Policy scenarios for transport under the 2030 Energy and Climate framework

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Contents

List of Figures

List of Tables

List of Acronyms

1G biofuel	First generation biofuel (produced from conventional food crops or waste oils and animal fats)
2G biofuel	Second generation biofuel (produced from waste streams such as municipal solid waste, manure, residues, lignocellulosic energy crops, microbial oils and microalgae)
EUETS	EU emissions trading scheme
EV	Electric Vehicle
FAME	Fatty Acid Methyl Ester (conventional biodiesel)
FQD	Fuel Quality Directive (refers specifically to Directive 2009/30/EC of the European Parliament and of the Council 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)
GHG	Greenhouse Gas
H_2	Hydrogen
HVO	Hydrotreated Vegetable Oil
MS	Member State
NGV	Natural Gas Vehicle
OEM	Original equipment manufacturer
RED	Renewable Energy Directive (refers specifically to 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)
TTW	Tank-to-wheel
UER	Upstream emission reduction
WTW	Well-to-wheel
ZEV	Zero emissions vehicle

Executive Summary

European transport decarbonisation policy in the period from 2020 to 2030 is still under discussion, and has been the subject of much debate. This report explores what different possible transport policy scenarios could achieve in terms of their contribution to policy goals, such as greenhouse gas (GHG) savings and renewable energy penetration.

This study undertook detailed modelling of the impacts of different types of target, (GHG targets, renewables targets, advanced (referred to as second generation, or 2G here) biofuels targets, or no EU-wide targets), on expected GHG savings, renewables contribution and the cost of carbon savings for biofuels. It also qualitatively assessed the expected environmental impact of alternative or complementary policy approaches, such as inclusion of transport in the EU Emissions Trading Scheme and changing car CO_2 standards from a tank-to-wheel (tailpipe) basis to a well-to-wheel basis.

Several key conclusions are made about how effectively different transport policies can contribute to policy goals:

- Renewable energy or greenhouse gas targets for transport are the only options considered that allow transport to contribute significantly towards 2030 energy and climate goals
- The absence of EU-level targets would lead to declining biofuels volumes, and a lack of investment in 2G biofuels
- Either a GHG or energy based-target, together with an 2G biofuel sub-target, could be an effective approach - the level at which the target is set, and the success of implementation of each is what would create any difference between the two. Biofuels make a contribution of around 11% to EU transport energy in 2030 in scenarios with targets modelled here.
- Blending limits are the main factor that could limit ethanol use. Continued roll out of E10 and introduction of E20 would require other actions alongside EU biofuels targets

1 Introduction

The purpose of this study is to explore how effectively different transport policies can contribute to policy goals and the role that biofuels (1G and 2G[1]) could play in different policy scenarios. To do this, E4tech set out a range of policy options for transport, and assessed their advantages and disadvantages through modelling or research.

Modelled options:

A. No specific framework for transport at EU level post-2020

B. Transport fuel GHG target in 2030 with 2G biofuels sub target

C. Renewable energy in transport target in 2030 with 2G biofuels sub target

Non-modelled options:

D. Inclusion of transport in the ETS

E. A well-to-wheel approach to car CO_2 standards

For each option A-E, we have set out the advantages and disadvantages from the point of view of a policymaker, in terms of:

- Likely impact on the fuel mix
- Likely GHG savings
- Cost effectiveness, based on consideration of the costs of GHG saving
- Risks to success of the policy in terms of: likelihood of it being achieved, political acceptability
- Effectiveness of the policy in enabling longer term GHG savings

[1] 1G biofuels are typically those made from food crops but also include those using waste vegetable oils or animal fats. 2G biofuels are those made from non-food crops and specifically listed in Annex IX-A to the amendment of the RED. See: Directive 2015/1513 OJ L 239 15.09.2015, p. 0001 (http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L:2015:239:TOC)

2 Modelled Scenarios

2.1 Methodology

2.1.1 Introduction to the model

All scenario modelling is based on E4tech's EU Auto-Fuel model, developed in 2013 to inform the development of a harmonised auto-fuel biofuel roadmap for the EU to 2030 (E4tech, 2013). This combines a biofuel supply potential model and a vehicle fleet model to estimate the biofuel uptake potential in the EU market. The model has been updated with additional functionality to reflect new and potential policies (e.g. crop cap, GHG targets, etc.).

The biofuel supply potential model has the following characteristics:

- The biofuel supply potential to the EU in 2020 and 2030 is based on 1G and 2G biofuels[2], taking into consideration a range of factors that affect availability and mix, including Renewable Energy Directive (RED) GHG thresholds and broader environmental constraints.
    - 1G biofuels availability is determined by crop expansion rates (taking into consideration environmental constraints), achievable yield increases, food/feed demand, GHG savings, and competition for biofuels from different markets.
    - 2G biofuels availability is determined by the plant build rate in the period to 2030 and the competition for biofuels from different markets.
- The model calculates biofuel production costs, to establish a cost merit order (although a cost of carbon saving merit order option has been added). Import duties are included.
- The supply potential is influenced by five key parameters that can be varied in the supply model: 2G build rate, 1G feedstock yields, competing demands, environmental constraints and export capacity to Europe

The biofuel uptake potential model has the following characteristics:

- The vehicle fleet model projects the evolution of the fleet (passenger cars, light duty vehicles and heavy duty vehicles) to 2030, the associated road transport energy demand, the maximum biofuel uptake capacity based on blend walls of different vehicle types, and a typical biofuel uptake potential considering biofuel availability at forecourts and predicted consumer behaviour
- The focus of the model is on liquid fuels, but electric and gaseous vehicles uptake are also modelled.
- The key factors influencing the total energy demand and biofuel uptake potential are changes in transport activity, sales rates of alternative fuel vehicles, new vehicle efficiency targets and the introduction date of higher biofuel blends.
    - The underlying transport activity is based on Primes-Tremove 2012[3] Scenario 0 for freight and the IEA ETP 4 Degree Scenario (IEA, 2012a) for passenger transport. These

[2]1G biofuels are produced from conventional crops or waste oils and fats. 2G biofuels are produced from waste streams such as MSW, residues, or lignocellulosic materials, energy crops, microbial oils and macroalgae. Note that all biogas in the model is assumed to be 2G.

[3] Primes-Tremove 2012, taken from the commission staff working document impact assessment SWD(2012) 213 final Part II.

growth rates align well with historic trends and show lower growth rates going forward, consistent with expected demographic changes.

- The central scenario from the EU Auto-Fuel study uptake model is used (Scenario C)
- The projection of EV penetration assumes 50% of the IEA Blue Map sales targets, based on industry consultation in the EU Auto-Fuel Roadmap study (IEA, 2010).
- TTW emission factors for fossil fuels are from the European Commission's October 2014 proposal (EC, 2014), and for electricity with the IEA data and projections from the EC Impact Assessment (EC, 2011; IEA, 2012).
- The following efficiency targets are used for new vehicle sales: 98gCO_2/km for PC in 2020, 67gCO_2/km in 2030[4], 147gCO_2/km for LDV in 2020, 117gCO_2/km in 2030, 662gCO_2/km for HDV in 2020 and 585gCO_2/km in 2030 (E4tech, 2013a). We account for the emission difference between test and real driving. This discrepancy is not fixed across the fleet and increases with increasing test efficiency. In 2020 the discrepancy of new PCs is 34% (EC, 2012) and the assumed discrepancy of the PC fleet in 2030 is 44%.

The vehicle fleet model gives a declining demand for fossil fuels to 2030, due to vehicle efficiency improvements. In particular, the demand for gasoline type fuels nearly halves (Figure 1).

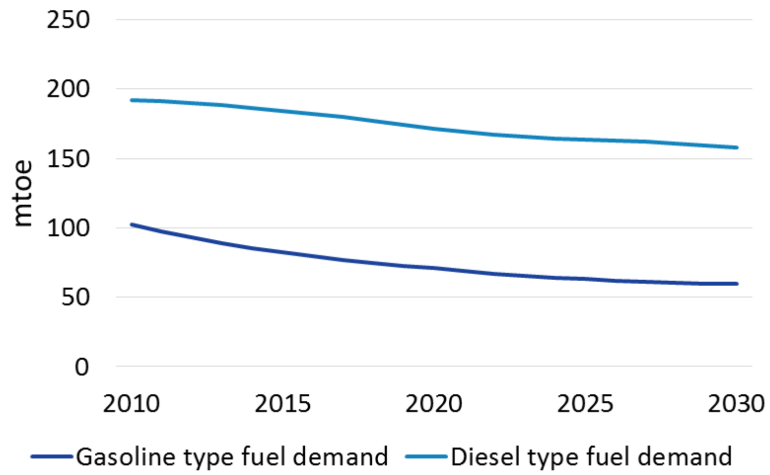

Figure 1: Gasoline and diesel type fuel demand to 2030 in road transport, as estimated by the Autofuel model

2.1.2 Timing of E20 introduction

This project has used different assumptions about the timeline for introduction of a 20% by volume blend of ethanol (E20) compared with the Autofuel study, to reflect the discussions since then on development of an E20 standard, and to show the impact of the timing of introduction on the results.

Different scenarios in our modelling take different views on the introduction of E20. E20 roll out depends on the availability of vehicles that can use E20, both tolerant vehicles (those that were not designed to use E20 but can do so) and homologated (those that were designed to use E20).[5] Any roll

[4] PC emission values are higher than in the reference as the 95gCO2/km target was postponed to 2021

[5] Note that it should not be inferred that cars that are not specifically identified as homologated or tolerant would be at severe risk of damage if they fuelled with gasoline containing ethanol at this blend level.

out relies on an E20 fuel standard, where development has been slower than expected, as shown in Table 1.

