Department for Transport

Annex A
Cost benefit analysis for:
Targeting net zero - Next steps for the Renewable Transport Fuels Obligation

Moving Britain Ahead

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Contents

Executive summary

1.1 Climate change is the most pressing environmental challenge of our time. There is a need to limit global warming to well below 2°C and the government have committed to end the UK's contribution to climate change by 2050. In line with the recommendation from the independent Climate Change Committee the government announced in April 2021 that it would set the sixth carbon budget to reduce emissions by 78% by 2035 compared to 1990 levels. To achieve these goals will require rapid and unprecedented action across the UK economy and wider society, supported by technology innovation and robust policy frameworks.

1.2 Low carbon fuels can deliver emissions reductions quickly and will play a key role in reducing emissions from the existing fleet and in transport sectors which cannot currently be easily electrified. These fuels have been supported in the UK for over a decade, principally by the Renewable Transport Fuel Obligation (RTFO). The RTFO commenced on 15 April 2008 and has already made a significant contribution to reducing emissions from transport, by mandating the supply of renewable fuels. However, amendments to the current target are vital to meet government's ambitious decarbonisation goals.

1.3 In line with this, in March 2021, the Department for Transport (DfT) consulted on a range of policy options for increasing the main RTFO target, including raising it by 1.5 percentage points, 2.5 percentage points, five percentage points, and not raising the target at all. Following analysis of the consultation responses and further consideration, the government have decided to increase the RTFO main obligation by 5%. This is expected to lead to significant additional GHG emissions savings compared to the current policy, giving the biggest contribution towards our Net Zero target of the options we consulted on. The target increase is estimated to generate between 19.3 and 23.6 MtCO2e of GHG savings between 2022 and 2032, depending on the speed with which electric vehicle uptake increases.

1.4 The government consultation also set out options for extending the eligibility of development fuels in the RTFO, including making RFNBOs used in maritime, rail and non-road vehicles and recycled carbon fuels (RCFs) eligible for support (further details are provided in the government's consultation response). These development fuels are of particular strategic importance. Following consideration of the responses received to the consultation the government have decided to proceed with the proposals, which are projected to lead to additional GHG emissions savings of between 2.3 to 6.4 MtCO2e across 2022 to 2032.

1.5 Together, the combined policy changes are projected to lead to an additional 21.6-30.0 MtCO2e savings. The annual GHG emission savings increase over time and are equivalent to the removal of an additional 1.9 million petrol/diesel cars from the road by 2032[1].

1.6 This cost-benefit analysis sets out the impacts of the policy measures in further detail and compares these to the costs and benefits of other options set out in the consultation.

[1] We have assumed the 2018 average car GHG emissions figure of 2.10710196170565 tCO2e is constant throughout the 2022-2032 appraisal period.

Changes to the main RTFO obligation

Key assumptions and methodology

The costs and benefits of the measures are appraised over the period 2022 to 2032, as this is the period over which the changes are implemented. Charts and tables show GHG emissions savings up to 2035, to demonstrate the ongoing impact of the measures and their contribution towards Carbon Budget 6. The analysis sets out the costs and benefits of the government’s chosen approach and compares this against the other options that were consulted on, as well as against a do-nothing baseline.

The consultation options are set out below – see Fig. 1 for the resulting trajectories.

Baseline - do nothing. The main obligation would remain at 9.6% throughout the entire period until 2032. This option acts as our baseline against which we can compare the effect of increasing the RTFO target.

Option 3 (chosen option) - 5 percentage point increase to the main obligation. The target will initially increase by 1.5 percentage points in 2022, and then increase by a further 3.5 percentage points over the period 2023 to 2032, resulting in a main obligation of 14.6% in 2032 and beyond.

Option 1 - 1.5 percentage point increase to the main obligation. This applies from 2022 and would result in a main obligation of 11.1% in 2022 and beyond.

Option 2 - 2.5 percentage point increase to the main obligation. This applies as a 1.5 percentage point increase in 2022, with an additional 1 percentage point increase over the period from 2023 to 2032, resulting in a main obligation of 12.1% in 2032 and beyond.

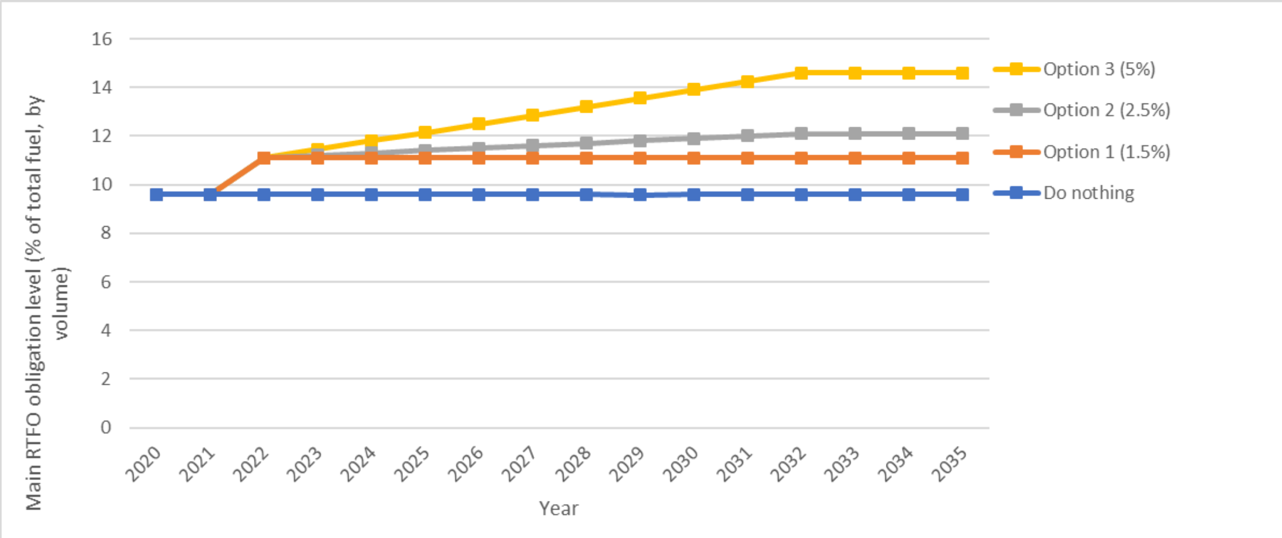

Figure 1 - Chart showing the main RTFO target trajectory under the options that were consulted on (2020-2035)

The costs and benefits of increasing the main RTFO obligation depend heavily on the projected demand for transport fuel over the coming years and decades. The government provides trajectories of transport fuel demand in its annual Energy Emission Projections (EEP)[2], which reflect all firm and funded policies and are typically used as the basis for assessing the impact of new policies. However, these projections do not currently reflect the government's commitment to end the sale of petrol and diesel vehicles by 2030, and for all new vehicles to be zero emission by 2035, which has the potential to significantly reduce the projected demand for transport fuel.

Several respondents to the consultation raised the issue of greater electric vehicle (EV) uptake, and its impact on the future demand for transport fuel and, in turn, the costs and benefits of an RTFO target increase. In recognition of the significant uncertainty over future fuel demand, the costs and benefits of the policy have been assessed against different scenarios – the projections set out in the 2019 Energy Emission Projections along with projections based on a rapid acceleration in the uptake of EVs over the 2020s, reaching 80% of vehicle sales in 2030 and 100% in 2035. The impact of increasing the RTFO target is expected to lie within this range presented.

The analysis also takes into consideration the expected rollout of E10 - a petrol with a higher blend of ethanol - in autumn 2021. Without any increase in the main RTFO target, the increased bioethanol supply due to E10 rollout is assumed to displace biodiesel derived from used cooking oil (UCO). This is in keeping with the Impact Assessment accompanying the government's announcement on introducing E10.

[2] Energy and emissions projections - GOV.UK (www.gov.uk)

Assumptions on fuels supplied under the RTFO

To estimate the costs and benefits of an increase in the main RTFO target, it is necessary to make assumptions about the order in which specific fuels fill the renewable fuel demand under the RTFO.

In all scenarios, crop derived bioethanol is assumed to be the first fuel that is supplied to meet the main RTFO obligation. This is in keeping with the fact that ethanol has historically been the renewable fuel with the lowest market price. Although we recognise that this may not always be the case at all points in the future, it is likely to continue being the cheapest. Ethanol is assumed to be supplied up to its maximum potential – that is, up to the E10 blend wall (we assume up to 9.8% in our modelling).

Biomethanol is modelled alongside bioethanol. They are presented together within the results and labelled as 'ethanol' as bioethanol comprises the substantial majority of the bioethanol/biomethanol component.

The RTFO includes a crop cap which limits the amount of crop-based biofuels which can be supplied. The level of the crop cap decreases over time from 4% in 2020 to 2% in 2032. Around 2026 the crop cap is filled, and it is assumed that waste-derived ethanol will replace the previously supplied crop derived ethanol.

After bioethanol/biomethanol, biodiesel derived from used cooking oil (FAME UCO) is assumed to fill any remaining demand up to the biodiesel blend wall, which is 7% of the standard diesel blend (B7). This is because of its cheaper cost relative to other renewable fuels with the exception of bioethanol. Because bioethanol and biomethanol are already being supplied up to their maximum potential in the baseline, FAME UCO is assumed to be the first fuel supplied to fill the additional demand when the target is increased. Hence, FAME UCO is the first marginal fuel. Feedback was sought on this during the consultation and the majority of respondents agreed with this assumption.

