8 %	55.6

Note that the list does not include a pathway for molasses and therefore, sugarcane was assumed instead.

6.2.2. WTT GHG intensity factors for FAME imports

The STRATAS database indicates that FAME feedstocks are likely either palm- or soy-based for the exporting countries. For both feedstocks, two pathway codes were used. The pathways and the shares of these were assumed to be the same as FAME produced in Europe. As for European production, linear interpolation was used to estimate the WTT factors for the years between 2017 and 2030.

Table 32 provides an overview of the assumed feedstocks, selected pathways, share of import, and WTT GHG intensity factors used for FAME.

Table 32. Assumed data for FAME imports

Assumed feedstock	Selected pathway code	Share of imports	WTT GHG intensity factor 2017 ($g\ CO_2$-eq/MJ_{fuel})	WTT GHG intensity factor 2030 ($g\ CO_2$-eq/MJ_{fuel})
Palm	POFA3a; POFA3b	63 %	35.7	31.8
Soy	SYFA3a; SYFA3b	37 %	58.2	58.5

6.3. WTT GHG INTENSITY FACTOR FOR ELECTRICITY

The 2016 EU-mix was chosen for 2016 and 2030 EU-mix chosen for 2030. Linear interpolation was used to estimate the WTT GHG intensity factor for the years between. The 2016 electricity mix consists of 19% renewables, while 2030 electricity mix consists of 25% renewables.

Table 33. Assumed data for electricity

Electricity	Pathway code	WTT GHG intensity factor ($g\ CO_2$-eq/MJ_{fuel})
Electricity – EU-mix low (2016 mix) - LV	EMEL3a	110.1
Electricity –EU-mix low (2030 mix) - LV	EMEL3b	74.5

6.4. WTT GHG INTENSITY FACTOR FOR HYDROGEN

For hydrogen, WTT emission factors were estimated based on the share of renewable sources. A share of 0% renewables was assumed from 2015 until 2022 and from 2023, the share of renewables increased linearly to 25% renewables in 2030.

Table 34. Assumed data for hydrogen

Hydrogen	Pathway code	WTT GHG intensity factor (g CO_2-eq/MJ_{fuel})
Compressed fossil hydrogen	GPCH2b	100.8
Compressed renewable hydrogen	WDEL1/CH2	9.5
Compressed hydrogen 2015 - 2022		100.8
Compressed hydrogen 2030		78.0

6.5. WTT+COMBUSTION - GHG INTENSITY FACTORS FOR FOSSIL FUELS

The GHG intensity factors for fossil fuels consists of the WTT GHG intensity factor and the combustion emission factor.

Table 35. Assumed data for fossil fuels

Fuel	Pathway code	WTT GHG intensity factor (g CO_2-eq/MJ_{fuel})	Combustion emission factor (g CO_2-eq/MJ_{fuel})	Total GHG intensity factor (g CO_2-eq/MJ_{fuel})
Gasoline	COG1	17.0	73.4	90.4
Diesel	COD1	18.9	73.2	92.1
Kerosene*	N/A			89.0
CNG	GMCG1	11.4	56.1	67.6
LPG	LRLP1	7.8	65.4	73.2
LNG	GRLG1	16.6	56.4	73.0

*Note that no suitable pathway was available for kerosene and the total emission factor was assumed to be 89 g CO_2-eq./MJ_{fuel}.

7. RES-T RESULTS

In this chapter, additional RES-T results are presented. The results from the sensitivity analyses are presented in sub-chapter 7.1. Finally, alternative results using energy use from all transport sectors (rather than only road and rail as directed by the RED II framework) in the denominator calculations are presented are presented in sub-chapter 7.2.

7.1. RES-T – SENSITIVITY ANALYSES RESULTS

The total RES-T results from the sensitivity analyses were summarized in the main report. Here, the complete results from the sensitivity analyses are provided.

7.1.1. Sensitivity 1 – EV: Higher share in passenger cars

(1) Interpretation 1

Table 36. Results in terms of energy content – Interpretation 1

Fuel or energy carrier	Unit	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport	Mtoe	2.5	10.0	10.0
Ren. electricity in rail transport	Mtoe	1.2	1.7	1.7
Ren. electricity in all other transport modes	Mtoe	0.0	0.0	0.0
Compliant biofuels	Mtoe	21.5	28.1	28.1
Advanced - Annex IX Part A	*Mtoe*	2.7	5.4	5.4
First generation - crop based	*Mtoe*	15.0	15.0	15.0
Advanced - Annex IX Part B	*Mtoe*	3.9	7.8	7.8
Other compliant biofuels	*Mtoe*	0.0	0.0	0.0
Non-compliant biofuels	Mtoe	0.0	0.0	0.0
Other renewable energies	Mtoe	0.5	0.5	0.5
Total RES-T numerator (all transport sectors)	Mtoe	25.7	40.4	40.4
Total RES-T denominator (road and rail)	Mtoe	246.3	246.3	262.7

Table 37. Results in terms of percentage shares - Interpretation 1

Fuel or energy carrier	RED II Target	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport		1.0 %	4.1 %	3.8 %
Ren. electricity in rail transport		0.5 %	0.7 %	0.7 %
Ren. electricity in all other transport modes		0.0 %	0.0 %	0.0 %
Compliant biofuels		8.7 %	11.4 %	10.7 %
Advanced - Annex IX Part A	*Min. 3.5%*	1.1 %	2.2 %	2.0 %
First generation - crop based	*Max. 7.0%*	6.1 %	6.1 %	5.7 %
Advanced - Annex IX Part B	*Max. 3.4%*	1.6 %	*3.2 %*	3.0 %
Other compliant biofuels		0.0 %	0.0 %	0.0 %
Non-compliant biofuels		0.0 %	0.0 %	0.0 %
Other renewable energies		0.2 %	0.2 %	0.2 %
Total RES-T share	Min. 14%	10.4 %	16.4 %	15.4 %

(2) Interpretation 2

Table 38. Results in terms of energy content - Interpretation 2

Fuel or energy carrier	Unit	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport	Mtoe	2.7	10.9	10.9
Ren. electricity in rail transport	Mtoe	2.9	4.4	4.4
Ren. electricity in all other transport modes	Mtoe	0.0	0.0	0.0
Compliant biofuels	Mtoe	21.5	28.1	28.1
Advanced - Annex IX Part A	*Mtoe*	2.7	5.4	5.4
First generation - crop based	*Mtoe*	15.0	15.0	15.0
Advanced - Annex IX Part B	*Mtoe*	3.9	7.8	7.8
Other compliant biofuels	*Mtoe*	0.0	0.0	0.0
Non-compliant biofuels	Mtoe	0.0	0.0	0.0
Other renewable energies	Mtoe	0.5	0.5	0.5
Total RES-T numerator (all transport sectors)	Mtoe	27.7	43.9	43.9
Total RES-T denominator (road and rail)	Mtoe	246.3	246.3	262.7