Table 1: Timeline for E20 introduction

Year	Autofuel assumption	No E20 in 2030	Early introduction in 2023
2013	Standard development		
2014			
2015			
2016	Homologated vehicle development	Horizon 2020 project on E20	Horizon 2020 project on E20
2017			
2018	Homologated vehicle sales start	Standard development (fastest)	Standard development (fastest)
2019			
2020		Homologated vehicle development	Homologated vehicle development
2021			
2022		Homologated vehicle sales start	Homologated vehicle sales start
2023			E20 roll out begins
2024			
2025	Roll out as standard grade		
2026			
2027			
2028			
2029			
2030			

In the no E20 in 2030 scenario, E20 is not rolled out by 2030. This could happen if roll out relied on penetration of homologated vehicles, rather than use in tolerant vehicles also being widespread, or if there were weak incentives for fuel suppliers to offer E20. In the Early introduction scenario, there is roll out from 2023. Using our model, we estimate that by 2023, more than 50% of passenger cars could be E20 tolerant, although only 4% would be E20 homologated (see Figure 2). If car companies were given incentives to identify vehicles that were E20 tolerant to give drivers confidence in fuelling with E20, roll out could begin at some fuelling stations in 2023, when around 50% of vehicles could be tolerant. Even though there would be very few homologated vehicles in 2023, an ambitious strategy could be envisaged in which policy was strong enough to incentivise some fuelling stations to start selling E20 at this date (e.g. at supermarkets which do not sell premium blends, or in countries where refuelling stations have more than two pumps). This would then be followed by a full roll out with all those fuelling stations that were going to introduce E20 doing so by 2030. However, in 2030, it is assumed 18% of forecourts would choose not to sell E20 and 20% of customers would choose not to fuel with it. Furthermore, 20% of vehicles would still not be E20 tolerant. Therefore, there would be further uptake of E20 post-2030 if these acceptance levels were to improve and as the number of E20 compatible vehicles increases beyond 80%.

For context, note that we assume E10 is introduced to the pumps in 2009, with full introduction across the EU by 2020. By 2023, 92% of vehicles are tolerant to E10, though the EU's E10 compatible vehicles are only effectively driving on E8.3 as some forecourts do not adopt E10 and 20% of customers that could use E10 choose not to. E10 becomes the protection grade in 2025, and no more E5 is assumed to be sold.

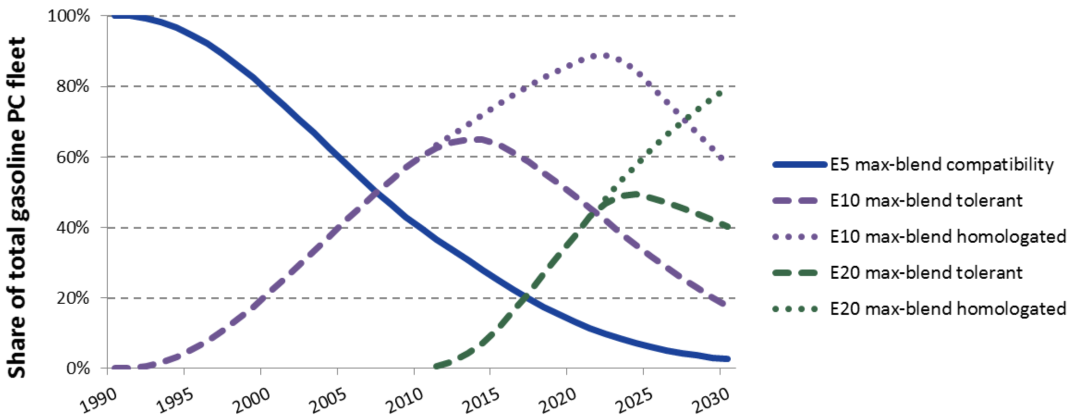

Figure 2: Gasoline passenger car fleet development

Figure 3 shows the uptake potential from the vehicle fleet for ethanol in a scenario in which E20 is rolled out from 2023. The additional cumulative ethanol that could be used in the period 2023-2030 as a result of introducing E20 in 2023, rather than when no E20 is used until after 2030 is 8.3 mtoe.

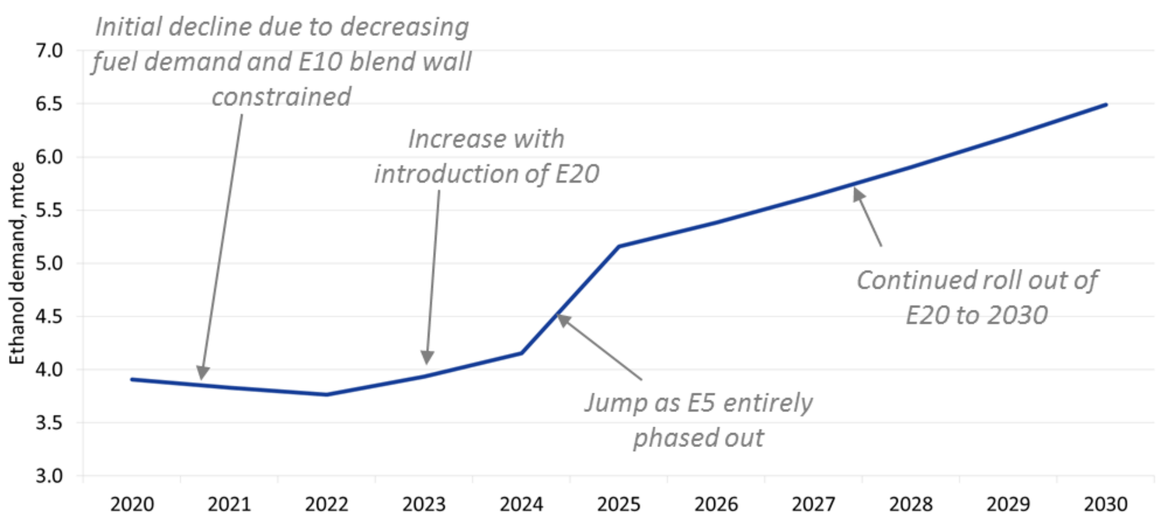

Figure 3: Ethanol uptake potential from the vehicle fleet in a scenario with E20 roll-out from 2023

2.2 Scenario A: No specific framework for transport at EU level in 2030

2.2.1 Scenario assumptions

Table 2 shows the key assumptions for this scenario.

Table 2: Scenario A assumptions

Policy in 2020	• Continuation of the Renewable Energy Directive (RED) and Fuel Quality Directive (FQD), with the 7% cap on food crop based biofuels and double counting. 2G biofuel policies are summarised in Table 3
Policy in 2030	• No EU-level policy beyond the 40% GHG emissions reduction and 27% RES target • Individual Member States' policies on 1G and 2G biofuels (see Table 3) are summed to give EU totals. No overall adherence to a 2G biofuel mandate. No double counting. • Note that Member States (MSs) are likely to still have targets for emissions reductions in non EU-ETS sectors through an effort sharing agreement, which means that there will be a driver for emissions reductions in the transport sector, to a certain extent, in each MS. However, MSs need not necessarily meet this through policy to support biofuels, and so not all MSs have biofuel policies (see Table 3). However, if less is done in the transport, other non-EUETS sectors would have to do more to meet overall energy and GHG targets.

Cap in 2030	• Two cap options in 2030 have been modelled:
	  • Continuation of the 7% cap after 2020
	  • Continuation of the 7% cap after 2020, but allowing biofuels that meet the GHG savings target including ILUC factors to be sold outside the cap

Merit order for biofuels uptake	• Based on cost.
Ethanol blends	• E10 roll out as in Autofuel (max E10 availability by 2020) • No E20 roll out by 2030

Where we or ePURE members had indications of potential MS targets from discussions with policymakers, these were used, otherwise the following assumptions were made:

- MSs that are large producers of ethanol are assumed to maintain support for ethanol. They are assumed to adopt E10 (including those that have not already done so), and for this to result in a penetration of ethanol of 8.3% by volume (=5.5% by energy, assuming some consumers do not ever fill up with E10). 2G ethanol will be sold as part of this if the MS has a 2G biofuels target
- MSs that are large producers of biodiesel are assumed to maintain support for 1G biodiesel. They are assumed to maintain the 2020 volume of biofuels sold (calculated in Autofuel project), or have an alternative level if there is policy post 2020. This includes going beyond

B7 through use of HVO in some cases. 2G biodiesel will be sold as part of this volume if the MS has a 2G biofuels target

- MSs that have 2G biofuels companies or have previously shown support for 2G biofuels targets are assumed to set an 0.25% target (double counted to 0.5%) in 2020, and an 0.5% target (not double counted) in 2030. Italy has its own target levels

These assumptions are summarised in Table 3.

Table 3: Scenario A – policy assumptions in 2030 (note, 2020 2G biofuels target shown below is before double counting is applied)

Country	Ethanol in 2030 (energy % of gasoline)	Biodiesel in 2030 (energy % of diesel)	2G biofuels in 2020 and 2030 (energy % of all fuels)
Belgium	5.5	7.6 (volume as 2020)	0.25, 0.5
Germany	5.5	10.0 (E4tech estimate to meet 6% GHG saving)	-
Denmark	5.5	7.0	0.5, 0.5
Spain	5.5	7.0 (volume as 2020)	0.25, 0.5
Finland	8	2 (volume as 2020)	2.5, 5
France	7	8.0 (due to B8)	0.25, 0.5
Hungary	4.9	5	0.25, 0.5
Italy	5.5	7.9 (volume as 2020)	0.8, 1.6
NL	-	6.8 (volume as 2020)	0.25, 0.5
Poland	5.5	-	0.25, 0.5
Portugal	-	7.3 (volume as 2020)	-
Sweden	5.5	6 (volume as 2020)	2, 2.5
UK	5.5	-	0.25, 0.5
Others[6]	-	-	-

2.2.2 Results

As shown in Figure 4, in 2020, biofuels' contribution to the RED is 8.7% (includes double counting). Ethanol is limited by the blend wall, and all available FAME and HVO is used, but the crop cap is not met. As the 2G target is low (10 countries have targets of 0.5% to 2.5%), it can be met through the cheapest options, which are biogas and diesel from wastes, with a very small amount of 2G ethanol. All available 2G biodiesel and biogas is used in addition to this target, but ethanol is limited by the blendwall.