After FAME UCO is filled up to the 7% blend wall, drop-in biodiesel is assumed to be supplied to fill any remaining renewable fuel demand under the RTFO. Drop-in biodiesel can be substituted for conventional fossil fuel with no impact on operational requirements. These can be blended into standard fuels above the blend wall (B7), with the fuel still complying with the same fuel standard as before. The most common biodiesel drop in fuel is hydrogenated vegetable oil (HVO).

Finally, any remaining demand is assumed to be met by high blend biodiesel, which refers to diesel blends which are blended with biofuels at a higher percentage than contained in standard blends (i.e. B7 and E5/E10 - for ethanol) or, above the so called "blend wall". At or below the current blend wall, vehicles do not need to be adapted to accommodate the biofuel. However, to use high blends some adaptions may be needed. Typical high blends are petrol with up to 20% (E20) or 65% to 85% ethanol (E85) and diesel with up to 30% (B30) or up to 100% biodiesel (B100).

The model has also assumed the use of biomethane in HGVs to grow over the next 15 years, with a growing volume of methane trucks displacing some diesel trucks.

CBA outputs

The key outputs of the cost-benefit analysis are presented below:

- Additional costs (£ millions)
- Additional GHG emissions savings (MtCO2e)
- Additional monetised GHG emissions savings (£ millions)
- Net present value[3] (NPV) of RTFO target increase option (£ millions)
- Carbon cost effectiveness (CCE) of RTFO target increase option (£/tCO2e) - this is a measure of how cost-effective the policy is in reducing carbon emissions.

The costs and benefits of the target increase are compared against the current RTFO policy (baseline/do-nothing option) across the appraisal period (2022 to 2032). Unless otherwise specified, all modelled outputs refer to additional costs and benefits relative to the do-nothing option (that is, the extra costs and benefits accrued relative to no changes being made).

Costs

The estimated cost of supplying different fuels is based on data from Argus Media. This provides historical prices of renewable fuels and fossil fuels which are then used as a basis for estimating future costs. As renewable fuels are typically more expensive to supply per litre than fossil fuels, increases to the RTFO target are expected to result in increased costs for fuel suppliers. It is anticipated that fuel suppliers will in turn pass these additional costs on to the motorist through the cost of the fuel. The different energy densities of each fuel have also been factored into the cost calculations.

To estimate the costs associated with an increase to the main RTFO target:

- First, we estimated the number of additional certificates required to meet the new obligation
- Then, the number of litres[4] of each type of biofuel required to obtain that number of certificates was estimated. The projected volume of fuels required was calculated in line with the assumed hierarchy order of fuels outlined above (and takes account of

[3] Net present value (NPV) - economic appraisal technique whereby discounted costs are subtracted from the discounted benefits of a policy. This resulting figure provides an indication of value for money linked to the policy.

[4] Some gaseous fuels such as biomethane are measured in kgs instead of litres

fuels that are eligible for double reward or which have a multiplier applied to the RTFCs they are eligible to receive)

- Next, the price-spread difference for each biofuel relative to the fossil fuel it would displace was estimated using the fuel prices data from Argus

- Each price spread was then multiplied by the projected volumes of the relevant biofuel to derive the total additional costs of the target increase (in £ millions).

The price-spread between renewable fuels and fossil fuels is central to the cost of the target increase; however, market volatility makes it extremely difficult to predict how these price-spreads will change over time. For the purposes of this cost-benefit analysis it is assumed that the price-spread between biofuels and fossil fuel equivalents remains constant at present levels throughout the appraisal period. However, in recognition of the significant degree of uncertainty around this, low and high price spread figures have also been used to test the sensitivity of these results to different price assumptions and present a range of potential costs. The central price assumptions (price spreads held constant at present levels) have been used to present the overall NPV and CCE figures.

Benefits

The benefits of increasing the main RTFO target arise from renewable fuels generating lower carbon emissions per litre than their fossil fuel equivalent. In general, the higher the supply of renewable fuels, the higher the GHG emissions savings accrued. However, as GHG savings vary by feedstock it is important to take that into account. To estimate the carbon savings associated with the higher target:

- The number of additional certificates required to meet the new obligation was first estimated

- Then the number of litres of each type of biofuel required to obtain that number of certificates was estimated. The projected volume of fuels required was calculated in line with the assumed hierarchy order of fuels outlined above (and takes account of fuels that are eligible for double reward or that have a multiplier applied to the RTFCs they are eligible to receive)

- The well-to-wheel carbon emissions of the different biofuels were then compared to the carbon emissions of the fossil fuel equivalents they displace, and the difference used to estimate the GHG emissions savings (expressed in MtCO2e) of the increased volume of biofuels.

The GHG emissions savings have been monetised to translate them into a financial value that can be compared to the estimated costs. To do this, the estimated carbon savings in each year were multiplied by the government’s current central carbon appraisal value. Because the carbon appraisal value increases over time, carbon savings in later years may equate to a higher monetised value compared to earlier years.

Annual costs and benefits estimates have been discounted in line with the HMT Green Book guidance, and then used to estimate the net present value of the measures. All input assumptions and values are in line the latest published data.

Results

Table 1 summarises the headline results for the different options put forward in the consultation to increase the main RTFO target. The government's chosen policy is shown to result in the greatest GHG emission savings and benefits. It also results in the greatest overall cost, although in terms of the cost per tonne of carbon equivalent (CCE) it is comparable to the other options. Ranges reflect the alternative EV uptake projections and are presented for central price assumptions and carbon values.

	Additional discounted costs (£million)	Additional benefits (MtCO2e)	Additional discounted benefits (£million)	Net present value (£million)	Carbon cost effectiveness (£/tCO2e)
Do nothing	-	-	-	-	-
1.50%	1,610 - 1,884	9.2 – 10.9	642 - 756	-968 to -1,128	175
2.50%	2,077 - 2,458	12.1 - 14.5	838 - 998	-1,239 to -1,460	170
5.0%	3,243 - 3,894	19.8 - 23.6	1,326 - 1,604	-1917 to -2,289	165 - 170

Table 1 - Discounted central monetised additional benefits, costs, NPV and CCE values of each increase to the main RTFO target, relative to the do-nothing baseline

It is likely that the additional costs of supplying renewable fuel will be passed on to the motorist through an increase in fuel prices at the pump. The estimated rise in costs, in pence per litre of fuel is shown in Table 2. The rate of EV uptake is not expected to affect the price per litre. This is due to a higher rate of EV uptake reducing the cost of supplying renewable fuels at the same rate of decline in fuel supply volumes. The chosen RTFO target increase is expected to result in an initial 0.5 pence per litre (including VAT) increase in 2022, rising to a total increase of 1.6 pence per litre by 2032, which is a little over 1% of current petrol and diesel prices.

Year	Do nothing	1.50%	2.50%	5.0%
2020	0.0	0.0	0.0	0.0
2021	0.0	0.0	0.0	0.0
2022	0.0	0.5	0.5	0.5
2023	0.0	0.5	0.5	0.6
2024	0.0	0.5	0.6	0.7
2025	0.0	0.5	0.6	0.8
2026	0.0	0.5	0.6	1.0
2027	0.0	0.5	0.7	1.1
2028	0.0	0.5	0.7	1.2
2029	0.0	0.5	0.7	1.3
2030	0.0	0.5	0.8	1.4
2031	0.0	0.5	0.8	1.5

Year	Do nothing	1.50%	2.50%	5.0%
2032	0.0	0.5	0.8	1.6
2033	0.0	0.5	0.8	1.6
2034	0.0	0.5	0.8	1.6
2035	0.0	0.5	0.8	1.6

Table 2 - Potential impacts on the cost of fuel arising from increasing the main RTFO target (VAT included). Figures shown are not cumulative.

More detailed results for the chosen option, and other consultation options, are presented below, after a brief summary of the estimated outcomes from the current RTFO policy i.e. the 'baseline – Do Nothing' option.

Baseline – Do Nothing

In 2019 the RTFO saved 4.9 MtCO2e, equivalent to taking approximately 2.3 million petrol/diesel cars off the road.

Waste-derived biodiesel and crop derived bioethanol/biomethanol currently account for the vast majority of the renewable fuel supply. Bioethanol is projected to make up a greater share of fuel in 2022, at the expense of waste-derived biodiesel, as E10 is introduced. An increasing share of bioethanol is projected to be derived from wastes as the crop cap limits the amount of crop-based fuels that can be accommodated.

Without any change to the RTFO target, waste-derived biodiesel is then projected to experience a continued fall over the next decade, as overall fuel demand declines, and in keeping with assumptions about the order in which biofuels are supplied.

Biomethane volumes are projected to rise due to the expected increase in vehicles which can use biomethane as fuel, and this is expected to further displace waste-derived biodiesel.