Table 39. Results in terms of percentage shares – Interpretation 2

Fuel or energy carrier	RED II Target	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport		1.1 %	4.4 %	4.2 %
Ren. electricity in rail transport		1.2 %	1.8 %	1.7 %
Ren. electricity in all other transport modes		0.0 %	0.0 %	0.0 %
Compliant biofuels		8.7 %	11.4 %	10.7 %
Advanced - Annex IX Part A	*Min. 3.5%*	1.1 %	2.2 %	2.0 %
First generation - crop based	*Max. 7.0%*	6.1 %	6.1 %	5.7 %
Advanced - Annex IX Part B	*Max. 3.4%*	1.6 %	3.2 %	3.0 %
Other compliant biofuels		0.0 %	0.0 %	0.0 %
Non-compliant biofuels		0.0 %	0.0 %	0.0 %
Other renewable energies		0.2 %	0.2 %	0.2 %
Total RES-T share	Min. 14%	11.2 %	17.8 %	16.7 %

7.1.2. Sensitivity 2 - Bio-kerosene: Higher uptake

(1) Interpretation 1

Table 40. Results in terms of energy content – Interpretation 1

Fuel or energy carrier	Unit	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport	Mtoe	2.0	7.9	7.9
Ren. electricity in rail transport	Mtoe	1.2	1.7	1.7
Ren. electricity in all other transport modes	Mtoe	0.0	0.0	0.0
Compliant biofuels	Mtoe	23.9	30.7	30.7
Advanced - Annex IX Part A	*Mtoe*	2.9	5.8	5.8
First generation - crop based	*Mtoe*	17.1	17.1	17.1
Advanced - Annex IX Part B	*Mtoe*	3.9	7.8	7.8
Other compliant biofuels	*Mtoe*	0.0	0.0	0.0
Non-compliant biofuels	Mtoe	0.0	0.0	0.0
Other renewable energies	Mtoe	0.5	0.5	0.5
Total RES-T numerator (all transport sectors)	Mtoe	27.5	40.9	40.9
Total RES-T denominator (road and rail)	Mtoe	244.9	244.9	259.6

Table 41. Results in terms of percentage shares - Interpretation 1

Fuel or energy carrier	RED II Target	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport		0.8 %	3.2 %	3.0 %
Ren. electricity in rail transport		0.5 %	0.7 %	0.7 %
Ren. electricity in other transport modes		0.0 %	0.0 %	0.0 %
Compliant biofuels		9.7 %	12.5 %	11.8 %
Advanced - Annex IX Part A	*Min. 3.5%*	1.2 %	2.4 %	2.2 %
First generation - crop based	*Max. 7.0%*	7.0 %	7.0 %	6.6 %
Advanced - Annex IX Part B	*Max. 3.4%*	1.6 %	3.2 %	3.0 %
Other compliant biofuels		0.0 %	0.0 %	0.0 %
Non-compliant biofuels		0.0 %	0.0 %	0.0 %
Other renewable energies		0.2 %	0.2 %	0.2 %
Total RES-T share	Min. 14%	11.2 %	16.7 %	15.7 %

(2) Interpretation 2

Table 42. Results in terms of energy content - Interpretation 2

Fuel or energy carrier	Unit	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport	Mtoe	2.2	8.8	8.8
Ren. electricity in rail transport	Mtoe	2.9	4.4	4.4
Ren. electricity in all other transport modes	Mtoe	0.0	0.0	0.0
Compliant biofuels	Mtoe	23.9	30.7	30.7
Advanced - Annex IX Part A	*Mtoe*	2.9	5.8	5.8
First generation - crop based	*Mtoe*	17.1	17.1	17.1
Advanced - Annex IX Part B	*Mtoe*	3.9	7.8	7.8
Other compliant biofuels	*Mtoe*	0.0	0.0	0.0
Non-compliant biofuels	Mtoe	0.0	0.0	0.0
Other renewable energies	Mtoe	0.5	0.5	0.5
Total RES-T numerator (all transport sectors)	Mtoe	29.5	44.4	44.4
Total RES-T denominator (road and rail)	Mtoe	244.9	244.9	259.6

Table 43. Results in terms of percentage shares – Interpretation 2

Fuel or energy carrier	RED II Target	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport		0.9 %	3.6 %	3.4 %
Ren. electricity in rail transport		1.2 %	1.8 %	1.7 %
Ren. electricity in other transport modes		0.0 %	0.0 %	0.0 %
Compliant biofuels		9.7 %	12.5 %	11.8 %
Advanced - Annex IX Part A	*Min. 3.5%*	1.2 %	2.4 %	2.2 %
First generation - crop based	*Max. 7.0%*	7.0 %	7.0 %	6.6 %
Advanced - Annex IX Part B	*Max. 3.4%*	1.6 %	3.2 %	3.0 %
Other compliant biofuels		0.0 %	0.0 %	0.0 %
Non-compliant biofuels		0.0 %	0.0 %	0.0 %
Other renewable energies		0.2 %	0.2 %	0.2 %
Total RES-T share	Min. 14%	12.0 %	18.1 %	17.1 %

7.1.3. Sensitivity 3 - Annex IX Part A feedstocks (HVOeq)

(1) Interpretation 1

Table 44. Results in terms of energy content – Interpretation 1

Fuel or energy carrier	Unit	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport	Mtoe	2.0	7.9	7.9
Ren. electricity in rail transport	Mtoe	1.2	1.7	1.7
Ren. electricity in all other transport modes	Mtoe	0.0	0.0	0.0
Compliant biofuels	Mtoe	23.1	31.3	31.3
Advanced - Annex IX Part A	*Mtoe*	*4.3*	*8.6*	*8.6*
First generation - crop based	*Mtoe*	*15.0*	*15.0*	*15.0*
Advanced - Annex IX Part B	*Mtoe*	*3.9*	*7.8*	*7.8*
Other compliant biofuels	*Mtoe*	*0.0*	*0.0*	*0.0*
Non-compliant biofuels	Mtoe	0.0	0.0	0.0
Other renewable energies	Mtoe	0.5	0.5	0.5
Total RES-T numerator (all transport sectors)	Mtoe	26.8	41.5	41.5
Total RES-T denominator (road and rail)	Mtoe	244.9	244.9	259.6