[6] Others: Austria, Bulgaria, Republic of Cyprus, Czech Republic, Estonia, Greece, Ireland, Latvia, Lithuania, Luxembourg, Malta, Romania, Slovenia Slovakia

In 2030, biofuels' overall contribution is limited by policy only driving biofuels sales in a few MSs. 1G ethanol, biodiesel and 2G fuels are all limited by the MS target levels. 2G fuels increase from 2020 as the targets in some MSs increase. Biogas alone is used to meet the 2G target (this clearly depends on how MSs define the 2G target). Other 2G biofuels are only used where they are cheaper than 1G fuels, to meet MS targets. As the cap is not hit in 2020 or 2030, allowing ILUC compliant biofuels to be sold outside it makes no difference to the results, so they are not presented separately here.

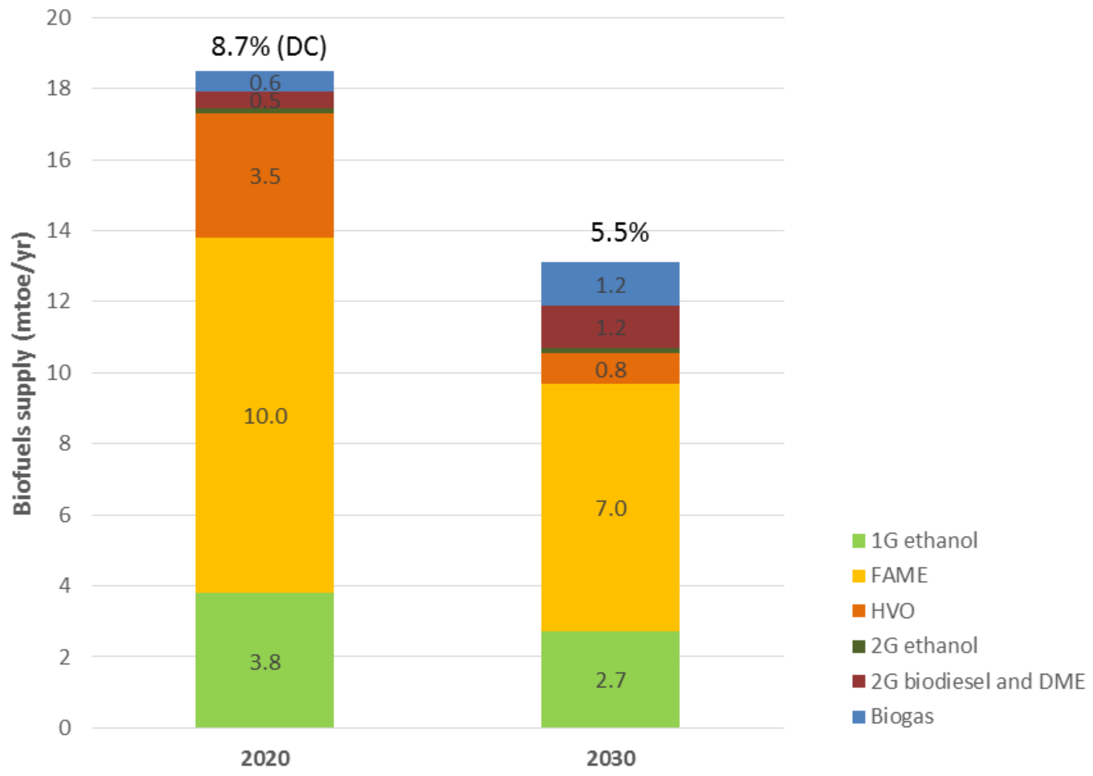

Figure 4: Scenario A biofuels supply (mtoe) and energy contribution (RED basis %) [7] **(DC=Double Counting)**

Key metrics for scenario A are shown in Table 4.

Table 4: Scenario A - results summary

	2020	2030
GHG savings $MtCO_2e/y$	48.3	40.1
% contribution to FQD	5.0%	4.4%

[7] The denominator for the calculation of the contribution to the RED is the total energy demand in road and rail, as per article 3.4a of the Renewable Energy Directive. E4tech have projected this demand for 2020 and 2030 based on expected improvements in vehicle efficiency, and other relevant parameters..

2.3 Scenario B: GHG target for transport in 2030

2.3.1 Scenario assumptions

The key assumptions for Scenario B are shown in Table 5.

Table 5: Scenario B assumptions

Policy in 2020	• Continuation of the RED and FQD, with the 7% crop cap, double counting and 0.5% 2G biofuels (including double counting)
Policy in 2030	• 10% GHG target for 2030, to be met through only biofuels (a carve out for biofuels) • 3% by energy 2G biofuels target[8] • Policy at an EU level – there is no consideration of individual MS policies in the modelling • No double counting

Cap in 2030	• Two cap options in 2030 have been modelled:
	  • Continuation of the 7% cap after 2020
	  • Continuation of the 7% cap after 2020, but allowing biofuels that meet the GHG savings target including ILUC factors to be sold outside the cap

Merit order for biofuels uptake	• Based on cost of carbon saving

Ethanol blends	• E5 no longer sold from 2025
	• E10 roll out as in Autofuel (max E10 availability by 2020)
	• E20 - two variations modelled:
	  • No E20 introduced by 2030
	  • E20 introduced gradually from 2023 with full roll out by 2030.

2.3.2 Results

Scenario B results are shown for two scenarios: the first with full E20 roll out by 2030 and the second with no E20 introduction by 2030.

Full E20 roll out by 2030:

Figure 5 shows that in 2020, the results for this scenario are very similar to scenario A, as most assumptions are the same, despite the different merit order. Ethanol is limited by the blend wall, all available FAME and HVO is used, and the crop cap is not met. However, there is more 2G ethanol than in scenario A as all MSs have a 0.5% 2G target. This backs out some 1G ethanol. Note that more 2G biofuels are used than the target (0.62%) – we have not curtailed these as the RED target is not being met.

In 2030, biofuels contribute 8.6% to the FQD. The contribution of upstream emission reductions (UERs), electric vehicles (EVs), natural gas vehicles (NGVs) and hydrogen (H_2) would be additional to

[8] The denominator for the advanced biofuels target is taken as the total energy demand in road and rail, as set out in the ILUC amendment to the RED, which references the RED Article 3.4.a.

this. Biofuels cannot reach a 10% FQD target because the blend walls are reached and so not all biofuels (i.e. 1G ethanol and FAME) available in the model are used. Ethanol is limited by the blend wall, even with E20 being rolled out before 2030. FAME is limited by its blend wall at B7. HVO and 2G biodiesel are used to the extent they are available. 2G biofuels supply 3.1% by energy, and contribute 2.8% of GHG savings. 2G ethanol is sold in preference to 1G ethanol, up to the 3% 2G target, with the total limited to the blend wall.

As the crop cap is not hit in 2020 or 2030, allowing ILUC compliant biofuels to be sold outside it makes no difference. The crop cap is at 16.8 mtoe in 2030, but there is only 14.7 mtoe of fuel that could be capped (comprised of 3.5 mtoe ethanol, 6.9 mtoe FAME and 4.3 mtoe HVO). Some of the non-capped FAME and HVO (e.g. from UCO) is contributing to the biodiesel blend wall, and 2G ethanol is contributing to the ethanol blend wall.

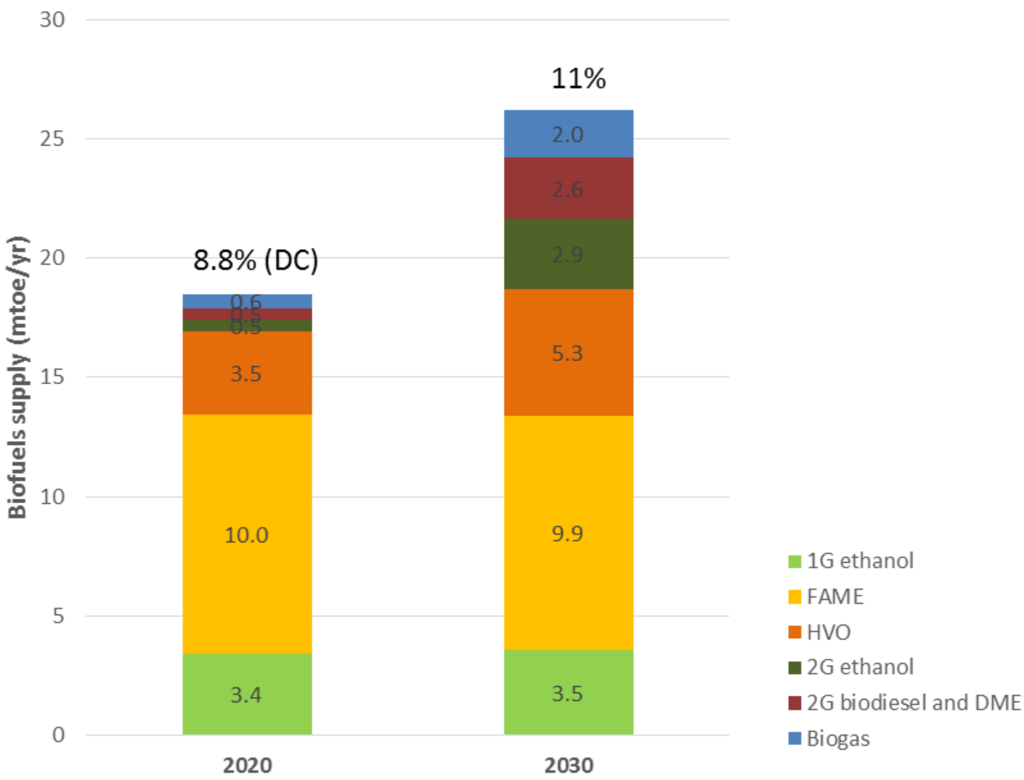

Figure 5: Scenario B (Full E20 by 2030) biofuels supply (mtoe) and energy contribution (RED basis %) (DC=Double Counting)

Key metrics for this scenario are shown in Table 6.