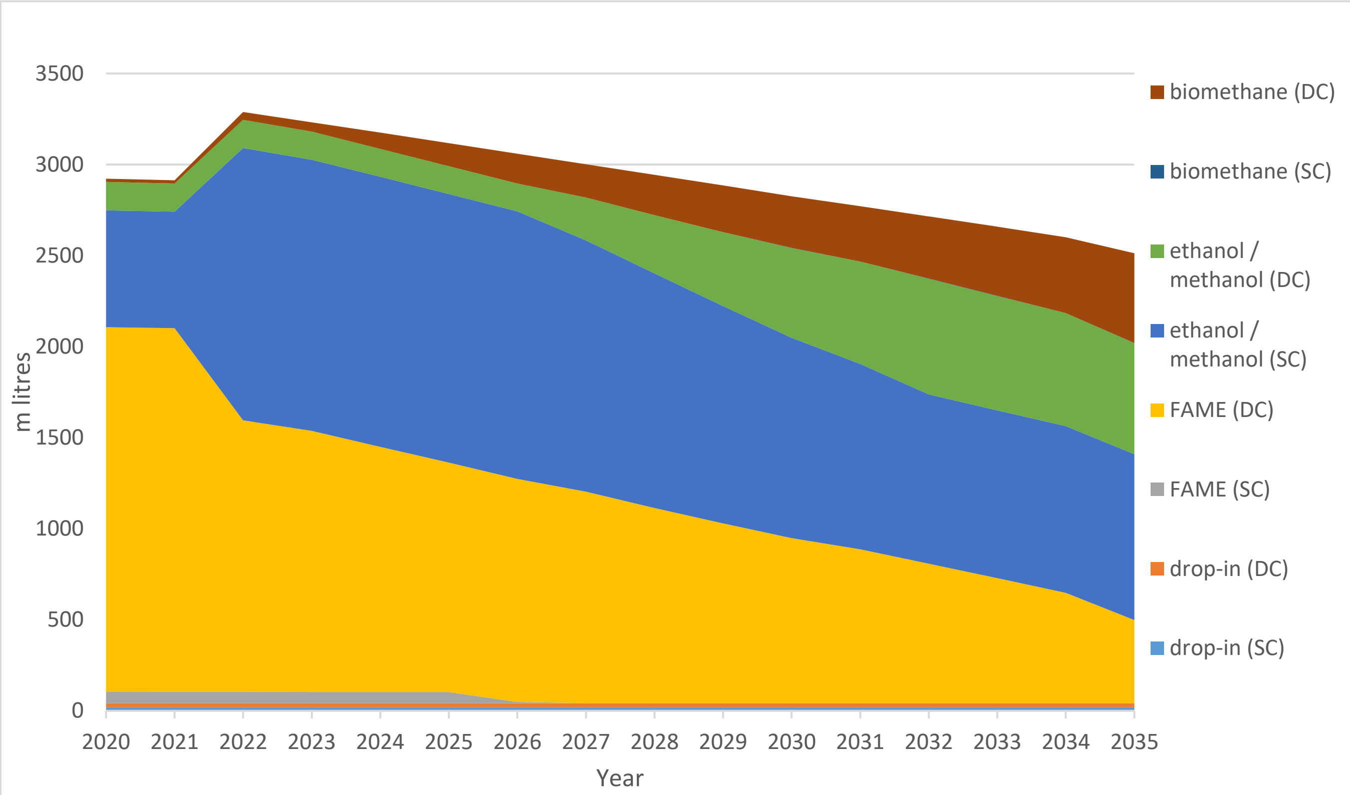

Figure 2 - Renewable fuel supply projections under the main RTFO – (EEP)

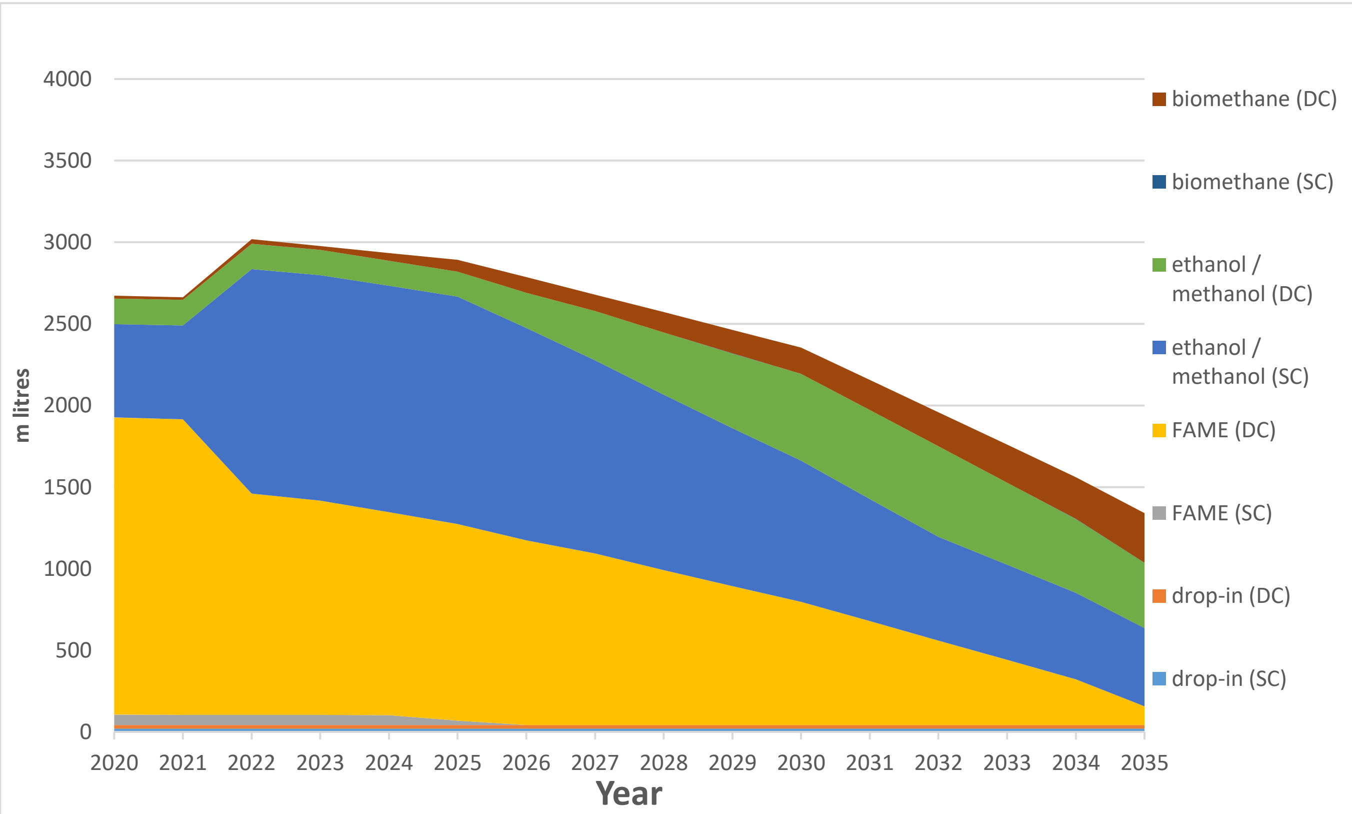

Figure 3 - Renewable fuel supply projections under the main RTFO – high EV

Option 3 - 5 percentage point increase to the main RTFO target (chosen option)

The government's chosen option is to increase the main RTFO target by five percentage points. This is expected to result in the greatest emission savings of all the options consulted on. Depending on the rate of EV uptake and subsequent fuel demand over the period the policy is expected to generate an additional 19.8 to 23.6 MtCO2e of GHG savings across the appraisal period, from 2022 to 2032.

Year	MtCO2e	MtCO2e
	EEP	High EV
2020	0.0	0.0
2021	0.0	0.0
2022	1.0	0.9
2023	1.3	1.2
2024	1.5	1.4
2025	1.7	1.6
2026	1.9	1.7
2027	2.2	1.9
2028	2.4	2.0
2029	2.6	2.2
2030	2.8	2.3
2031	3.0	2.3
2032	3.2	2.3
2033	3.2	2.1
2034	3.2	1.9
2035	3.1	1.7

Table 3 - Additional GHG emissions savings for 5 percentage point increase to the main RTFO target for both EEP and High EV (2020-2035)

As well as delivering the greatest benefits, a five percentage point increase in the main RTFO target is predicted to result in the highest costs (see Table 4), resulting in an overall net present value of -£1917 to -£2,289 million. Whilst the costs are greatest under this option, the policy compares well in terms of the cost per tonne of carbon saved, at an estimated £165 to 170/tCO2e. This is similar to the other target increases and within the range of cost effectiveness for measures required to meet the government's carbon commitments.