Table 45. Results in terms of percentage shares - Interpretation 1

Fuel or energy carrier	RED II Target	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport		0.8 %	3.2 %	3.0 %
Ren. electricity in rail transport		0.5 %	0.7 %	0.7 %
Ren. electricity in other transport modes		0.0 %	0.0 %	0.0 %
Compliant biofuels		9.4 %	12.8 %	12.1 %
Advanced - Annex IX Part A	*Min. 3.5%*	1.7 %	3.5 %	3.3 %
First generation - crop based	*Max. 7.0%*	6.1 %	6.1 %	5.8 %
Advanced - Annex IX Part B	*Max. 3.4%*	1.6 %	3.2 %	3.0 %
Other compliant biofuels		0.0 %	0.0 %	0.0 %
Non-compliant biofuels		0.0 %	0.0 %	0.0 %
Other renewable energies		0.2 %	0.2 %	0.2 %
Total RES-T share	Min. 14%	10.9 %	16.9 %	16.0 %

(2) Interpretation 2

Table 46. Results in terms of energy content - Interpretation 2

Fuel or energy carrier	Unit	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport	Mtoe	2.2	8.8	8.8
Ren. electricity in rail transport	Mtoe	2.9	4.4	4.4
Ren. electricity in all other transport modes	Mtoe	0.0	0.0	0.0
Compliant biofuels	Mtoe	23.1	31.3	31.3
Advanced - Annex IX Part A	*Mtoe*	4.3	8.6	8.6
First generation - crop based	*Mtoe*	15.0	15.0	15.0
Advanced - Annex IX Part B	*Mtoe*	3.9	7.8	7.8
Other compliant biofuels	*Mtoe*	0.0	0.0	0.0
Non-compliant biofuels	Mtoe	0.0	0.0	0.0
Other renewable energies	Mtoe	0.5	0.5	0.5
Total RES-T numerator (all transport sectors)	Mtoe	28.8	45.0	45.0
Total RES-T denominator (road and rail)	Mtoe	244.9	244.9	259.6

Table 47. Results in terms of percentage shares – Interpretation 2

Fuel or energy carrier	RED II Target	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport		0.9 %	3.6 %	3.4 %
Ren. electricity in rail transport		1.2 %	1.8 %	1.7 %
Ren. electricity in other transport modes		0.0 %	0.0 %	0.0 %
Compliant biofuels		9.4 %	12.8 %	12.1 %
Advanced - Annex IX Part A	*Min. 3.5%*	1.7 %	3.5 %	3.3 %
First generation - crop based	*Max. 7.0%*	6.1 %	6.1 %	5.8 %
Advanced - Annex IX Part B	*Max. 3.4%*	1.6 %	3.2 %	3.0 %
Other compliant biofuels		0.0 %	0.0 %	0.0 %
Non-compliant biofuels		0.0 %	0.0 %	0.0 %
Other renewable energies		0.2 %	0.2 %	0.2 %
Total RES-T share	Min. 14%	11.7 %	18.4 %	17.3 %

7.1.4. Sensitivity 4 – Biomethane: Higher uptake

(1) Interpretation 1

Table 48. Results in terms of energy content – Interpretation 1

Fuel or energy carrier	Unit	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport	Mtoe	2.0	7.9	7.9
Ren. electricity in rail transport	Mtoe	1.2	1.7	1.7
Ren. electricity in all other transport modes	Mtoe	0.0	0.0	0.0
Compliant biofuels	Mtoe	23.0	31.1	31.1
Advanced - Annex IX Part A	*Mtoe*	4.2	8.3	8.3
First generation - crop based	*Mtoe*	15.0	15.0	15.0
Advanced - Annex IX Part B	*Mtoe*	3.9	7.8	7.8
Other compliant biofuels	*Mtoe*	0.0	0.0	0.0
Non-compliant biofuels	Mtoe	0.0	0.0	0.0
Other renewable energies	Mtoe	0.5	0.5	0.5
Total RES-T numerator (all transport sectors)	Mtoe	26.7	41.2	41.2
Total RES-T denominator (road and rail)	Mtoe	244.9	244.9	261.0

Table 49. Results in terms of percentage shares - Interpretation 1

Fuel or energy carrier	RED II Target	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport		0.8 %	3.2 %	3.0 %
Ren. electricity in rail transport		0.5 %	0.7 %	0.7 %
Ren. electricity in other transport modes		0.0 %	0.0 %	0.0 %
Compliant biofuels		9.4 %	12.7 %	11.9 %
Advanced - Annex IX Part A	*Min. 3.5%*	1.7 %	3.4 %	3.2 %
First generation - crop based	*Max. 7.0%*	6.1 %	6.1 %	5.7 %
Advanced - Annex IX Part B	*Max. 3.4%*	1.6 %	*3.2 %*	3.0 %
Other compliant biofuels		0.0 %	0.0 %	0.0 %
Non-compliant biofuels		0.0 %	0.0 %	0.0 %
Other renewable energies		0.2 %	0.2 %	0.2 %
Total RES-T share	Min. 14%	10.9 %	16.8 %	15.8 %

(2) Interpretation 2

Table 50. Results in terms of energy content - Interpretation 2

Fuel or energy carrier	Unit	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport	Mtoe	2.2	8.8	8.8
Ren. electricity in rail transport	Mtoe	2.9	4.4	4.4
Ren. electricity in all other transport modes	Mtoe	0.0	0.0	0.0
Compliant biofuels	Mtoe	23.0	31.1	31.1
Advanced - Annex IX Part A	*Mtoe*	4.2	8.3	8.3
First generation - crop based	*Mtoe*	15.0	15.0	15.0
Advanced - Annex IX Part B	*Mtoe*	3.9	7.8	7.8
Other compliant biofuels	*Mtoe*	0.0	0.0	0.0
Non-compliant biofuels	Mtoe	0.0	0.0	0.0
Other renewable energies	Mtoe	0.5	0.5	0.5
Total RES-T numerator (all transport sectors)	Mtoe	28.6	44.8	44.8
Total RES-T denominator (road and rail)	Mtoe	244.9	244.9	261.0