Table 6: Scenario B (Full E20 by 2030) - results summary

	2020	2030
GHG savings $MtCO_2e/y$	49.2	78.7
% contribution to FQD	5.1%	8.6%

No E20 roll out by 2030:

In 2020, the results are the same as for when E20 is fully introduced by 2030, as there are no differences in 2020. However, as shown in Figure 6, in 2030, the lack of E20 means the total uptake capacity of vehicles for ethanol is lower. Ethanol is used up to the blend limit, but with 2G ethanol being used preferentially to 1G ethanol due to the 2G biofuels target. The difference between these two variations of scenario B is therefore the reduction in the volume of 1G ethanol that is used in 2030 when E20 is not introduced.

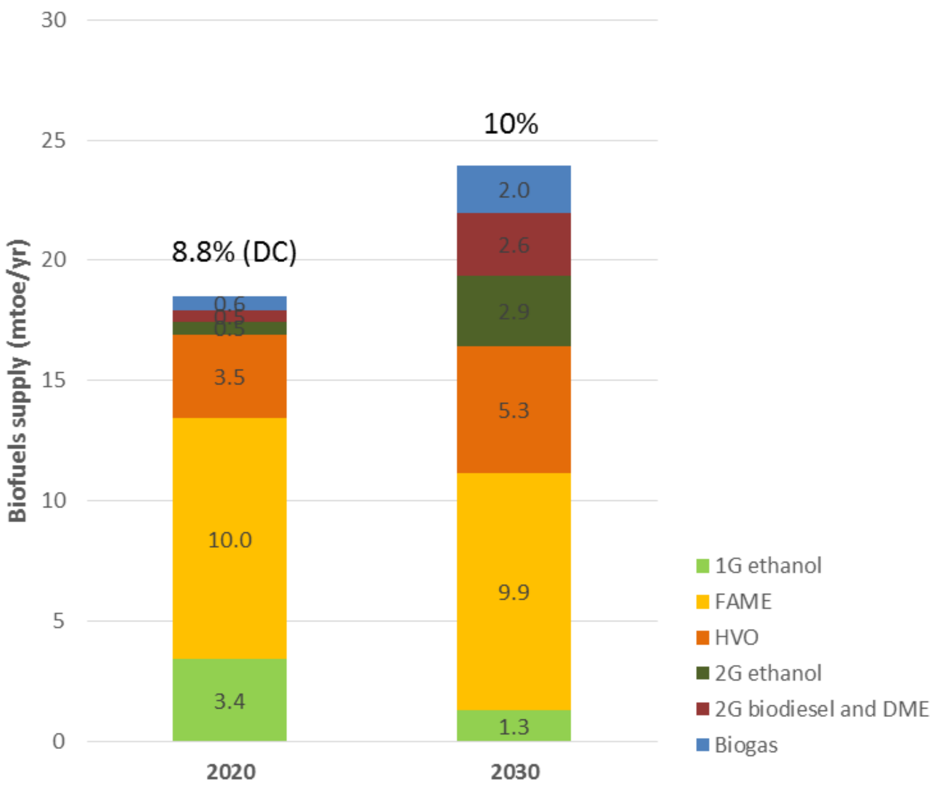

Figure 6: Scenario B (no E20 by 2030) biofuels supply (mtoe) and energy contribution (RED basis %) (DC=Double Counting)

Key metrics for this scenario are shown in Table 7.

Table 7: Scenario B (no E20 by 2030) – results summary

	2020	2030
GHG savings $MtCO_2e/y$	49.2	72.3
% contribution to FQD	5.1%	7.9%

Table 8 gives an indication of the biofuel prices and Table 9 shows the average cost of carbon saving in 2030 in scenario B (with full E20 by 2030). Results are similar in scenario C. On average, 1G ethanol has the lowest cost of carbon saving in 2030 of the different groups of biofuels.

Table 8: Biofuel prices[9]

	$/barrels oil equivalent	€/GJ	€/l
Average for all biofuels	158	25.2	0.54
Range for all biofuels	71-266	11.2-42.1	0.24-0.90
Average for 1G ethanol	114	18	0.39
Average for 2G ethanol	180	29	0.61

Table 9: Biofuel costs and cost of carbon saving in 2030 in scenario B (with full E20 by 2030)

Fuel type	Average cost of C saving [EUR/tCO_2e saved]
1G biodiesel (HVO + FAME)	411
2G diesel	313
1G ethanol	269
2G ethanol	356

2.4 Scenario C: Renewable energy target for transport in 2030

2.4.1 Scenario assumptions

Assumptions for Scenario C are shown in Table 10.

Table 10: Scenario C assumptions

Policy in 2020	• Continuation of the RED and FQD, with the 7% cap, double counting, and 0.5% 2G biofuels (including double counting)
Policy in 2030	• 15% target for renewable energy in transport in 2030, to be met through biofuels, electricity. • No consideration of individual MS policies in the modelling • 3% by energy sub target for 2G biofuels • No double counting

Cap in 2030	• Two cap options in 2030 have been modelled:
	  • Continuation of the 7% cap after 2020
	  • Continuation of the 7% cap after 2020, but allowing biofuels that meet the GHG savings target including ILUC factors to be sold outside the cap

Merit order for biofuels uptake	• Based on cost within each sub target, with 2G biofuels target being met first

[9] Note that the prices in Table 8 and Table 9 include import tariffs. Cost of carbon saving is compared with 2014-15 average gasoline and diesel prices. NB: 2G diesel and 2G ethanol have similar costs within the margins of error of cost projections for these fuels.

Ethanol blends	• E5 no longer sold from 2025
	• E10 roll out as in Autofuel (max E10 availability by 2020)
	• E20 - two variations modelled:
	  • No E20 introduced by 2030
	  • E20 introduced gradually from 2023 with full roll out by 2030

2.4.2 Results

Scenario C results are shown for two scenarios; the first with full E20 roll out by 2030 and the second with no E20 introduction by 2030.

Full E20 roll out by 2030:

In 2020, the volume results are very similar to those as in scenario B, as the assumptions are the same. However, the changed merit order (based on cost, rather than cost of carbon saving) means more EU ethanol is used instead of non-EU ethanol. Ethanol hits the blend wall, and all FAME, HVO and 2G biodiesel available are used. Very slightly more 1G ethanol (0.03 mtoe) is used in scenario C.

In 2030, exactly the same results are achieved as for scenario B, as both these scenarios use the maximum amount of biofuels possible, apart from those that would be beyond the ethanol and FAME blend wall limits. Biofuels contribute 11.0% of energy in transport (road and rail). The 3% 2G target is met, and slightly exceeded (3.15% is achieved). The maximum 2G biofuels that could be supplied at the medium build rate in our model is 3.18%. However, a higher target could be achieved with more ambitious build rates (as shown by projections by 2G biofuels companies) but these would require much stronger incentives. As the crop cap is not hit in 2020 or 2030, allowing ILUC compliant biofuels to be sold outside it makes no difference, as in Scenario B.

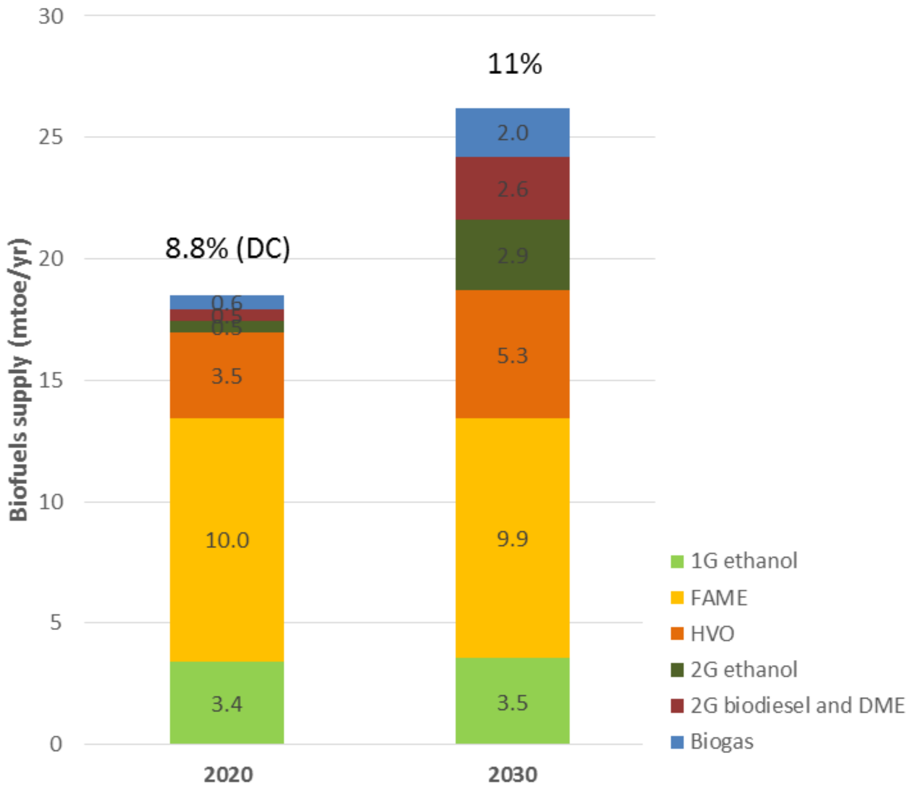

Figure 7: Scenario C (full E20 by 2030) biofuels supply (mtoe) and energy contribution (RED basis %) (DC=Double Counting)

The key metrics for this scenario are shown in Table 11.

Table 11: Scenario C (full E20 by 2030) – results summary

	2020	2030
GHG savings $MtCO_2e/y$	48.7	78.7
% contribution to FQD	5.0%	8.6%

No E20 roll out by 2030:

As shown in Figure 8, with no E20 by 2030, biofuels can contribute 10% to RE in transport in 2030. In 2020, the results are the same as for when E20 is fully introduced by 2030, as there are no differences in 2020.

In 2030, the lack of E20 means the total uptake capacity of vehicles for ethanol is lower. Ethanol is used up to the blend limit, but with 2G ethanol being used preferentially to 1G ethanol because of the 2G biofuel target. The difference between these two variations of scenario C is therefore the reduction in the volume of 1G ethanol that is used in 2030 when E20 is not introduced.