	Discounted benefits (£million)		Discounted costs (£million)		Net benefit (£million)	
	EEP	High EV	EEP	High EV	EEP	High EV
Year	Central	Central	Central	Central	Central	Central
2020	0	0	0	0	0	0
2021	0	0	0	0	0	0
2022	77 (39-115)	71 (35-105)	210 (133-363)	191 (121-331)	-132 (-324 to -18)	-121 (-296 to -17)
2023	93 (46-139)	85 (42-126)	248 (158-421)	226 (144-384)	-156 (-376 to -19)	-142 (-342 to -17)
2024	107 (54-161)	98 (49-146)	283 (180-471)	258 (163-428)	-176 (-417 to-19)	-160 (-379 to -17)
2025	121 (61-182)	110 (56-165)	315 (200-512)	286 (181-465)	-194 (-451 to -18)	-176 (-409 to -16)

2026	133 (67-200)	118 (59-178)	343 (217-546)	304 (193-485)	-209 (-480 to -17)	-186 (-426 to -15)
2027	145 (73-218)	126 (64-189)	368 (233-574)	319 (202-497)	-223 (-500 to -15)	-193 (-434 to -13)
2028	158 (78-236)	133 (66-199)	390 (247-596)	329 (209-503)	-242 (-518 to -12)	-196 (-438 to -10)
2029	168 (84-252)	138 (69-207)	410 (260-613)	337 (214-504)	-242 (-529 to -8)	-199 (-435 to -7)
2030	177 (87-265)	141 (70-211)	427 (271-626)	341 (216-500)	-250 (-538 to -6)	-200 (-430 to -5)
2031	200 (100-299)	150 (75-225)	443 (281-636)	332 (211-477)	-243 (-536 to 18)	-182 (-402 to 14)
2032	225 (112-337)	157 (79-236)	457 (290-642)	320 (203-450)	-232 (-530 to 47)	-163 (-371 to 33)
		Total additional net benefits (net present value - £million, appraisal period 2022-2032)				**-1,917 to - 2,289**
		Carbon cost effectiveness (£/tCO2e, appraisal period 2022-2032)				**165 - 170**

Table 4 - Discounted additional benefits and costs, total additional net benefits and carbon cost effectiveness for increasing the main RTFO target by five percentage point (2020-2032), presented as a range between EEP and High EV results

The chosen target increase is expected to result in a greater volume of biofuels. In line with the assumptions set out above, the increase is expected to be met mainly through waste-derived biodiesel. Depending on the overall level of fuel consumption the target increase could lead to a slight increase in biofuels over the appraisal period. After a sharp increase in ethanol from 2021-2022 due to the introduction of E10, volumes of bioethanol and waste-derived biodiesel maintained at broadly the same level over the period. Under a scenario where fuel demand drops more quickly, waste-derived biodiesel is expected to reach the B7 limit in the late 2020s, and drop-in biodiesel is projected to be required to fill some of the obligation. If produced from sustainable waste feedstocks, drop-in fuels provide an opportunity to achieve further greenhouse gas savings from conventional road vehicles with little to no adaptations required.

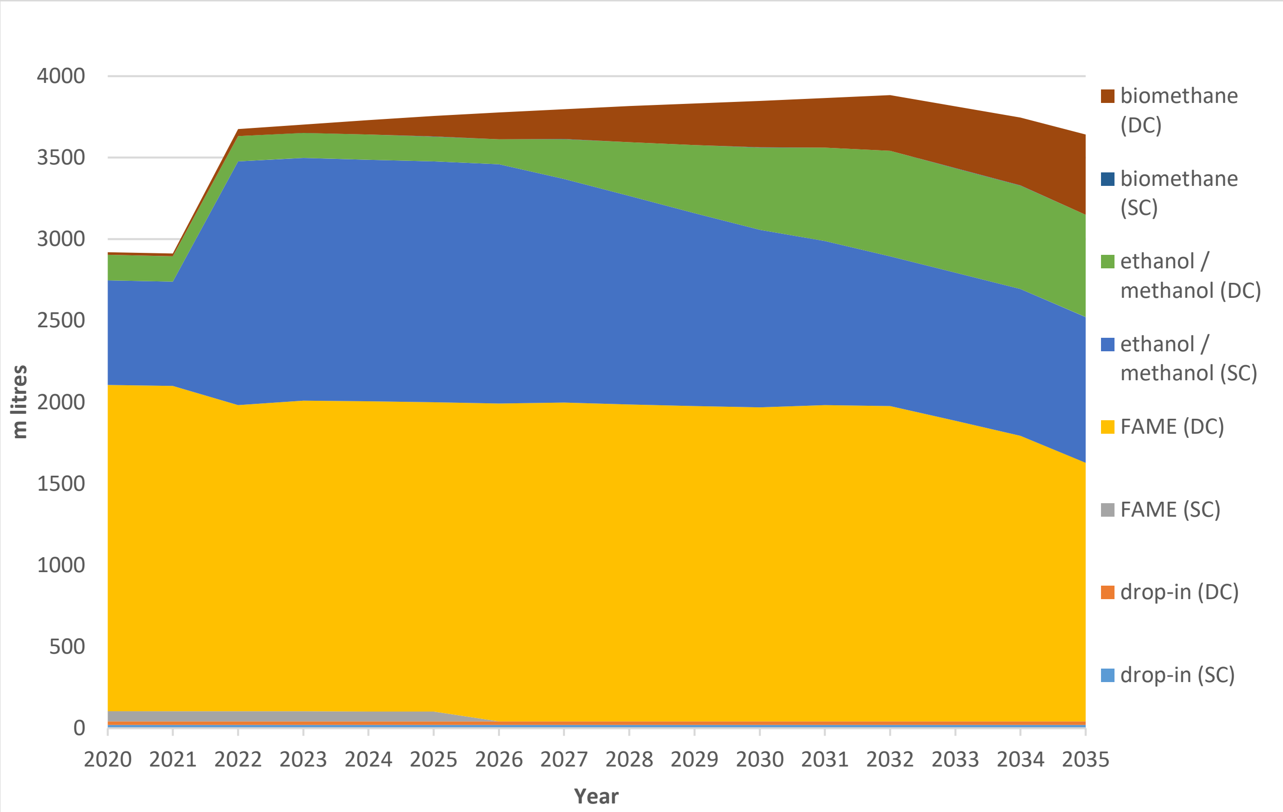

Figure 4 - Renewable fuel supply projections under the main RTFO – 5 percentage point target (EEP)

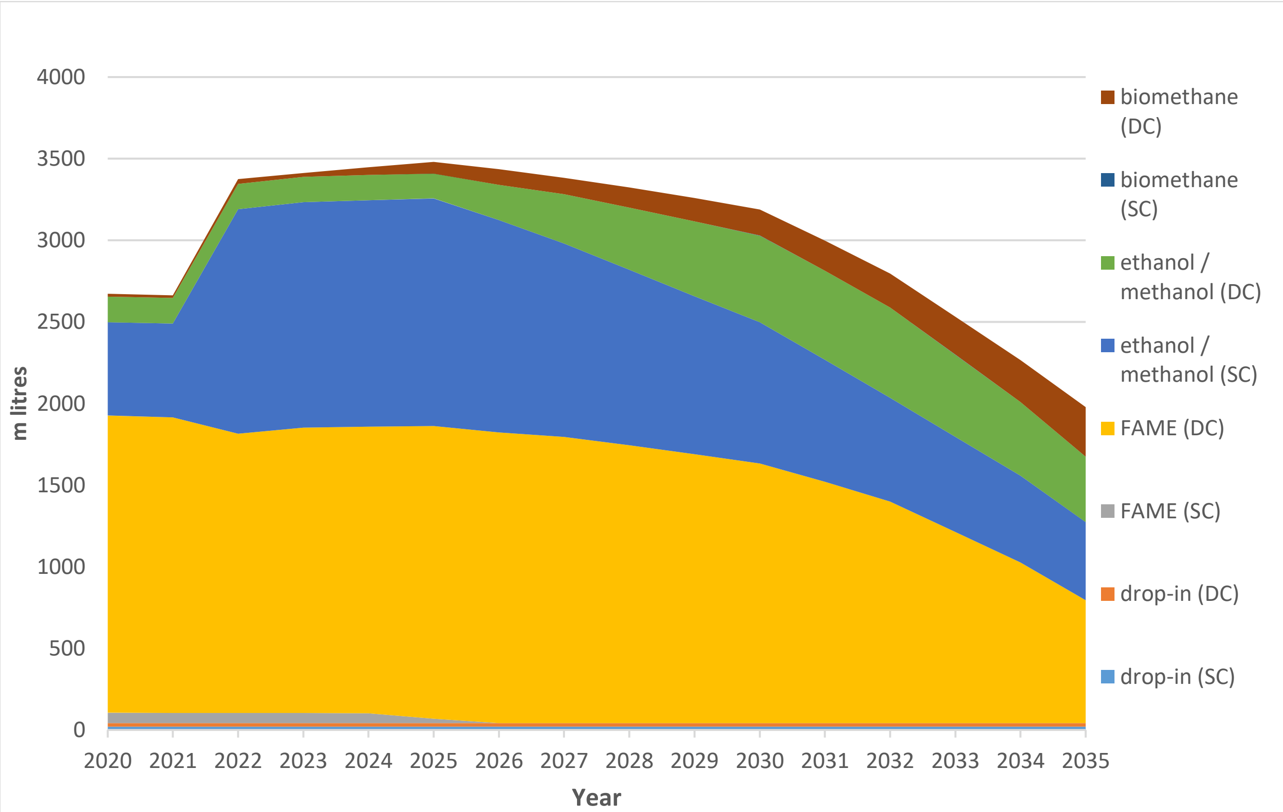

Figure 5 - Renewable fuel supply projections under the main RTFO – 5 percentage point target (High EV)

To understand more fully the range of outcomes that might arise under the government's chosen option, two further scenarios have been tested. Building on feedback received during the consultation, the impact of a 5 percentage point target increase on the biofuel mix has been assessed under a scenario where (i) biomethane demand does not grow as quickly as expected; and (ii) waste-derived bioethanol is not available in the quantities required for bioethanol to continue to be blended to the E10 blend-wall as the crop cap tightens. These options have been chosen to examine the impact of the B7 blend wall on the required biodiesel supply.

The results are summarised in Figures 6 to 9 below. In both cases, volumes of waste-derived biodiesel is projected to rise to meet the obligation that would otherwise have been filled by biomethane or waste-derived bioethanol. However, in either case waste-derived biodiesel cannot fully compensate for the lower volumes of the other fuels, due to the biodiesel blend wall being reached. Drop-in biodiesel, or high blends, is required in each scenario to meet the increased obligation because the maximum amount of B7 would be reached.

Sensitivity 1 - Lower biomethane growth

The charts below show projected biofuel supply under the main RTFO in a scenario where biomethane volume grows at only half the rate assumed in the central analysis.