Table 51. Results in terms of percentage shares – Interpretation 2

Fuel or energy carrier	RED II Target	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport		0.9 %	3.6 %	3.4 %
Ren. electricity in rail transport		1.2 %	1.8 %	1.7 %
Ren. electricity in other transport modes		0.0 %	0.0 %	0.0 %
Compliant biofuels		9.4 %	12.7 %	11.9 %
Advanced - Annex IX Part A	*Min. 3.5%*	1.7 %	3.4 %	3.2 %
First generation - crop based	*Max. 7.0%*	6.1 %	6.1 %	5.7 %
Advanced - Annex IX Part B	*Max. 3.4%*	1.6 %	3.2 %	3.0 %
Other compliant biofuels		0.0 %	0.0 %	0.0 %
Non-compliant biofuels		0.0 %	0.0 %	0.0 %
Other renewable energies		0.2 %	0.2 %	0.2 %
Total RES-T share	Min. 14%	11.7 %	18.3 %	17.1 %

7.1.5. Sensitivity 5 – Annex IX Part B feedstock: 1.7% administrative cap

(1) Interpretation 1

Table 52. Results in terms of energy content – Interpretation 1

Fuel or energy carrier	Unit	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport	Mtoe	2.0	7.9	7.9
Ren. electricity in rail transport	Mtoe	1.2	1.7	1.7
Ren. electricity in all other transport modes	Mtoe	0.0	0.0	0.0
Compliant biofuels	Mtoe	19.7	24.5	24.5
Advanced - Annex IX Part A	*Mtoe*	2.7	5.3	5.3
First generation - crop based	*Mtoe*	15.0	15.0	15.0
Advanced - Annex IX Part B	*Mtoe*	2.1	4.2	4.2
Other compliant biofuels	*Mtoe*	0.0	0.0	0.0
Non-compliant biofuels	Mtoe	0.0	0.0	0.0
Other renewable energies	Mtoe	0.5	0.5	0.5
Total RES-T numerator (all transport sectors)	Mtoe	23.4	34.6	34.6
Total RES-T denominator (road and rail)	Mtoe	244.9	244.9	259.6

Table 53. Results in terms of percentage shares - Interpretation 1

Fuel or energy carrier	RED II Target	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport		0.8 %	3.2 %	3.0 %
Ren. electricity in rail transport		0.5 %	0.7 %	0.7 %
Ren. electricity in other transport modes		0.0 %	0.0 %	0.0 %
Compliant biofuels		8.8 %	11.5 %	9.4 %
Advanced - Annex IX Part A	*Min. 3.5%*	1.1 %	2.2 %	2.1 %
First generation - crop based	*Max. 7%*	6.1 %	6.1 %	5.8 %
Advanced - Annex IX Part B	*Max. 1.7%*	0.8 %	1.7 %	1.6 %
Other compliant biofuels		0.0 %	0.0 %	0.0 %
Non-compliant biofuels		0.0 %	0.0 %	0.0 %
Other renewable energies		0.2 %	0.2 %	0.2 %
Total RES-T share	Min. 14%	9.5 %	14.1 %	13.3 %

(2) Interpretation 2

Table 54. Results in terms of energy content - Interpretation 2

Fuel or energy carrier	Unit	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport	Mtoe	2.2	8.8	8.8
Ren. electricity in rail transport	Mtoe	2.9	4.4	4.4
Ren. electricity in all other transport modes	Mtoe	0.0	0.0	0.0
Compliant biofuels	Mtoe	19.7	24.5	24.5
Advanced - Annex IX Part A	*Mtoe*	2.7	5.3	5.3
First generation - crop based	*Mtoe*	15.0	15.0	15.0
Advanced - Annex IX Part B	*Mtoe*	2.1	4.2	4.2
Other compliant biofuels	*Mtoe*	0.0	0.0	0.0
Non-compliant biofuels	Mtoe	0.0	0.0	0.0
Other renewable energies	Mtoe	0.5	0.5	0.5
Total RES-T numerator (all transport sectors)	Mtoe	25.3	38.1	38.1
Total RES-T denominator (road and rail)	Mtoe	244.9	244.9	259.6

Table 55. Results in terms of percentage shares – Interpretation 2

Fuel or energy carrier	RED II Target	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport		0.9 %	3.6 %	3.4 %
Ren. electricity in rail transport		1.2 %	1.8 %	1.7 %
Ren. electricity in other transport modes		0.0 %	0.0 %	0.0 %
Compliant biofuels		8.8 %	11.5 %	9.4 %
Advanced - Annex IX Part A	*Min. 3.5%*	1.1 %	2.2 %	2.1 %
First generation - crop based	*Max. 7.0%*	6.1 %	6.1 %	5.8 %
Advanced - Annex IX Part B	*Max. 3.4%*	0.8 %	1.7 %	1.6 %
Other compliant biofuels		0.0 %	0.0 %	0.0 %
Non-compliant biofuels		0.0 %	0.0 %	0.0 %
Other renewable energies		0.2 %	0.2 %	0.2 %
Total RES-T share	Min. 14%	10.3 %	15.6 %	14.7 %

7.1.6. Sensitivity 6 – Ethanol: E10 limited uptake

(1) Interpretation 1

Table 56. Results in terms of energy content – Interpretation 1

Fuel or energy carrier	Unit	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport	Mtoe	2.0	7.9	7.9
Ren. electricity in rail transport	Mtoe	1.2	1.7	1.7
Ren. electricity in all other transport modes	Mtoe	0.0	0.0	0.0
Compliant biofuels	Mtoe	21.0	27.6	27.6
Advanced - Annex IX Part A	*Mtoe*	2.6	5.3	5.3
First generation - crop based	*Mtoe*	14.5	14.5	14.5
Advanced - Annex IX Part B	*Mtoe*	3.9	7.8	7.8
Other compliant biofuels	*Mtoe*	0.0	0.0	0.0
Non-compliant biofuels	Mtoe	0.0	0.0	0.0
Other renewable energies	Mtoe	0.5	0.5	0.5
Total RES-T numerator (all transport sectors)	Mtoe	24.7	37.7	37.7
Total RES-T denominator (road and rail)	Mtoe	244.9	244.9	259.6

Table 57. Results in terms of percentage shares - Interpretation 1

Fuel or energy carrier	RED II Target	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport		0.8 %	3.2 %	3.0 %
Ren. electricity in rail transport		0.5 %	0.7 %	0.7 %
Ren. electricity in other transport modes		0.0 %	0.0 %	0.0 %
Compliant biofuels		8.6 %	11.3 %	10.6 %
Advanced - Annex IX Part A	*Min. 3.5%*	1.1 %	2.2 %	2.0 %
First generation - crop based	*Max. 7.0%*	5.9 %	5.9 %	5.6 %
Advanced - Annex IX Part B	*Max. 3.4%*	1.6 %	*3.2 %*	3.0 %
Other compliant biofuels		0.0 %	0.0 %	0.0 %
Non-compliant biofuels		0.0 %	0.0 %	0.0 %
Other renewable energies		0.2 %	0.2 %	0.2 %
Total RES-T share	Min. 14%	10.1 %	15.4 %	14.5 %