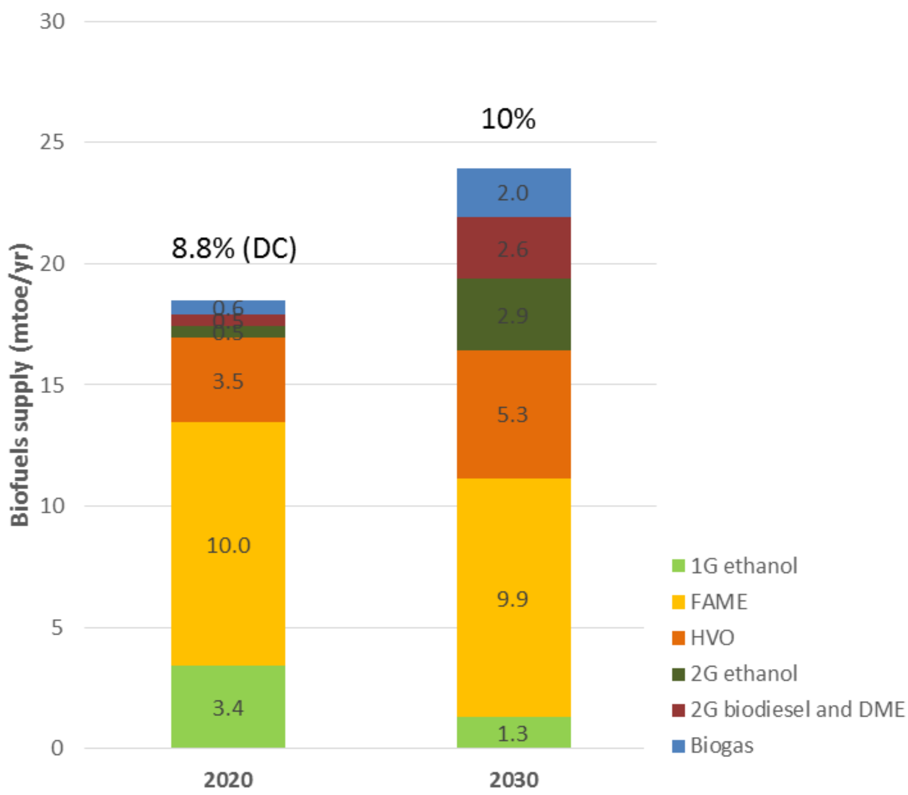

Figure 8: Scenario C (no E20 by 2030) biofuels supply (mtoe) and energy contribution (RED basis %) (DC=Double Counting)

The key metrics for this scenario are shown in Table 12.

Table 12: Scenario C (No E20 by 2030) – results summary

	2020	2030
GHG savings $MtCO_2e/y$	48.7	72.3
% contribution to FQD	5.0%	7.9%

In scenarios B and C, with early introduction of E20, the share of 2G ethanol increases significantly in 2030, to meet 2G biofuels targets (see Figure 9). To meet 2G biofuel targets, a number of biogas chains are used first as they have the lowest cost of carbon saving (Scenario B) or costs (Scenario C), followed by a mixture of 2G diesel and ethanol routes. In these scenarios, 2030 2G biofuel targets are set at 3%, which encourages a greater share of 2G ethanol.

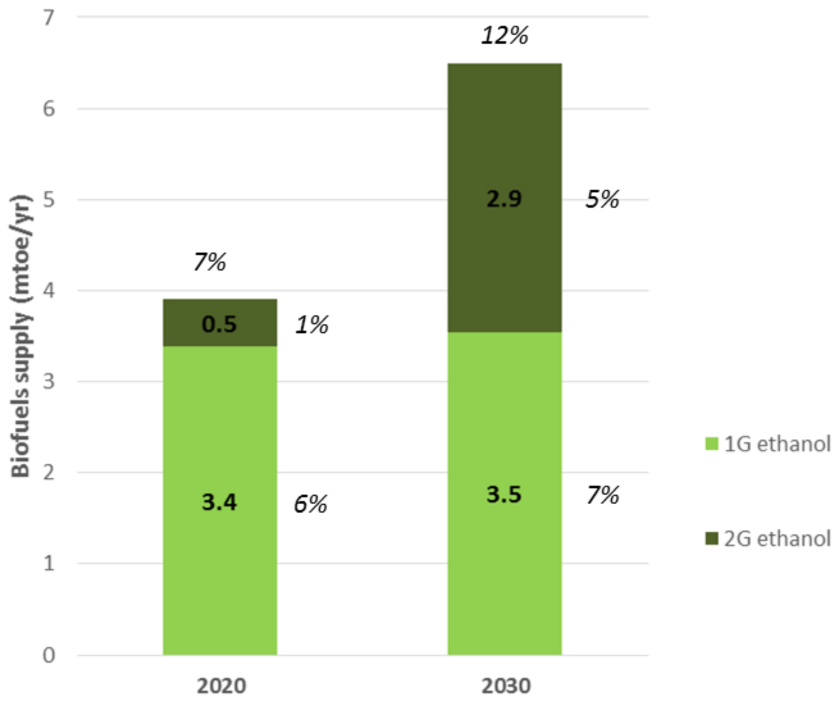

Figure 9: Scenario B/C (full E20 by 2030) biofuels supply (mtoe) and (in italics) share in gasoline (energy basis %)

2.5 Sensitivities

2.5.1 Maintaining the octane of the blendstock

Ethanol blending can increase the octane of gasoline-ethanol blends, if the octane of the gasoline blendstock is maintained rather than reduced, as is currently the case. Increasing the octane level can increase the tank-to-wheels fuel efficiency of the vehicle.

In scenarios B & C in 2030, the average blend across the fleet is E16.7 with fuel demand 59 mtoe. If this blend increased the mileage driven by 3.5%, the demand for E16.7 fuel would be reduced to 57mtoe, a decrease of 2.0 mtoe. The GHG impact of this fuel demand reduction would be 7.12MtCO_2e/yr in addition to the savings outlined in the previous sections. The impact on the average cost of C saving for ethanol is illustrated in Table 13.

Table 13: Average cost of C saving for different types of biofuels with reductions in cost of carbon savings if the TTW benefit is considered

Fuel type	Average cost of C saving [EUR/tCO_2e saved]
1G biodiesel	411
2G biodiesel	313
1G ethanol	269 → 190
2G ethanol	356 → 264

However, it might not be easy in policy terms to specify the octane level of the blendstock to guarantee this benefit. A more plausible option is that minimum octane (RON) levels in the standard for the finished fuel could be increased to the equivalent of the desired ethanol blend plus the current blendstock. In conjunction with biofuels targets this would ensure that the blendstock was maintained.

2.5.2 Implications of changes to the fossil fuel comparator

In this study, fossil fuel comparators of 93.1 gCO_2e/MJ and 95.1gCO_2e/MJ were used for gasoline and diesel respectively[10]. However, the fossil fuel comparator may change in the future, as more information on the origin of fossil fuels supplied is reported under the FQD. Changes to the fossil fuel comparator will have an impact on the cost of carbon saving. This is illustrated in Figure 10.

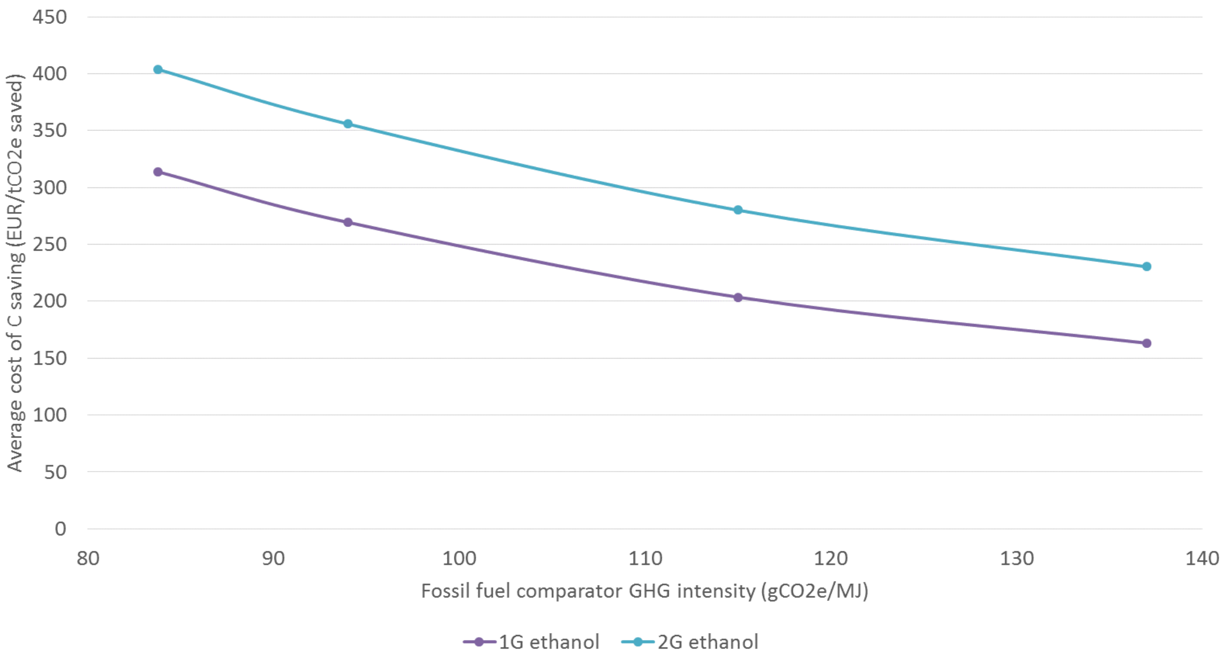

Figure 10: Average cost of carbon saving for 1G and 2G ethanol for scenario C in 2030, when different fossil fuel comparator GHG intensities are considered

The range given is from the RED comparator of 83.8gCO_2e/MJ to values seen from studies assessing the GHG intensity of marginal sources of fossil fuels.[11]

[10] As set out in the 2014 Annexes to the Methodology for the calculation and reporting of the life cycle greenhouse gas intensity of fuels and energy by fuel suppliers for the Proposal for a Council Directive on 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. Available online at: http://ec.europa.eu/clima/policies/transport/fuel/docs/com_2014_617_annexes_en.pdf

[11] Note that a change to a marginal approach for the fossil fuel comparator might necessitate a change of approach to the methodology for calculation of GHG intensity for biofuels, which is currently predominantly based on an attributional approach to lifecycle analysis (LCA).