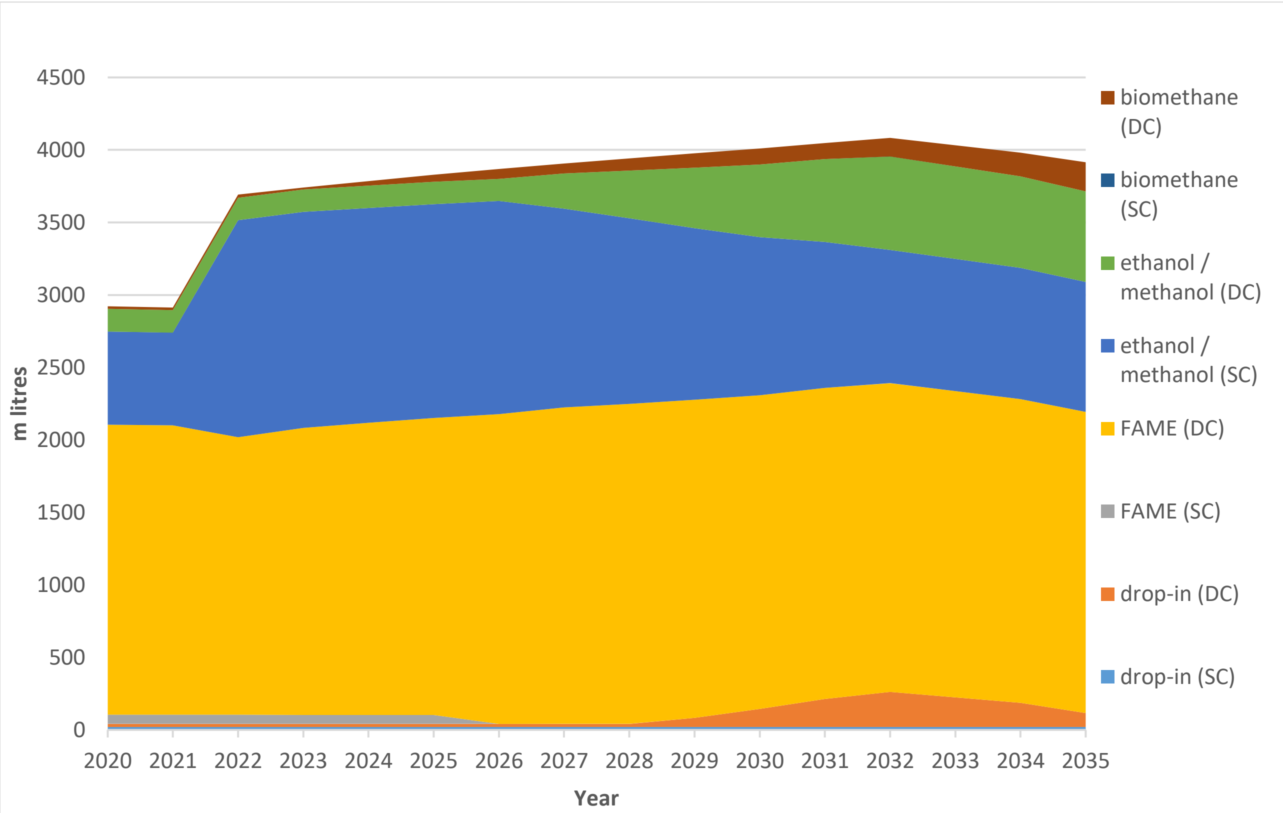

Figure 6 - Renewable fuel supply projections under the main RTFO – 5 percentage point target increase with lower biomethane (EEP)

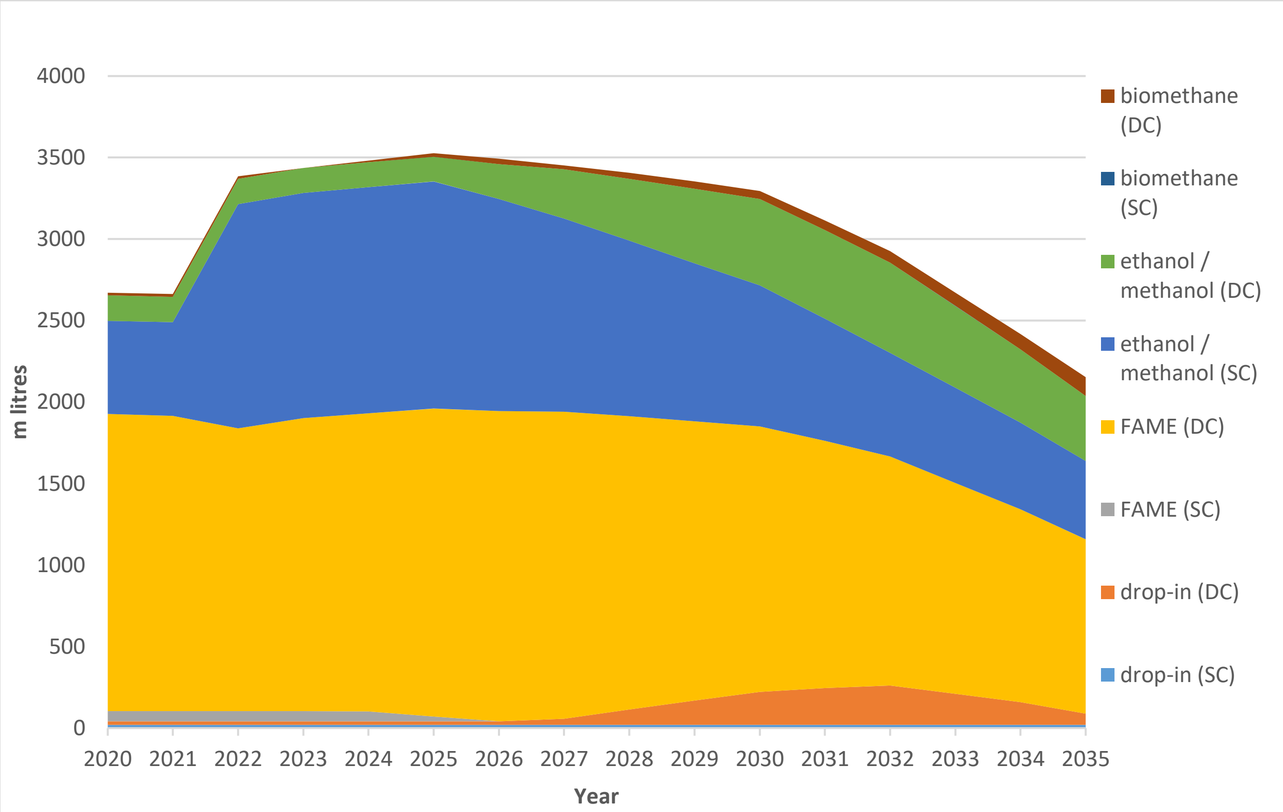

Figure 7 - Renewable fuel supply projections under the main RTFO – 5 percentage point target increase with lower biomethane (high EV)

Sensitivity 2 - Low waste-derived bioethanol growth

The charts below show projected biofuel supply under the main RTFO in a scenario where volumes of waste-derived bioethanol are not available in the quantities required to ensure bioethanol can continue to be blended up to the blend wall after the crop cap tightens. In this scenario, ethanol (DC) is flatlined and FAME (DC) is supplied instead due to it being the marginal fuel. FAME (DC) is therefore supplied up to the B7 blendwall, after which drop-in biodiesel is supplied.