(2) Interpretation 2

Table 58. Results in terms of energy content - Interpretation 2

Fuel or energy carrier	Unit	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport	Mtoe	2.2	8.8	8.8
Ren. electricity in rail transport	Mtoe	2.9	4.4	4.4
Ren. electricity in all other transport modes	Mtoe	0.0	0.0	0.0
Compliant biofuels	Mtoe	21.0	27.6	27.6
Advanced - Annex IX Part A	*Mtoe*	2.6	5.3	5.3
First generation - crop based	*Mtoe*	14.5	14.5	14.5
Advanced - Annex IX Part B	*Mtoe*	3.9	7.8	7.8
Other compliant biofuels	*Mtoe*	0.0	0.0	0.0
Non-compliant biofuels	Mtoe	0.0	0.0	0.0
Other renewable energies	Mtoe	0.5	0.5	0.5
Total RES-T numerator (all transport sectors)	Mtoe	26.7	41.3	41.3
Total RES-T denominator (road and rail)	Mtoe	244.9	244.9	259.6

Table 59. Results in terms of percentage shares – Interpretation 2

Fuel or energy carrier	RED II Target	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport		0.9 %	3.6 %	3.4 %
Ren. electricity in rail transport		1.2 %	1.8 %	1.7 %
Ren. electricity in other transport modes		0.0 %	0.0 %	0.0 %
Compliant biofuels		8.6 %	11.3 %	10.6 %
Advanced - Annex IX Part A	*Min. 3.5%*	1.1 %	2.2 %	2.0 %
First generation - crop based	*Max. 7.0%*	5.9 %	5.9 %	5.6 %
Advanced - Annex IX Part B	*Max. 3.4%*	1.6 %	3.2 %	3.0 %
Other compliant biofuels		0.0 %	0.0 %	0.0 %
Non-compliant biofuels		0.0 %	0.0 %	0.0 %
Other renewable energies		0.2 %	0.2 %	0.2 %
Total RES-T share	Min. 14%	10.9 %	16.9 %	15.9 %

7.1.7. Sensitivity 7 – Ethanol: Theoretical only E5 grade

(1) Interpretation 1

Table 60. Results in terms of energy content – Interpretation 1

Fuel or energy carrier	Unit	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport	Mtoe	2.0	7.9	7.9
Ren. electricity in rail transport	Mtoe	1.2	1.7	1.7
Ren. electricity in all other transport modes	Mtoe	0.0	0.0	0.0
Compliant biofuels	Mtoe	19.4	25.8	25.8
Advanced - Annex IX Part A	*Mtoe*	2.5	5.1	5.1
First generation - crop based	*Mtoe*	13.0	13.0	13.0
Advanced - Annex IX Part B	*Mtoe*	3.9	7.8	7.8
Other compliant biofuels	*Mtoe*	0.0	0.0	0.0
Non-compliant biofuels	Mtoe	0.0	0.0	0.0
Other renewable energies	Mtoe	0.5	0.5	0.5
Total RES-T numerator (all transport sectors)	Mtoe	23.0	36.0	36.0
Total RES-T denominator (road and rail)	Mtoe	245.7	245.7	260.3

Table 61. Results in terms of percentage shares - Interpretation 1

Fuel or energy carrier	RED II Target	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport		0.8 %	3.2 %	3.0 %
Ren. electricity in rail transport		0.5 %	0.7 %	0.7 %
Ren. electricity in other transport modes		0.0 %	0.0 %	0.0 %
Compliant biofuels		7.9 %	10.5 %	9.9 %
Advanced - Annex IX Part A	*Min. 3.5%*	1.0 %	2.1 %	2.0 %
First generation - crop based	*Max. 7.0%*	5.3 %	5.3 %	5.0 %
Advanced - Annex IX Part B	*Max. 3.4%*	1.6 %	*3.2 %*	3.0 %
Other compliant biofuels		0.0 %	0.0 %	0.0 %
Non-compliant biofuels		0.0 %	0.0 %	0.0 %
Other renewable energies		0.2 %	0.2 %	0.2 %
Total RES-T share	Min. 14%	9.4 %	14.6 %	13.8 %

(2) Interpretation 2

Table 62. Results in terms of energy content - Interpretation 2

Fuel or energy carrier	Unit	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport	Mtoe	2.2	8.8	8.8
Ren. electricity in rail transport	Mtoe	2.9	4.4	4.4
Ren. electricity in all other transport modes	Mtoe	0.0	0.0	0.0
Compliant biofuels	Mtoe	19.4	25.8	25.8
Advanced - Annex IX Part A	*Mtoe*	2.5	5.1	5.1
First generation - crop based	*Mtoe*	13.0	13.0	13.0
Advanced - Annex IX Part B	*Mtoe*	3.9	7.8	7.8
Other compliant biofuels	*Mtoe*	0.0	0.0	0.0
Non-compliant biofuels	Mtoe	0.0	0.0	0.0
Other renewable energies	Mtoe	0.5	0.5	0.5
Total RES-T numerator (all transport sectors)	Mtoe	25.0	39.5	39.5
Total RES-T denominator (road and rail)	Mtoe	245.7	245.7	260.3

Table 63. Results in terms of percentage shares – Interpretation 2

Fuel or energy carrier	RED II Target	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport		0.9 %	3.6 %	3.4 %
Ren. electricity in rail transport		1.2 %	1.8 %	1.7 %
Ren. electricity in other transport modes		0.0 %	0.0 %	0.0 %
Compliant biofuels		7.9 %	10.5 %	9.9 %
Advanced - Annex IX Part A	*Min. 3.5%*	1.0 %	2.1 %	2.0 %
First generation - crop based	*Max. 7.0%*	5.3 %	5.3 %	5.0 %
Advanced - Annex IX Part B	*Max. 3.4%*	1.6 %	3.2 %	3.0 %
Other compliant biofuels		0.0 %	0.0 %	0.0 %
Non-compliant biofuels		0.0 %	0.0 %	0.0 %
Other renewable energies		0.2 %	0.2 %	0.2 %
Total RES-T share	Min. 14%	10.2 %	16.1 %	15.2 %