3 Non-Modelled Options

3.1 Scenario D: Inclusion of transport in the EU Emissions Trading Scheme (EUETS)

How could road transport be included in the EUETS?

There are a number of studies that have considered how road transport could be included in the EUETS. Most of these take the approach of assuming that fuel suppliers would be brought under the EUETS, and be required to surrender allowances for each tonne of CO_2 emitted as a result of their fuel sales. Some studies have also considered the options of regulating drivers or OEMs rather than fuel suppliers, but this would be much more difficult to implement (ZEW, 2015). Inclusion in the EUETS could work in practice by fuel suppliers receiving some allowances for free, and/or bidding for them through auctions, with the remaining allowances bought on the market. In most existing EUETS sectors, the proportion auctioned rather than given freely is growing (Cambridge Econometrics, 2014; ZEW, 2015).

Most reports consider an open ETS as the main option, where emission allowances could be traded between transport and other sectors, as this would be most cost–efficient (ZEW, 2015). Other alternatives are:

- Semi-open system: emission allowances from all sectors can be used by road fuel suppliers, but allowances for road transport cannot be used in other sectors, as in aviation (Oko-institut, 2015; ZEW, 2015). This is unlikely to happen anyway, as the road transport sector will be a buyer of allowances.
- Closed system: an ETS for transport only - effectively an FQD with traded certificates. This would be more likely to lead to emissions reductions within the transport sector and mitigate distributional impacts on the sectors covered in the existing ETS.

Finally, most reports consider that the EUETS inclusion would replace car CO_2 targets, but some assume they are kept.

What impact would inclusion in the EUETS have on fuel prices?

The price of EUETS allowances considered in the reports reviewed ranges from €5-25/tonne CO_2 depending on the scenario. This has a minimal impact on fuel prices (Table 14).

Table 14: Impact of changing EUETS price on fuel prices

Allowance price €/tCO_2e	Gasoline allowance cost €/l	Diesel allowance cost €/l
5	0.012	0.013
10	0.024	0.027
25	0.059	0.067

However, very large allowance prices would be required to achieve abatement in the transport sector:

- An average carbon price of €217/tCO_2 over the period 2020-2030 would be required to achieve the same level of road transport emissions abatement as that achieved with continued car fuel efficiency targets (Cambridge Econometrics, 2014)
- Even at the maximum carbon price of €100/tonne allowed in the ETS, the price of transport fuel would only increase by €0.25/l, leading to road transport emission cuts of around 10% (T&E, 2014a)
- To reach a similar level of technology innovation as expected for the EU's 2020/21 CO_2 target of 95 grams per kilometre a price of about €370 per ton of CO_2 would be required (Mock, 2014)

Arguments for inclusion of transport in the EUETS

Effectiveness in reducing emissions:

- Emissions reductions would be achieved - albeit in the power sector rather than the transport sector (Heinrichs et al, 2014; ZEW, 2015; Paltsev, 2015). There would be more certainty of this than with car CO_2 targets (cepInput ,2015)
- Other policies do not give an incentive for drivers to reduce emissions through how much, or how, they drive. If allowance prices were high enough, the EUETS would incentivise savings across fuel carbon intensity, fuel economy in cars, driving behaviour and demand for vehicle miles travelled. It would also reduce rebound effects from regulations on fuel efficiency in cars (ZEW, 2015)

Reduced abatement costs:

- Abatement occurs in the sectors that face the lowest marginal abatement cost. The more sectors covered, the greater the increase in efficiency (cepInput, 2015)
- Reduces the cost of meeting GHG targets for MSs with large emission reduction obligations in non-ETS sectors
- Includes used cars as well as new ones, and heavy-duty vehicles and thus brings the abatement costs in all ETS sectors into line (cepInput, 2015)

Fairness between sectors:

- The road transport sector is a large sector that is not covered in the EUETS (cepInput, 2015)
- As the transport sector moves towards EVs, the power sector will need to provide additional electricity. This means that existing transport emissions will shift into the EU ETS over time anyway but there is no allowance for this in the future caps proposed for the power sector (Redshaw Advisors, 2015)

Driving innovation:

- The EUETS is a more stable long term policy mechanism than car targets of an uncertain level of stringency, with a clear planned level of cap reduction (ZEW, 2015)
- An overarching policy such as the EUETS gives more driver and scope for innovation at the system level, rather than within individual actors, which can lead to large scale changes (ZEW, 2015)

Monitoring and compliance:

- The abatement cost is revealed by the allowance price so policy makers can observe the cost of the policy implemented directly (ZEW, 2015).

- Less subject to cheating than car CO_2 targets "the emissions would be calculated from the fuel used, not based on what the car company tells us they should be" (Redshaw Advisors, 2015)

Arguments against inclusion of transport in the EUETS

GHG savings will not be made in the transport sector now:

- The allowance price's effect on fuel prices would not lead to CO_2 savings in transport high enough to meet long term goals. Regulation via the ETS alone would result in emissions reductions of only ~1% by 2030 at current ETS prices, or of ~3% if prices were to rise as projected in PRIMES 2009 to around €35/tCO_2 in 2030 (Cambridge Econometrics, 2014).
- Note that the high price level required to achieve savings does not stem from the fact that vehicle technologies are an especially expensive means of reducing CO_2. It is due to the fact that mainstream customers strongly discount future savings or costs, and so fuel costs do not strongly affect vehicle purchase decisions. A higher price is therefore needed to drive change (ICCT, 2014)
- Making savings where there is the lowest cost of saving is rational with a short-term perspective, but ignores the time needed for sectors to change. The transport sector needs time to decarbonise, so should be decarbonised now (ICCT, 2014)

The EUETS will not be managed to suit the transport sector:

- The ETS covers both sectors that could be sensitive to carbon leakage and sectors that can take very high carbon prices without any risk of delocalisation. ETS prices will only be allowed to increase to a level perceived affordable for the most exposed sectors (T&E, 2014a).
- The market stability reserve is supposed to drive investments in low carbon technologies (inter-temporal efficiency) but it will not drive them in transport, as it will not drive prices high enough.

Less effective at reducing GHG emissions from transport than car CO_2 targets - lack of driver for emissions reductions in the short term and innovation in the long term by OEMs:

- All sources – even those that are pro-inclusion of transport in the EUTS – agree that ETS price signals would not be high enough to encourage change by OEMs in the transport sector, and so emissions reduction in the transport sector will be delayed.
- An average carbon price of €217/tCO_2 over 2020-2030 would be required to achieve the same level of abatement as that achieved with continued car fuel efficiency targets (Cambridge Econometrics, 2014)
- Policies directly supporting vehicles with lower emissions at the point of purchase (e.g. feebate systems) are more effective than those which address the costs arising during vehicle operation (Oko-institut, 2015). ZEW proposes combining the EUETS inclusion with emissions-linked purchase taxes or annual circulation taxes
- The ETS would not give any investment certainty on emissions reduction measures, compared with vehicle targets (T&E, 2014a; ICCT, 2014)

Potential for MS to use domestic policy to counteract the EUETS:

- Cost increases brought about by the EUETS are substantially lower than the current energy tax rates, and MSs may reduce fuel taxes with inclusion in the EUETS (Oko Institut, and cep advocate for this)

Implementation is complicated and could possibly weaken the EUETS:

- Will not solve the problems of the EUETS: oversupply of credits and low price, particularly if the cap were increased to allow for transport when it was included (T&E, 2014a)
- Complicated to implement – brings more regulated parties into the EUETS, and requires thinking about more sectors simultaneously
- Could persuade policymakers to scale back more effective measures such as CO_2 standards and road taxes (T&E, 2014a).

Not a good fit with biofuels

- If biofuels were counted as zero, the EUETS would overestimate the benefits of biofuels use
- Any benefit given by EUETS would not be large enough or be bankable for investors in (2G) biofuels plants
- An EUETS only considers transport in terms of cost of CO_2 abatement and not the need to address other objectives like reduced dependency on oil, air quality, etc.

3.2 Scenario E: Changing car CO_2 standards to a well-to-wheel basis

How could car CO_2 standards be changed to a well-to-wheel basis?

The current car CO_2 standards are based only on tank-to-wheels emissions (TTW) i.e. the CO_2 emitted when the fuel is burnt. The proposal considered here is to change this to a well-to-wheel basis (WTW), and so consider the whole lifecycle emissions of producing and using the fuel. Emissions from production and disposal of the vehicle would not be considered in this option.

The European Commission (EC) is considering this as one option for car CO_2 targets post 2020. CE Delft, Cambridge Econometrics and TNO were commissioned by the EC to assess the modalities (i.e options) for the targets, in a project which was due to finish in September 2015. The latest presentation on this project from April 2015 still has the option open for a TTW or WTW approach, however, later results are not yet available.

Within a WTW approach, it would need to be decided whether the WTT portion of emissions should be consistent at an EU level or specific to a MS, whether they should be provided on a yearly basis, and whether projections should be provided.

The aforementioned EC study also leaves the option open for including embedded emissions, either with default values or harmonised LCA-reporting by OEMs.

A survey conducted as part of the project showed that only component OEMs, the steel industry and energy carrier companies saw including WTT emissions as an important issue, but vehicle OEMs, NGOs and MSs did not consider this an important issue.