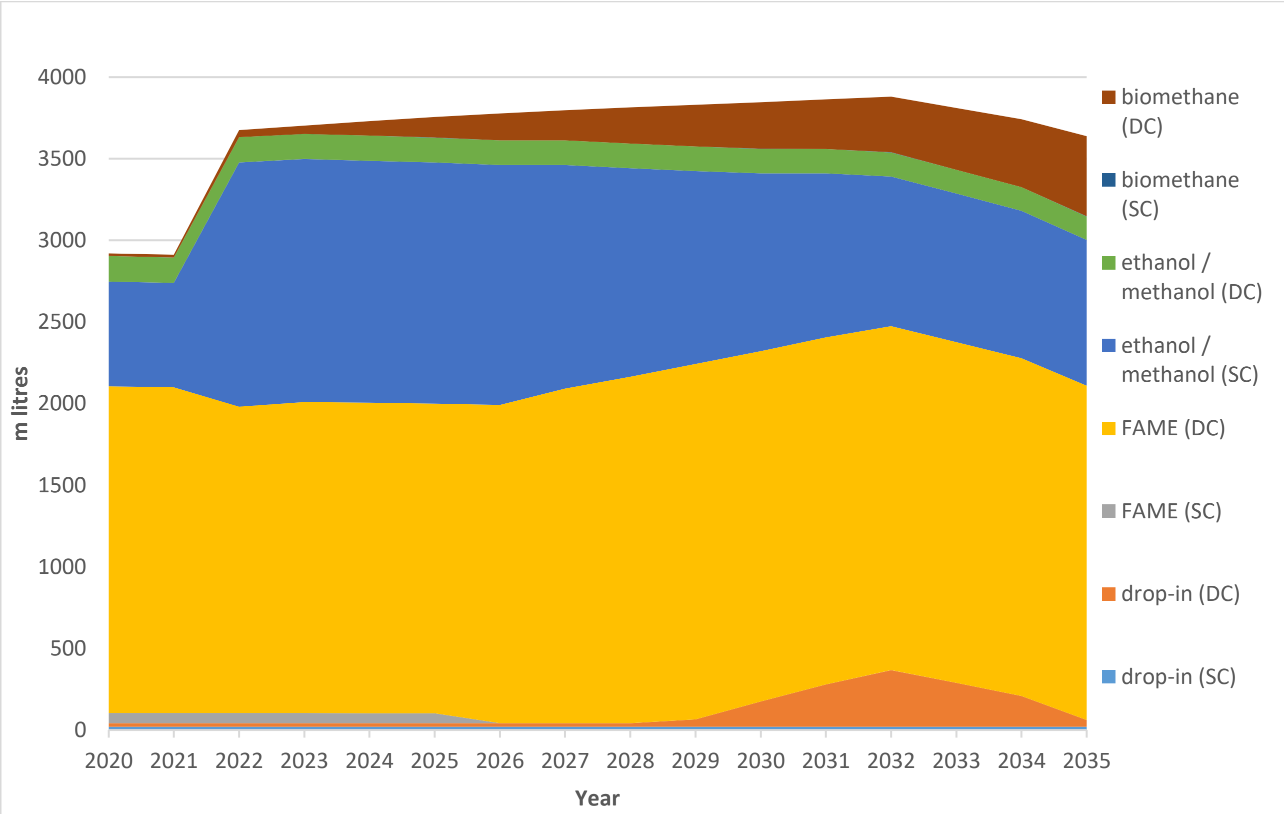

Figure 8 - Renewable fuel supply projections under the main RTFO – 5 percentage point target increase with ethanol DC flatlined (EEP)

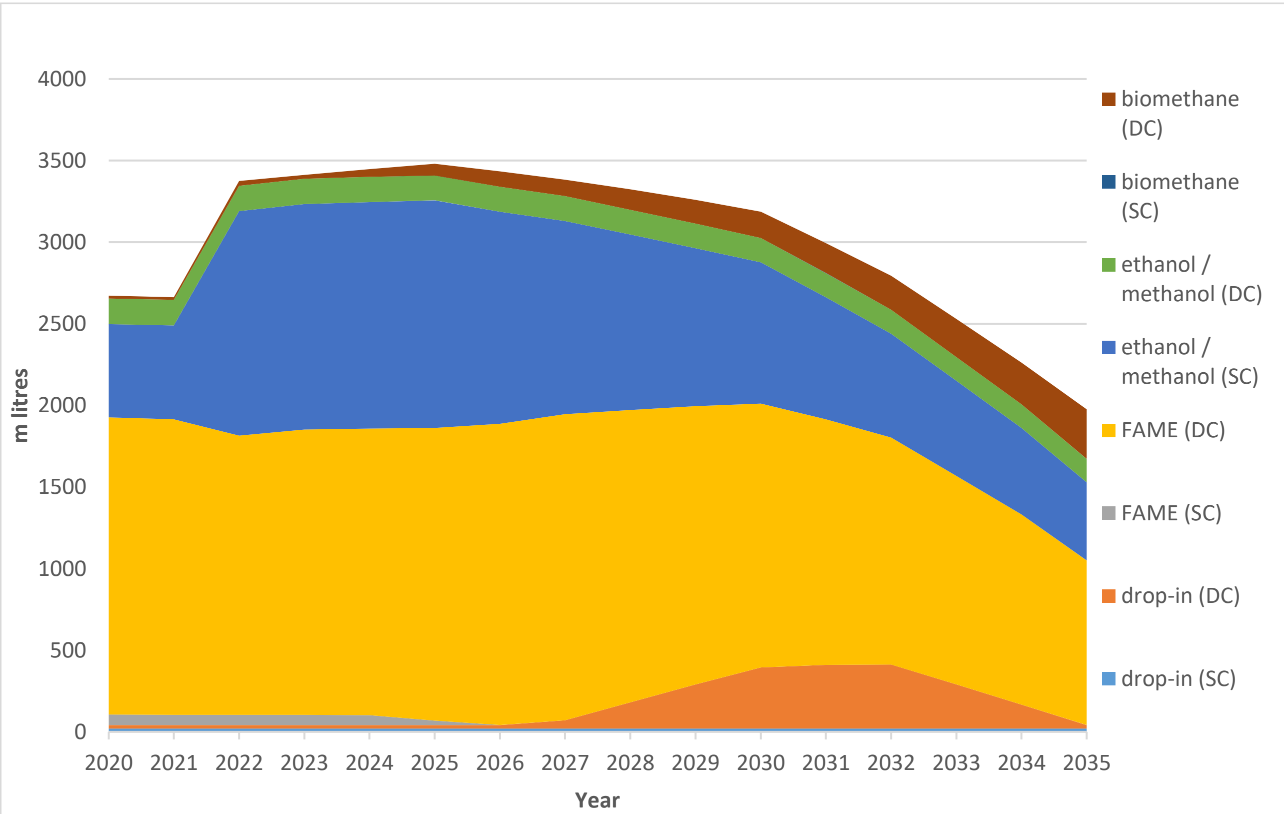

Figure 9 - Renewable fuel supply projections under the main RTFO – 5 percentage point target increase with ethanol DC flatlined (High EV)

Option 2 – 2.5 percentage point increase to the main RTFO target

Option 2 is projected to lead to additional GHG savings of 12.1 to 14.5 MtCO2e across the appraisal period, from 2022-2032, depending on the level of EV uptake and fuel demand over the next 15 years. See Table 5.

Year	MtCO2e	MtCO2e
	EEP	EV
2020	0.0	0.0
2021	0.0	0.0
2022	1.0	0.9
2023	1.1	1.0
2024	1.2	1.0
2025	1.2	1.1
2026	1.3	1.1
2027	1.3	1.1
2028	1.4	1.2
2029	1.4	1.2
2030	1.5	1.2
2031	1.5	1.1
2032	1.6	1.1
2033	1.6	1.0
2034	1.6	0.9
2035	1.5	0.8

Table 5 - Additional GHG emissions savings for increasing the RTFO main target by 2.5 percentage points (2020-2035) under EEP scenario and EV scenario

Overall, the net present value of the target increase is projected to be -£1,239 to -£1,460 million, and the cost per tonne of carbon saved is estimated to be £170/tCO2e (see Table 6).

	Discounted Benefits (£million)		Discounted Costs (£million)		Net Benefit (£million)	
Year	EEP	High EV	EEP	High EV	EEP	High EV
2020	0	0	0	0	0	0
2021	0	0	0	0	0	0
2022	77 (39-115)	71 (35-105)	210 (133-363)	191 (121-331)	-132 (-324 to -18)	-121 (-296 to -17)
2023	80 (40-120)	73 (36-109)	215 (136-365)	196 (124-332)	-135 (-325 to -16)	-123 (-296 to -15)
2024	83 (41-124)	75 (38-113)	219 (139-364)	199 (126-331)	-136 (-322 to -14)	-124 (-293 to -13)
2025	85 (43-129)	77 (39-117)	222 (141-362)	202 (128-328)	-137 (-318 to -12)	-124 (-289 to -11)
2026	87 (44-131)	78 (39-116)	225 (142-358)	199 (126-318)	-137 (-314 to -11)	-122 (-279 to -10)
2027	89	77	226	196	-137	-119

	Discounted Benefits (£million)		**Discounted Costs (£million)**		**Net Benefit (£million)**	
	(45-134)	(39-117)	(144-353)	(124-306)	(-308 to -9)	(-267 to -8)
2028	92 (45-138)	78 (38-116)	228 (144-348)	192 (122-294)	-135 (-302 to -7)	-114 (-255 to -6)
2029	94 (47-140)	77 (38-115)	228 (145-342)	188 (119-281)	-135 (-295 to -4)	-111 (-242 to -4)
2030	95 (47-141)	76 (37-113)	228 (145-335)	182 (116-267)	-134 (-288 to -3)	-107 (-230 to -3)
2031	103 (52-155)	77 (39-116)	229 (145-328)	171 (109-246)	-126 (-277 to 10)	-94 (-207 to 7)
2032	112 (56-168)	79 (39-118)	228 (145-321)	160 (101-225)	-116 (-265 to 24)	-81 (-186 to 17)
Total additional net benefits (Net present value - £million, appraisal period 2022-2032)					**-1,239 to -1,460**	
Carbon cost effectiveness (£/tCO2, appraisal period 2022-2032)					**170**	

Table 6 - Additional discounted benefits and costs, total additional net benefits and carbon cost effectiveness for increasing the RTFO target by 2.5 percentage points (2020-2035): EEP vs. High EV scenarios.

Option 2 is projected to lead to a lower volume of biofuel than Option 3, with volumes falling under all fuel demand scenarios (see Figure 10), although volumes fall less than would otherwise be the case.