7.1.8. Sensitivity 8 – Liquid biofuels in other modes

(1) Interpretation 1

Table 64. Results in terms of energy content – Interpretation 1

Fuel or energy carrier	Unit	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport	Mtoe	2.0	7.9	7.9
Ren. electricity in rail transport	Mtoe	1.2	1.7	1.7
Ren. electricity in all other transport modes	Mtoe	0.0	0.0	0.0
Compliant biofuels	Mtoe	22.3	29.1	29.1
Advanced - Annex IX Part A	*Mtoe*	2.7	5.3	5.3
First generation - crop based	*Mtoe*	15.6	15.6	15.6
Advanced - Annex IX Part B	*Mtoe*	4.0	8.1	8.1
Other compliant biofuels	*Mtoe*	0.0	0.0	0.0
Non-compliant biofuels	Mtoe	0.0	0.0	0.0
Other renewable energies	Mtoe	0.5	0.5	0.5
Total RES-T numerator (all transport sectors)	Mtoe	26.0	39.2	39.2
Total RES-T denominator (road and rail)	Mtoe	244.9	244.9	259.6

Table 65. Results in terms of percentage shares - Interpretation 1

Fuel or energy carrier	RED II Target	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport		0.8 %	3.2 %	3.0 %
Ren. electricity in rail transport		0.5 %	0.7 %	0.7 %
Ren. electricity in other transport modes		0.0 %	0.0 %	0.0 %
Compliant biofuels		9.1 %	11.9 %	11.2 %
Advanced - Annex IX Part A	*Min. 3.5%*	1.1 %	2.2 %	2.1 %
First generation - crop based	*Max. 7.0%*	6.4 %	6.4 %	6.0 %
Advanced - Annex IX Part B	*Max. 3.4%*	1.6 %	3.3 %	3.1 %
Other compliant biofuels		0.0 %	0.0 %	0.0 %
Non-compliant biofuels		0.0 %	0.0 %	0.0 %
Other renewable energies		0.2 %	0.2 %	0.2 %
Total RES-T share	Min. 14%	10.6 %	16.0 %	15.1 %

(2) Interpretation 2

Table 66. Results in terms of energy content - Interpretation 2

Fuel or energy carrier	Unit	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport	Mtoe	2.2	8.8	8.8
Ren. electricity in rail transport	Mtoe	2.9	4.4	4.4
Ren. electricity in all other transport modes	Mtoe	0.0	0.0	0.0
Compliant biofuels	Mtoe	22.3	29.1	29.1
Advanced - Annex IX Part A	*Mtoe*	2.7	5.3	5.3
First generation - crop based	*Mtoe*	15.6	15.6	15.6
Advanced - Annex IX Part B	*Mtoe*	4.0	8.1	8.1
Other compliant biofuels	*Mtoe*	0.0	0.0	0.0
Non-compliant biofuels	Mtoe	0.0	0.0	0.0
Other renewable energies	Mtoe	0.5	0.5	0.5
Total RES-T numerator (all transport sectors)	Mtoe	27.9	42.8	42.8
Total RES-T denominator (road and rail)	Mtoe	244.9	244.9	259.6

Table 67. Results in terms of percentage shares – Interpretation 2

Fuel or energy carrier	RED II Target	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport		0.9 %	3.6 %	3.4 %
Ren. electricity in rail transport		1.2 %	1.8 %	1.7 %
Ren. electricity in other transport modes		0.0 %	0.0 %	0.0 %
Compliant biofuels		9.1 %	11.9 %	11.2 %
Advanced - Annex IX Part A	*Min. 3.5%*	1.1 %	2.2 %	2.1 %
First generation - crop based	*Max. 7.0%*	6.4 %	6.4 %	6.0 %
Advanced - Annex IX Part B	*Max. 3.4%*	1.6 %	3.3 %	3.1 %
Other compliant biofuels		0.0 %	0.0 %	0.0 %
Non-compliant biofuels		0.0 %	0.0 %	0.0 %
Other renewable energies		0.2 %	0.2 %	0.2 %
Total RES-T share	Min. 14%	11.4 %	17.5 %	16.5 %

7.1.9. Sensitivity 9 – Dual-fuel LNG trucks

(1) Interpretation 1

Table 68. Results in terms of energy content – Interpretation 1

Fuel or energy carrier	Unit	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport	Mtoe	2.0	7.9	7.9
Ren. electricity in rail transport	Mtoe	1.2	1.7	1.7
Ren. electricity in all other transport modes	Mtoe	0.0	0.0	0.0
Compliant biofuels	Mtoe	21.4	27.8	27.8
Advanced - Annex IX Part A	*Mtoe*	2.5	5.1	5.1
First generation - crop based	*Mtoe*	15.0	15.0	15.0
Advanced - Annex IX Part B	*Mtoe*	3.9	7.8	7.8
Other compliant biofuels	*Mtoe*	0.0	0.0	0.0
Non-compliant biofuels	Mtoe	0.0	0.0	0.0
Other renewable energies	Mtoe	0.5	0.5	0.5
Total RES-T numerator (all transport sectors)	Mtoe	25.0	38.0	38.0
Total RES-T denominator (road and rail)	Mtoe	244.5	244.5	259.1

Table 69. Results in terms of percentage shares - Interpretation 1

Fuel or energy carrier	RED II Target	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport		0.8 %	3.2 %	3.0 %
Ren. electricity in rail transport		0.5 %	0.7 %	0.7 %
Ren. electricity in other transport modes		0.0 %	0.0 %	0.0 %
Compliant biofuels		8.7 %	11.4 %	10.7 %
Advanced - Annex IX Part A	*Min. 3.5%*	1.0 %	2.1 %	2.0 %
First generation - crop based	*Max. 7.0%*	6.1 %	6.1 %	5.8 %
Advanced - Annex IX Part B	*Max. 3.4%*	1.6 %	3.2 %	3.0 %
Other compliant biofuels		0.0 %	0.0 %	0.0 %
Non-compliant biofuels		0.0 %	0.0 %	0.0 %
Other renewable energies		0.2 %	0.2 %	0.2 %
Total RES-T share	Min. 14%	10.2 %	15.5 %	14.7 %

(2) Interpretation 2

Table 70. Results in terms of energy content - Interpretation 2

Fuel or energy carrier	Unit	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport	Mtoe	2.2	8.8	8.8
Ren. electricity in rail transport	Mtoe	2.9	4.4	4.4
Ren. electricity in all other transport modes	Mtoe	0.0	0.0	0.0
Compliant biofuels	Mtoe	21.4	27.8	27.8
Advanced - Annex IX Part A	*Mtoe*	2.5	5.1	5.1
First generation - crop based	*Mtoe*	15.0	15.0	15.0
Advanced - Annex IX Part B	*Mtoe*	3.9	7.8	7.8
Other compliant biofuels	*Mtoe*	0.0	0.0	0.0
Non-compliant biofuels	Mtoe	0.0	0.0	0.0
Other renewable energies	Mtoe	0.5	0.5	0.5
Total RES-T numerator (all transport sectors)	Mtoe	27.0	41.5	41.5
Total RES-T denominator (road and rail)	Mtoe	244.5	244.5	259.1