Advantages of changing car CO_2 standards to a well-to wheel basis

Regulating TTW emissions alone does not provide a fair comparison between technologies:

- It favours vehicles running on electricity or hydrogen, with zero TTW emissions. As their WTW emissions are not zero, this has led to concerns that they could be wrongly favoured

- It is a barrier for adoption of fuels such as non drop-in biofuels and natural gas, which have non-zero TTW emissions, and require action from OEMs in producing vehicles that can run on them
- It is not so much of a barrier for drop-in biofuels: although it also does not favour them either, they do not rely on the action of OEMs for uptake
- It favours diesel over gasoline, even though adjusting refinery outputs towards a higher diesel/petrol ratio has led to increased WTT energy consumption and GHG emissions over the last decade (TNO, 2010)

Moving to a WTW basis is a more technology neutral approach:

- It would give OEMs an incentive to produce vehicles that can run on lower WTW emission fuels, so that the penetration of the fuels could be increased i.e. E20 compliant vehicles, NGVs

Disadvantages of changing car CO_2 standards to a well-to wheel basis

OEMs have very little control over WTT emissions, and so would find it hard to plan:

- OEMs would have difficulty in planning investments to meet targets, given the uncertainty on the WTT emissions.
- Using actual WTW or WTT emission factors, or very frequent updates of these factors, would make planning more difficult for OEMs. Different electricity mixes in different countries and the EU-ETS complicate this. Forecasting the WTT emissions could be an option, though risks inaccuracy and manipulation (TNO et al., 2013)
- In setting the target, the regulator would need to assume a certain share of ZEVs and ICEVs, with particular TTW efficiencies. If the number of vehicles sold or the efficiencies of those vehicles varied a lot from this, it could be hard for OEMs to meet the targets

A WTW approach increases complexity and effort in policymaking:

- Car CO_2 targets are already a complex area, with questions over test methods and other modalities chosen. Policymakers may not be keen to increase this
- The new target would need to be set at a level that still encourages TTW savings from gasoline and diesel vehicles, but this would be difficult given WTT uncertainties
- Most policymakers want to incentivise electric and hydrogen vehicles to some extent e.g. for air quality reasons, and because they think they are the main long term solution for cars. Introducing a disadvantage to them by moving to a WTW approach would mean that stronger complementary policies were needed to make sure that they are deployed

These disadvantages mean that separate policy on fuels and vehicles is considered preferable by OEMs and NGOs. TTW targets are considered the most efficient way to drive TTW emissions reductions in conventional vehicles.

In addition, emissions from fuels are currently regulated through other policies, which will continue for some electricity and hydrogen production. Some electricity and hydrogen production is, and will continue to be, included in the EUETS. As such, marginal WTT CO_2 emissions from increased production of electricity and hydrogen for the transport sector are compensated by CO_2 reductions in other sectors under the ETS, meaning that the marginal CO_2 emissions are zero. Note that this is not true for all electric and hydrogen vehicles: electricity or hydrogen produced in small plants will not be covered by the EUETS. Also, it takes a marginal rather than average emissions approach, which some consider more appropriate (TNO et al, 2013). Furthermore, all fuel emissions are regulated through the FQD. Continuing to regulate through an extension of the FQD may be an easier option in the future than moving to a WTW basis for car CO_2 targets.

There are potentially other mechanisms by which WTW benefits can be recognised without changing the car standards to a fully WTW basis. For example, there is precedent for having a credit in the car CO_2 targets, for vehicles that can use lower carbon fuels such as E85 (TNO, 2011).

Article 6 of Regulation (EC) 443/2009/ specifies that "the specific emissions of CO_2 of each vehicle designed to be capable of running on a mixture of petrol with 85 % ethanol ('E85') […] shall be reduced by 5 % until 31 December 2015 in recognition of the greater technological and emissions reduction capability when running on biofuels." However this "reduction shall apply only where at least 30 % of the filling stations in the Member State in which the vehicle is registered provide this type of alternative fuel complying with the sustainability criteria for biofuels set out in relevant Community legislation."

One option would be to introduce a similar credit for E20 compliant vehicles, once E20 was rolled out at refuelling stations.

4 Conclusions

Several key conclusions are made about how effectively different transport policies can contribute to policy goals, which are explained further in this chapter:

- Renewable energy or greenhouse gas targets for transport are the only options considered that allow transport to contribute significantly towards 2030 energy and climate goals
- The absence of EU-level targets would lead to declining biofuels volumes, and a lack of investment in 2G biofuels
- Either a GHG or energy based-target, together with a 2G biofuel sub-target, could be an effective approach.
- Blending limits are the main factor that could limit ethanol use. EU biofuel targets alone would not be sufficient to promote introduction of E20

4.1 Biofuel targets are the only options considered that allow transport to contribute significantly towards 2030 energy and climate goals

If there is no EU-level policy, the contribution of biofuels to GHG savings and energy diversification decreases between 2020 and 2030 (Scenario A). This makes it unlikely that expected GHG savings would be achieved in the transport sector, and additional savings would be required elsewhere.

A GHG-based target (Scenario B) and an energy based target (Scenario C) would both drive an increase in biofuels contribution to energy and GHG emissions savings, and introduction of significant volumes of 2G biofuels, compared with a situation in which no targets are put in place (Scenario A). As shown in Table 15, biofuels make a significant contribution to the overall 27% and 40% targets for 2030, and a lack of targets increases the burden on other non-ETS sectors. There is little difference between scenarios B and C in 2030; the level at which the target is set, and the success of implementation of each is what would create any difference between the two. Biofuels make a maximum contribution of around 11% to EU transport energy in 2030 in scenarios B and C, with no double counting, similar to the renewables share in transport energy envisaged in the impact assessment of the Climate and Energy Framework, before any renewable electricity contribution. Both a GHG-based or energy-based target could be placed on fuel suppliers rather than MSs.

Including transport in the EU ETS (option D) could lead to GHG savings, but these would be very unlikely to be in the transport sector, unless there were very high allowance costs.

Changing car CO_2 targets to a WTW basis (option E) could support increased penetration of non drop-in biofuels and natural gas. However, this option is seen as complex for policymakers and OEMs.

Table 15: Comparison of modelled scenario results

Scenario	A		B (early E20)		C (early E20)	
	2020	2030	2020	2030	2020	2030
GHG savings, [$MtCO_2e/y$]	48.3	40.1	49.2	78.7	48.7	78.7
Cost of GHG savings [EUR/tCO_2e]	195	91	195	149	196	149
Emissions savings relative to the 2030 40% GHG emissions reduction target (relative to 1990 levels)[12]		1.2%		2.3%		2.3%
Contribution of biofuels to the 2030 27% renewable energy target for all energy[13]		4.4%		8.8%		8.8%

4.2 The absence of EU-level targets would lead to declining biofuels volumes, and a lack of investment in 2G biofuels

Energy and GHG saving contributions from biofuels are likely to decline to 2030 in the absence of EU-level policy. Renewable energy and GHG saving expectations in transport are unlikely to be achieved in 2030 without biofuels, as other options will not ramp up fast enough. There would be an increase in use of fossil fuels in transport, compared with the options with biofuels targets. In this case, other non-EUETS sectors would have to do more to meet overall energy and GHG targets.

The small market and lack of harmonised policy framework would be a barrier to investment in 2G biofuels. There would also be a risk to the development of 2G biofuels at all as the EU would be relying on policy in other regions to allow 2G biofuel companies to make a business case for growth, reducing the options available for long term GHG savings.

4.3 A GHG based-target has advantages in theory over an energy based target, although there is less experience with GHG targets

A GHG basis is perceived by some to have a stronger link to the policy aim than an energy target. In principle, it should be a more cost effective mechanism for GHG saving but, it is a weaker investable proposition than an energy basis, as it is harder for the market to anticipate supply and price, which could lead to targets not being met. In addition, uncertainty on contributions from different

[12] Estimated using the 1990 baseline of emissions ex. LULUCF of 5,626MtCO2e (Ref: http://newsroom.unfccc.int/media/262718/profile-eu.pdf)
[13] Estimated based on the Final Energy Consumption projections for 2030 in the EC Trends to 2050 report (Ref: https://ec.europa.eu/energy/sites/ener/files/documents/trends_to_2050_update_2013.pdf)
Cost of GHG savings are based on average EU gasoline and diesel prices between November 2014 and November 2015.

technologies e.g. UERs, EVs, biofuels, and uncertainty over their relative costs will lead to investor reluctance unless there are sub targets. Sub-targets reduce risk to each technology but also decrease short term economic efficiency and increase the risk of each sub-target, and the whole target, not being met.

There is less experience in GHG based targets than energy based targets. GHG-based approaches have only been adopted in Germany and California, which means there is less experience in policymaking and operation. The fact that the FQD has not been widely implemented also means that there is little experience from this policy.

The GHG basis has advantages and challenges in its operation. On the plus side it encourages competition between biofuels players to reduce their emissions, and innovate. As GHG savings of the fuels increase, volumes will go down. This is not a problem in itself for policymakers only interested in GHG savings, but if policymakers are also interested in other objectives such as renewable energy contribution, jobs etc., they will need to increase targets regularly. Moreover, individual companies would have an interest in reducing their emissions to gain an advantage, but the industry as a whole would be incentivised to maintain emissions levels to maintain market volumes. If a type of biofuel is found to be worse than previously thought in GHG terms e.g. ILUC, more will need to be supplied to meet the target. If there are associated non-GHG impacts these will increase too. Lastly, the GHG basis could lead to biofuel shuffling, i.e. imports of low GHG biofuels and exports of higher GHG biofuels, increasing emissions globally.

4.4 A GHG based-policy could still have an energy-based 2G sub-target

It is important to emphasise that a GHG-based biofuels target alone will not encourage 2G biofuels. Some argue that for a biofuel to be 2G, it should have higher GHG savings than 1G biofuels: this ignores the fact that 2G biofuels could have lower non GHG impacts, and allow access to new types of biomass resources

A 2G sub-target might arguably be better set on an energy basis than a GHG basis. There is even less market knowledge on volumes and GHG savings of 2G biofuels than of 1G ones. The 2G biofuels industry is also at an earlier stage, with higher technology risk, and so additional risk from a GHG-based policy has more of an impact. In addition there are fewer perceived concerns over the sustainability of 2G biofuels than 1G ones, meaning the perceived risk of an energy target will be lower.