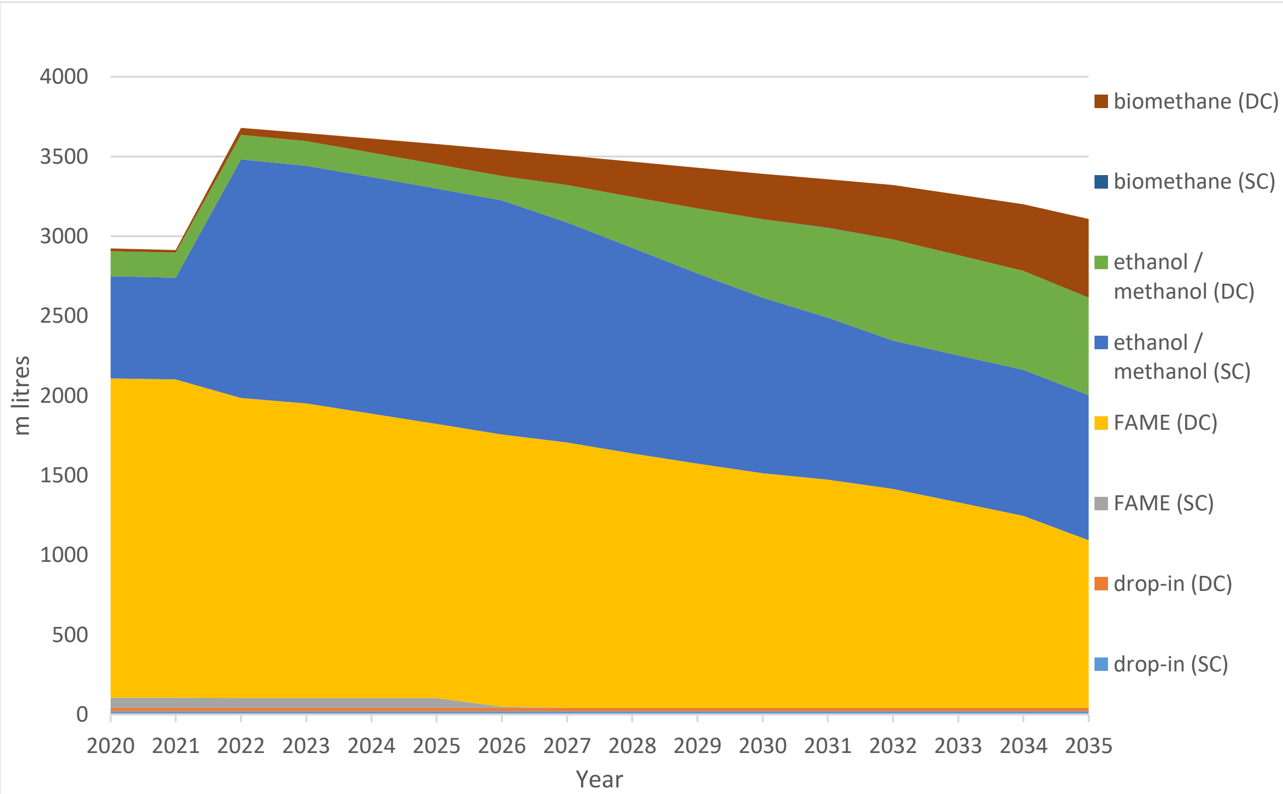

Figure 10 - Renewable fuel supply projections under the main RTFO – 2.5 percentage point target increase (EEP)

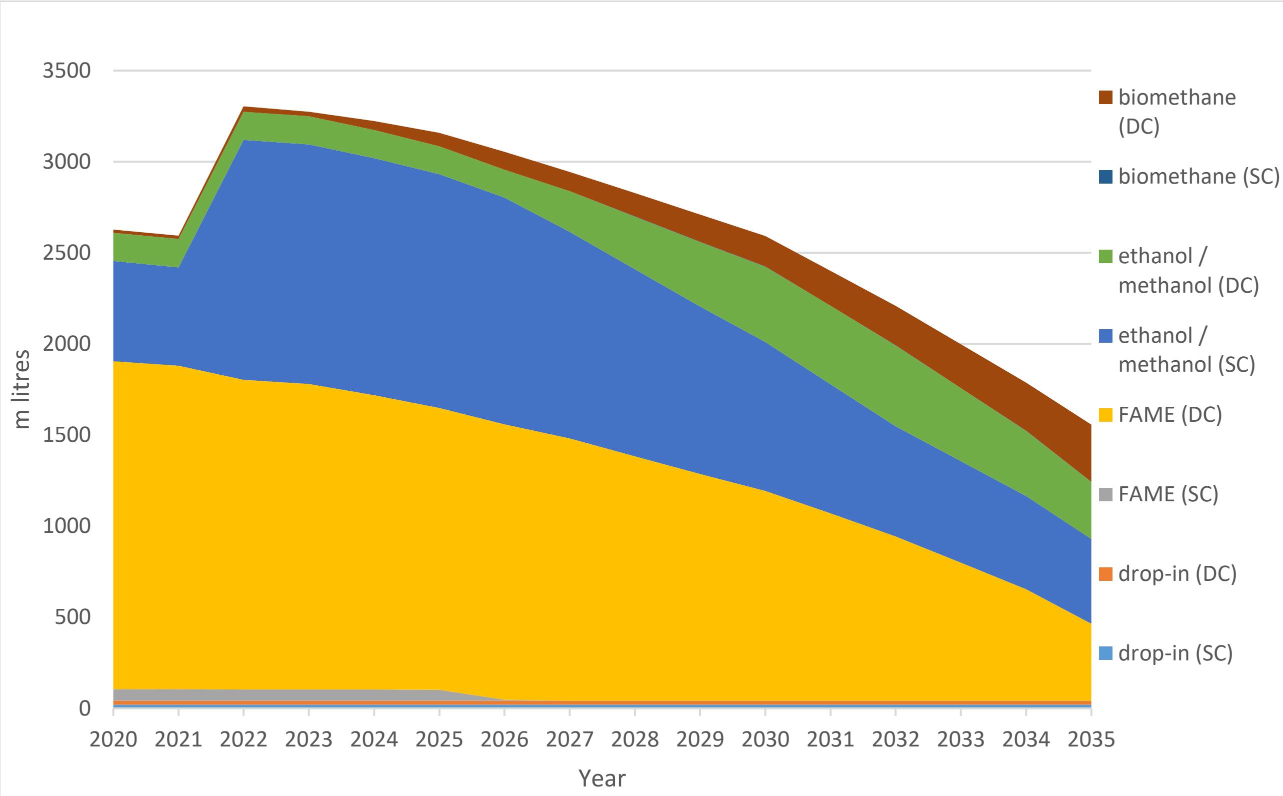

Figure 11 - Renewable fuel supply projections under the main RTFO – 2.5 percentage point target increase (High EV)

Option 1 - 1.5 percentage points increase to the main RTFO target

Option 1 is projected to lead to the lowest additional GHG savings of all the options; between 9.2 and 10.9 MtCO2e across the appraisal period, 2022 to 2032.

Year	MtCO2e	MtCO2e
	EEP	EV
2020	0.0	0.0
2021	0.0	0.0
2022	1.0	0.9
2023	1.0	0.9
2024	1.0	0.9
2025	1.0	0.9
2026	1.0	0.9
2027	1.0	0.9
2028	1.0	0.8
2029	1.0	0.8
2030	1.0	0.8
2031	1.0	0.7
2032	1.0	0.7
2033	0.9	0.6
2034	0.9	0.6
2035	0.9	0.5

Table 7 - Additional GHG emissions savings for increasing the RTFO main target by 1.5 percentage points (2020-2035) for EEP and High EV

The estimated (discounted) costs and benefits are presented in Table 8 below. The overall net present value of a 1.5 percentage point target increase is projected to be -£968m to -£1,128 million, depending on the rate of EV uptake and fuel demand over the period. A 1.5 percentage point increase to the main RTFO target is estimated to have a cost per tonne of carbon saved of £175/tCO2e (see Table 8).

	Discounted Benefits (£million)		**Discounted Costs (£million)**		**Net Benefit (£million)**	
Year	EEP	High EV	EEP	High EV	EEP	High EV
2020	0	0	0	0	0	0
2021	0	0	0	0	0	0
2022	77 (39-115)	71 (35-105)	210 (113-363)	191 (121-331)	-132 (-324 to -18)	-121 (-296 to -17)
2023	75 (37-112)	69 (34-102)	201 (128-342)	184 (116-311)	-126 (-305 to -15)	-115 (-277 to -14)
2024	73 (37-110)	67 (33-100)	193 (123-321)	176 (111-292)	-120 (-284 to -13)	-109 (-259 to -12)
2025	71 (36-107)	65 (33-97)	185 (118-301)	168 (107-273)	-114 (-265 to -10)	-104 (-241 to -9)
2026	69 (35-104)	61 (31-92)	177 (112-283)	157 (100-251)	-108 (-248 to -9)	-96 (-220 to -8)
2027	67 (34-101)	58 (29-87)	170 (108-265)	147 (93-230)	-103 (-231 to -7)	-89 (-200 to -6)
2028	66 (62-98)	56 (27-83)	163 (103-248)	137 (87-210)	-97 (-216 to -5)	-82 (-182 to -4)
2029	64 (32-96)	52 (26-79)	156 (99-233)	128 (81-191)	-92 (-201 to -3)	-76 (-165 to -3)
2030	62 (31-92)	49 (24-74)	149 (94-218)	119 (75-174)	-87 (-188 to -2)	-70 (-150 to -2)
2031	64 (32-97)	48 (24-72)	143 (91-205)	107 (68-154)	-78 (-173 to 6)	-59 (-130 to 4)
2032	67 (34-101)	47 (24-71)	137 (87-193)	96 (61-135)	-70 (-159 to 14)	-49 (-111 to 10)
Total additional net benefits (Net present value - £million, appraisal period 2022-2032)					**-1,128 to -968**	
Carbon cost effectiveness (£/tCO2, appraisal period 2022-2032)					**175**	

Table 8 - Discounted benefits and costs, overall net benefits and carbon cost effectiveness for increasing the RTFO main target by 1.5 percentage points (2020-2032)

Figure 12 below shows the projected volumes of each fuel type supplied under the main RTFO with a 1.5 percentage point increase. The trends are similar to those projected under the baseline, with waste-derived biodiesel expected to fall steadily over the period. Fuel consumption declines and the obligation is met by other fuels, although the increased target does result in slightly greater volumes of biofuels, and FAME(DC) in particular, being supplied than otherwise would be the case.