Table 71. Results in terms of percentage shares – Interpretation 2

Fuel or energy carrier	RED II Target	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport		0.9 %	3.6 %	3.4 %
Ren. electricity in rail transport		1.2 %	1.8 %	1.7 %
Ren. electricity in other transport modes		0.0 %	0.0 %	0.0 %
Compliant biofuels		8.7 %	11.4 %	10.7 %
Advanced - Annex IX Part A	*Min. 3.5%*	1.0 %	2.1 %	2.0 %
First generation - crop based	*Max. 7.0%*	6.1 %	6.1 %	5.8 %
Advanced - Annex IX Part B	*Max. 3.4%*	1.6 %	3.2 %	3.0 %
Other compliant biofuels		0.0 %	0.0 %	0.0 %
Non-compliant biofuels		0.0 %	0.0 %	0.0 %
Other renewable energies		0.2 %	0.2 %	0.2 %
Total RES-T share	Min. 14%	11.1 %	17.0 %	16.0 %

7.2. RES-T FOR THE ENTIRE TRANSPORT SECTOR

Alternative to the RED II framework that considers only road and rail in the denominator, the RES-T calculation and results presented here considers *all transport sectors* in the denominator.

7.2.1. RES-T calculation – the entire transport sector

In RED II, the targeted share for RES-T has been set to at least 14% by 2030. As an alternative approach to the RED II framework, here *all transport sectors* are considered in both the numerator and denominator.

For the calculation of the denominator, the energy content of gasoline, diesel, natural gas, biofuels, biogas, renewable liquid and gaseous transport fuels of non-biological origin, recycled carbon fuels and electricity supplied to *all transport sectors* are considered (rather than only road and rail). Note that in line with the calculation rules, LPG is not included in the calculation. For the calculation of the numerator, the energy content from all renewable sources supplied to all transport sectors shall be considered. The RES-T equation below shows the calculation approach mathematically.

The numerator is calculated as follows:

$$Numerator\ RES - T_{all\ transport\ sectors} = E_{REN,road} + E_{REN,rail} + E_{REN,off-road} + E_{REN,aviation} + E_{REN,inland\ maritime}$$

And the denominator is calculated as follows:

$$Denominator\ RES-T_{all\ transport\ sectors} = E_{total,road} + E_{total,rail} + E_{total,off-road} + E_{total,aviation} + E_{total,inland\ maritime}$$

The total RES-T for *all transport sector* thus equals:

$$RES-T_{all\ transport\ sectors} = \frac{Numerator\ RES-T_{all\ transport\ sectors}}{Denominator\ RES-T_{all\ transport\ sectors}}$$

7.2.2. RES-T result - the entire transport sector

(1) Interpretation 1

Table 72. Results in terms of energy content - Interpretation 1

Fuel or energy carrier	Unit	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport	Mtoe	2.0	7.9	7.9
Ren. electricity in rail transport	Mtoe	1.2	1.7	1.7
Ren. electricity in all other transport modes	Mtoe	0.0	0.0	0.0
Compliant biofuels	Mtoe	21.5	28.1	28.1
Advanced - Annex IX Part A	*Mtoe*	*2.7*	*5.3*	*5.3*
First generation - crop based	*Mtoe*	*15.0*	*15.0*	*15.0*
Advanced - Annex IX Part B	*Mtoe*	*3.9*	*7.8*	*7.8*
Other compliant biofuels	*Mtoe*	*0.0*	*0.0*	*0.0*
Non-compliant biofuels	Mtoe	0.0	0.0	0.0
Other renewable energies	Mtoe	0.5	0.5	0.5
Total RES-T numerator (all transport sectors)	Mtoe	25.2	38.2	38.2
Total RES-T denominator (all transport sectors)	Mtoe	315.9	315.9	330.9

Table 73. Results in terms of percentage shares – Interpretation 1

Fuel or energy carrier	RED II Target	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport		0.6 %	2.5 %	2.4 %
Ren. electricity in rail transport		0.4 %	0.6 %	0.5 %
Ren. electricity in other transport modes		0.0 %	0.0 %	0.0 %
Compliant biofuels		6.8 %	8.9 %	8.5 %
Advanced - Annex IX Part A	*Min. 3.5%*	0.8 %	1.7 %	1.6 %
First generation - crop based	*Max. 7.0%*	4.7 %	4.7 %	4.5 %
Advanced - Annex IX Part B	*Max. 3.4%*	1.2 %	2.5 %	2.3 %
Other compliant biofuels		0.0 %	0.0 %	0.0 %
Non-compliant biofuels		0.0 %	0.0 %	0.0 %
Other renewable energies		0.2 %	0.2 %	0.2 %
Total RES-T share	Min. 14%	8.0 %	12.1 %	11.6 %

(2) Interpretation 2

Table 74. Results in terms of energy content – Interpretation 2

Fuel or energy carrier	Unit	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport	Mtoe	2.2	8.8	8.8
Ren. electricity in rail transport	Mtoe	2.9	4.4	4.4
Ren. electricity in all other transport modes	Mtoe	0.0	0.0	0.0
Compliant biofuels	Mtoe	21.5	28.1	28.1
Advanced - Annex IX Part A	*Mtoe*	*2.7*	*5.3*	*5.3*
First generation - crop based	*Mtoe*	*15.0*	*15.0*	*15.0*
Advanced - Annex IX Part B	*Mtoe*	*3.9*	*7.8*	*7.8*
Other compliant biofuels	*Mtoe*	*0.0*	*0.0*	*0.0*
Non-compliant biofuels	Mtoe	0.0	0.0	0.0
Other renewable energies	Mtoe	0.5	0.5	0.5
Total RES-T numerator (all transport sectors)	Mtoe	27.1	41.8	41.8
Total RES-T denominator (all transport sectors)	Mtoe	315.9	315.9	330.9

Table 75. Results in terms of percentage shares - Interpretation 2

Fuel or energy carrier	RED II Target	Without multiplicators	With multiplicators in numerator	With multiplicators in numerator and denominator
Ren. electricity in road transport		0.7 %	2.8 %	2.7 %
Ren. electricity in rail transport		0.9 %	1.4 %	1.3 %
Ren. electricity in other transport modes		0.0 %	0.0 %	0.0 %
Compliant biofuels		6.8 %	8.9 %	8.5 %
Advanced - Annex IX Part A	*Min. 3.5%*	0.8 %	1.7 %	1.6 %
First generation - crop based	*Max. 7.0%*	4.7 %	4.7 %	4.5 %
Advanced - Annex IX Part B	*Max. 3.4%*	1.2 %	2.5 %	2.3 %
Other compliant biofuels		0.0 %	0.0 %	0.0 %
Non-compliant biofuels		0.0 %	0.0 %	0.0 %
Other renewable energies		0.2 %	0.2 %	0.2 %
Total RES-T share	Min. 14%	8.6 %	13.2 %	12.6 %

8. GLOSSARY

The main report as well as this appendix use a list of acronyms for various fuels. This Chapter presents a brief overview of the acronyms used in the report and appendix.