A 2G sub-target set at 3% by energy in 2030 is reasonable based on our modelling and on ramp up estimates provided by the 2G biofuels industry. A buy-out from the sub-target is useful in limiting the cost of compliance for obligated parties, and reducing the risk of the policy being removed/not enforced. It also gives an indication of price to biofuels suppliers. If the target was set directly on fuel suppliers, rather than via MSs, this buy-out could be set at EU level, as with car CO_2 non-compliance penalties.

4.5 An energy based target could be a simpler approach, but there has been varying support for this type of approach

An energy based target is more straightforward to introduce and maintain than a GHG based target, both for policymakers and biofuels suppliers as there is more experience with energy based targets. In addition it is easier for policymakers to estimate the energy contribution from biofuels and the level of non GHG impacts such as feedstock demands and it is easier for the industry to plan, and to raise investment.

However, there have been concerns over biofuels' GHG impacts when driven primarily by the RED, despite the fact that including GHG thresholds ensures a minimum level of GHG saving.

There has been varying support for this type of approach, for example previous statements that the RED targets for transport will not be continued, compared with recent support from T&E for a "Clean Fuel Regulation" with credits on an energy basis, weighted by sustainability and innovation (see ICCT, 2015).

A sub target for 2G biofuels would work equally well as part of an energy or GHG target, with success depending on the level of the target, and the mechanism (e.g. buy out price).

4.6 Blending limits are the main factor that could limit ethanol

Blending limits are the biggest limiting factor for ethanol; EU-level targets, whether on an energy or GHG basis, would be needed to drive more countries to roll out E10 and and E20. Without this, there may be E10 and even E20 in some countries, but ethanol blending volumes may decline in others, and will decline in all with the projected reduction in volume of the gasoline pool.

Either a GHG or energy based target could encourage European 1G and 2G biofuels. The level of the target is more important than the mechanism, to support E10 and E20. A GHG based target could have benefits for ethanol, as ethanol often has higher GHG savings than biodiesel and so would have higher premiums. However, a GHG target is less transparent for planning purposes and a risk to industry through loss of market as GHG emissions decrease across the sector. In either approach, any continuation of double counting would reduce volumes and so reduce pressure to overcome the blend wall. The crop cap is not a limiting factor for ethanol according to this modelling. However, as countries can set lower caps (e.g. 1.5% is currently being discussed in the UK) this could be important in some markets.

4.7 Continued roll out of E10 and introduction of E20 would require other actions alongside EU biofuels targets

Incentives would be needed across the whole supply chain to facilitate the roll out of E20. These could induce actors in the supply chain to get the E20 standards process moving more quickly.

EU targets, implemented via MSs or directly on fuel suppliers, would incentivise fuel suppliers to supply higher blends. However, these policies could also be supported by additional policies to influence consumers and OEMs such as:

- Tax differentials for blends – as being introduced in France to support the move from E5 to E10
- Rebalancing of fuel taxation on gasoline, diesel and ethanol e.g. use of an energy or GHG basis
- Support for fuel suppliers to deploy E20 infrastructure
- Acknowledgement in policy of the importance of E20 (including in public procurement)
- Minimum octane requirements for fuels, which combined with biofuels policy would
    - encourage use of ethanol to provide the octane, and
    - ensure that base fuel quality is maintained when ethanol is blended

- Incentivising OEMs to produce E20 homologated vehicles through a credit towards car CO_2 targets once E20 is available
- Similarly, incentivising OEMs to declare their vehicles tolerant to E20
- Retrospective application of new fuel labelling rules to be introduced this year showing vehicle compatibility with different fuels (Fuel Labelling Directive), e.g. applied at annual check

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6 Annex: Additional information

6.1 Changes to underlying Autofuel model data

The following changes were made to the underlying Autofuel model data

- Feedstock costs have been updated with new FAOStat data
- GHG intensity of biofuels – changed to UK RTFO reported values where available, RED typical values where not (see section 6.4)
- Import tariffs on biofuels have been added (see section 6.3)
- Costs of 2G biofuels and some 1G biofuels have been updated
- E10 and E20 roll out has been changed according to the scenario assumptions
- Fossil fuel costs have been updated
- Build rates have been compared with data from members but existing data has been kept, as it was considered realistic and comparable

6.2 Feedstock Prices

Table 16: Feedstock prices used in model

Feedstock	Country/ Region	Price (€/tonne as received)	Source	Notes
Sugarcane	Brazil	18	FAO Stat 2007-2013	
	Colombia	14	FAO Stat 2007-2013	
	South Africa	28	FAO Stat 2007-2013	
Sugarbeet	EU	34	FAO Stat 2007-2010	Weighted average of top 6 sugarbeet producing countries in EU
Sweet Sorghum	Brazil	15	ICRISAT	
Wheat	EU	192	FAO Stat 2007-2013	Average of top 5 grain producing countries in EU
	Ukraine	112	FAO Stat 2007-2013	
	Russia	130	FAO Stat 2007-2013	
Corn	EU	182	FAO Stat 2007-2013	Average of top 5 corn producing countries in EU
	USA	143	FAO Stat 2007-2013	
Cassava	Nigeria	124	FAO Stat 2007-2013	
	Indonesia	132	FAO Stat 2007-2013	
Barley	EU	160	FAO Stat 2007-2013	

Feedstock	Country/ Region	Price (€/tonne as received)	Source	Notes
	Ukraine	115	FAO Stat 2007-2013	
Rapeseed Oil	Europe	842	AgraCEAS	
	Global	819	Index Mundi 2007-2014	
Soybean Oil	Global	721	Index Mundi 2007-2014	
Palm Oil	Colombia	681	FAO Stat 2007-2013	
	Nigeria	760	FAO Stat 2007-2013	
	Indonesia & Malaysia	527	FAO Stat 2007-2013	Average
Sunflower Oil	Global	932	Index Mundi 2007-2014	
Jatropha Oil	Latin America	729	Zelt, 20121	
	Africa	879	Zelt, 2012	
	Asia	819	Zelt, 2012	
Camelina Oil	EU, Ukraine	851	E4tech internal	
Microalgae Oil	UK, Oceania, MENA, EU	2437	Carbon Trust	
UCO	Europe	730	E4tech internal	
Tallow	Europe	779	E4tech internal	
Manure / Sewage	EU	10	E4tech internal	
Municipal / Industrial Waste	EU, Canada, Ukraine, Russia, USA	0	E4tech internal	
2G - Woody	EU, Canada, Ukraine, Russia, USA, Brazil, ROW	34 (€/dry tonne)	Biomass Futures	
2G – Residues	EU, Canada, Ukraine, Russia, USA, Brazil, ROW	58 (€/dry tonne)	Biomass Futures	
2G – Energy Crops	EU, Canada, Ukraine, Russia, USA, Brazil, ROW	62 (€/dry tonne)	Biomass Futures	
Aquatic Biomass	EU, Canada, Ukraine, Russia, USA	442	Biomass Futures	

6.3 Tariffs

Table 17: Ethanol and 2G ethanol tariffs applied in the model

Fuel	Country of Origin	Tariff (€/hl)[14]	Additional Duties (€/tonne)
Ethanol & 2G ethanol	EU	0	
	Ukraine	10.2 (first 27,000 tonnes imported is exempt from tariff)	
	USA	10.2	62.3 (anti-dumping duty[15])
	Canada[16] Central Africa South-East Asia Brazil Russia ROW	10.2	

Table 18: FAME, HVO and 2G diesel tariffs applied in the model

Fuel	Country of Origin	Tariff (% of price)	Additional Duties (€/tonne)
FAME, HVO and 2G diesel	EU	0	
	Ukraine	6.5	
	USA Canada	6.5	409.2 (anti-dumping duty & countervailing duty)
	Argentina	6.5	236.89 (anti-dumping duty)
	Central Africa Southern Africa South-East Africa South-East Asia South America (other) MENA Oceania Brazil Russia ROW	6.5	

[14] Tariffs for denatured ethanol are used. It is assumed that countries with duty free access to the EU will typically export undenatured ethanol to the EU, while countries without duty free access will typically export denatured ethanol to the EU (since this has a lower import duty).
[15] Anti-dumping duties have been kept in the modelling, as even though an expiration date is set before 2020, the conditions that led to their introduction do not appear to have changed and so there is uncertainty about whether they will expire or be extended.
[16] This could change in the future if the EU-Canadian free trade agreement is ratified and implemented, although this will not significantly change the results.

6.4 GHG Emissions

For the fuel chains not listed below (i.e. many of the 2G fuels supplied in low quantities), GHG emissions were estimated by E4tech from a variety of literature sources.

Table 19: GHG emissions values used in the model

Pathway	GHG emissions from UK RTFO (RED Typical Value if not reported by UK RTFO) $gCO_2eq./MJ$
Sugar beet ethanol	32
Wheat ethanol (process fuel not specified)	41
Corn (maize) ethanol, Community produced (NG as process fuel in CHP plant)	29
Sugar cane ethanol	27
Rape seed biodiesel	51
Sunflower biodiesel	(35)
Soybean biodiesel	43
Palm oil biodiesel (process not specified)	42
Waste vegetable or animal oil biodiesel	15
Hydrotreated vegetable oil from rape seed	(41)
Hydrotreated vegetable oil from sunflower	(29)
Hydrotreated vegetable oil from palm oil	(38.5)[17]
Pure vegetable oil from rape seed	(35)
Biogas from municipal organic waste as compressed natural gas	10
Biogas from wet manure as compressed natural gas	(13)
Biogas from dry manure as compressed natural gas	(12)
Wheat straw ethanol	(11)
Waste wood ethanol	(17)
Farmed wood ethanol	(20)
Waste wood Fischer-Tropsch diesel	(4)
Farmed wood Fischer-Tropsch diesel	(6)
Waste wood DME	(5)
Farmed wood DME	(7)
Waste wood methanol	(5)
Farmed wood methanol	(7)

[17] Average taken of typical values with and without methane capture