BEV	Battery Electric Vehicle
B7	Fuel with max 7% (volume) blending of FAME into diesel
CCS	Carbon Capture and Storage
CNG	Compressed Natural Gas
CO_2-eq	Carbon dioxide equivalent
Den. (w)	Denominator value with multiplicator values
Den. (w/o)	Denominator value without multiplicator values
DME	Dimethyl Ether
E10	Fuel with 10% (volume) blending of ethanol into gasoline
E20	Fuel with 20% (volume) blending of ethanol into gasoline
E5	Fuel with 5% (volume) blending of ethanol into gasoline
E85	Fuel with max 85% (volume) blending of ethanol into gasoline
EBB	European Biodiesel Board
ED95	95% ethanol fuel
e-diesel	Synthetic diesel fuel made from carbon dioxide, water, and electricity
ePURE	European renewable ethanol
$E_{sector,fuel}$	Total use of fuels and energy carriers from all sectors per sector
$E_{fuel,sector}$	Total use of fuels and energy carriers from all sectors per fuel
$E_{res,sector}$	Total use of renewable energy source in sector
$E_{Fossil,sector}$	Total use of fossil energy in sector
EF_{fuel}	Emission factor of a given fuel or energy carrier
ETBE	Ethyl Tertiary Butyl Ether
EU27+3	EU27 plus United Kingdom, Switzerland, and Norway
EU28	EU27 and United Kingdom
EV	Electric Vehicle (BEV+PHEV)
FAME	Fatty Acid Methyl Ester
FCEV	Fuel Cell Electric Vehicle
FFV	Flex-Fuel vehicle
FQD	The Fuel Quality Directive
FT	Fischer-Tropsch
GHG	Greenhouse gas
H2 - fossil	Hydrogen from fossil sources
H2 - renewable	Hydrogen from renewable sources

HDV	Heavy-Duty Vehicle
HEFA	Hydro-processed esters and fatty acids
HEV	Hybrid Electric Vehicle
HFO	Heavy Fuel Oil
HSFO	High Sulphur Fuel Oil
HVO	Hydrotreated Vegetable Oil
IMO	International Maritime Organization
JEC	Joint Research Center, EUCAR, CONCAWE
ktoe	kilo tonnes oil equivalent
LCV	Light Commercial Vehicle
LDV	Light-Duty Vehicle
LNG	Liquified natural gas
LPG	Liquefied petroleum gas
MGO	Marine Gas Oil
MTBE	Methyl Tertiary Butyl Ether (MTBE)
Mtoe	Million tonnes oil equivalent
NEDC	New European Driving Cycle
PC	Passenger Car
PHEV	Plug-in Hybrid Electric Vehicle
RED-II	The Renewable Energy Directive II
RES	Renewable Energy Source
RES-T	Renewable Energy in Transport
SAF	Sustainable Aviation Fuel
SNG	Synthetic Natural Gas
TTW	Tank-to-Wheel
UCO	Used Cooking oil
WLTP	Worldwide Harmonised Light Vehicle Test Procedure
WTT	Well-to-Tank
WTW	Well-to-Wheel

9. BIBLIOGRAPHY

ACEA. (2018). *ACEA Statistics*. Retrieved from https://www.acea.be/statistics

Deloitte. (2020). Retrieved from Electric vehicles: Setting a course for 2030: https://www2.deloitte.com/content/dam/Deloitte/at/Documents/presse/at-report-electric-vehicles-2020.pdf

EC. (2017). *JRC-IDEES: Integrated Database of the European Energy Sector*. Retrieved from https://ec.europa.eu/jrc/en/publication/jrc-idees-integrated-database-european-energy-sector-methodological-note

EC. (2018). *EU 2050 Long-term Strategy*. Retrieved from https://ec.europa.eu/clima/policies/strategies/2050_en

European Biodiesel Board. (2019). Presentation.

European renewable ethanol. (2018). *European renewable ethanol - key figures 2017*.

Eurostat. (2017). *Eurostat Statistics*. Retrieved from https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Road_transport_by_load_capacity,_2016_(million_tonne-kilometres).png

Flach, B., Lieberz, S., & Bolla, S. (2018). *EU Biofuels Annual 2018*. USDA Foreign Agriculture Service. Retrieved from https://www.fas.usda.gov/data/eu-28-biofuels-annual-0

Flach, B., Lieberz, S., & Bolla, S. (2019). *EU Biofuels Annual 2019*. USDA Foreign Agricultural Service. Retrieved from https://www.fas.usda.gov/data/eu-28-biofuels-annual-1

ICCT. (2017). *ICCT Pocketbook*. Retrieved from https://www.theicct.org/sites/default/files/publications/ICCT_Pocketbook_2016.pdf

IEA. (2017). *The Future of Trucks*. Retrieved from https://www.iea.org/reports/the-future-of-trucks

IEA. (2020). *Global EV Outlook 2020. Entering the decade of electric drive?* Paris: International Energy Agency.

ITF. (2017). *ITF Transport Outlook*. Retrieved from https://www.oecd.org/about/publishing/itf-transport-outlook-2017-9789282108000-en.htm

NGVA. (2018). *Statistics Report 2017*. Retrieved from NGVA Europe | Statistical Report 2017 - NGVA Europe

Roland Berger. (2016). *Integrated Fuels and Vehicles Roadmap to 2030+*. Munich, Germany: Roland Berger GmbH.

Concawe
Environmental Science
for European Refining

Concawe
Boulevard du Souverain 165
B-1160 Brussels
Belgium

Tel: +32-2-566 91 60
Fax: +32-2-566 91 81
e-mail: info@concawe.org
http://www.concawe.eu

ISBN 978-2-87567-139-4