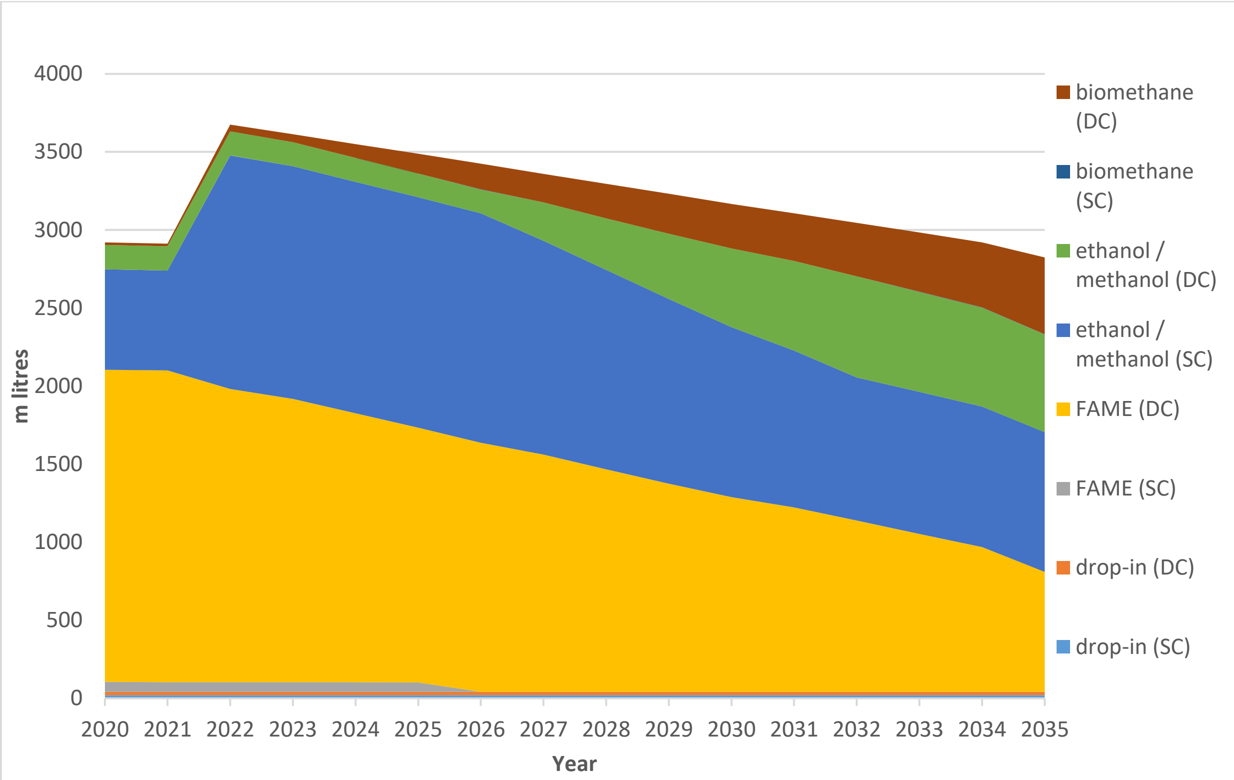

Figure 12 - Fuel volume supply under the main RTFO – 1.5 percentage point target increase (EEP)

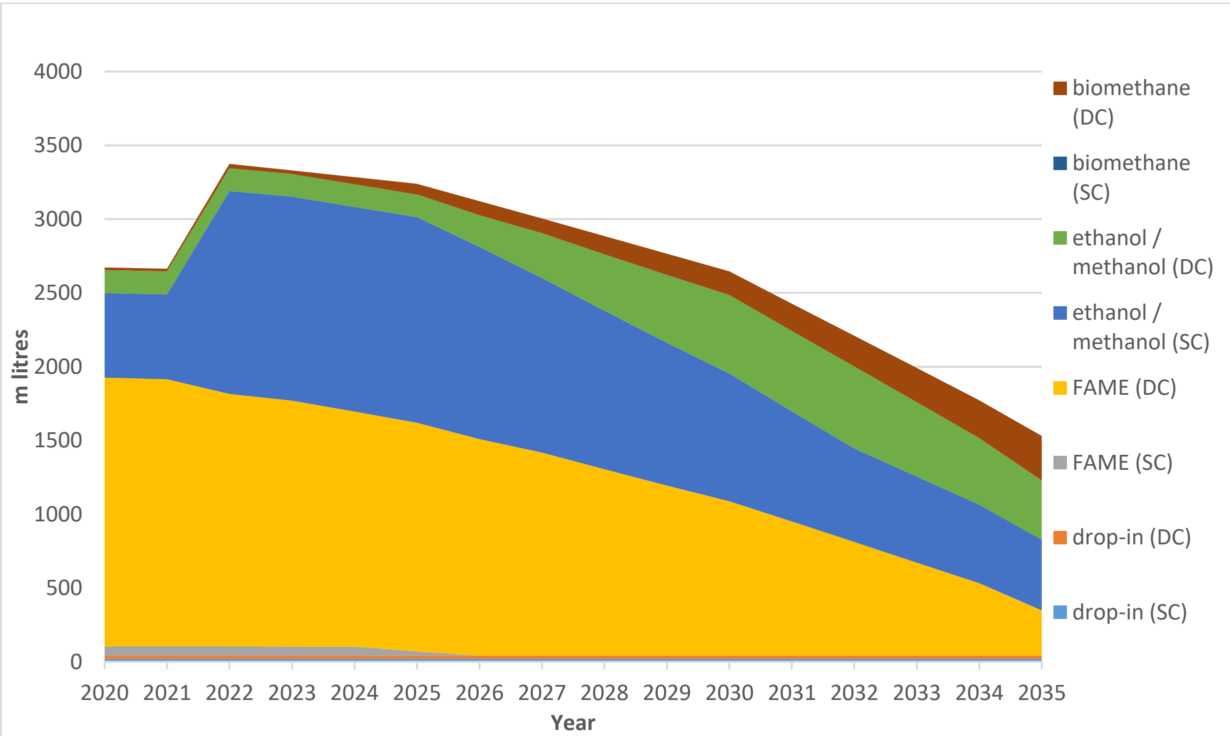

Figure 13 - Fuel volume supply under the main RTFO – 1.5 percentage point target increase (High EV)

Changes to development fuels supply under the RTFO

In 2019, a development fuel target was introduced to sit alongside the main RTFO target. The purpose was to incentivise the supply of advanced renewable fuels, which are of strategic importance to the UK and which can be used by harder to decarbonise transport modes such as HGVs and aviation. The target was set at 0.1% of total fuel by volume in 2019, rising to 2.8% by 2032, and remaining at this level in subsequent years unless further legislation is brought forward to change it.

The government consulted on two proposals which would expand the fuels eligible for development fuel support:

- Expanding the forms of transport in which hydrogen and other RFNBOs can be used and be eligible for RTFO development fuel support;
- Making recycled carbon fuels eligible for RTFO development fuel support.

Following the consultation, the government have decided to proceed with these proposals.

Key assumptions and methodology

Because the RTFO development fuel target has only recently been introduced there remains limited data and considerable uncertainty around how much development fuel will be supplied, the mix of fuels that may be supplied, and the costs. A number of assumptions are therefore required to assess the impact of the measures. In making these assumptions, the focus has been on ensuring the full range of costs and benefits of the proposed changes is considered, rather than attempting to forecast the most likely scenarios for future development fuel supply.

Development fuels costs and the buy-out price

Like the main RTFO, the development fuels RTFO obligation (dRTFO) operates as a certificate trading mechanism, whereby certificates (dRTFCs) are issued to suppliers of renewable transport development fuel to demonstrate that an obligated supplier has met their obligation. Alternatively, suppliers can pay a fixed sum for each litre of fuel for which they wish to 'buy-out' of their obligation. The buy-out price for development fuels currently stands at a fixed level of 80 pence per litre of obligation not met. Note that development fuels receive 2 x dRTFCs per litre[5] of fuel supplied which is worth up to £1.60.

Because there is significant uncertainty about future development fuel prices, for the purposes of this analysis it is assumed throughout that the additional cost of supplying all development fuels is 80 pence per litre of obligation. The cost of development fuels should not go above this level, because suppliers would choose to pay the fixed 80 pence per litre to buy out of their obligations rather than supply fuels which were more expensive. The cost of supplying development fuels may be lower than this, but in the absence of data to reliably estimate what the actual costs of these fuels will be, this assumption ensures that we do not underestimate the possible costs.

Baseline development fuel supply

When analysing the main RTFO obligation, a baseline supply scenario was created where the target was met in accordance with the assumed hierarchy of fuels set out. This is not possible for development fuels, due to insufficient data and evidence on the fuels used to meet the development fuels target.

Because of this uncertainty in future development fuel supply, two alternative baselines have been developed. Neither scenario is intended to represent what is expected to happen in practice, but rather as two extremes of the range of possibilities, in order to explore the range of possible impacts from the policy changes.

Baseline 1 – buy-out

In this 'buy-out' baseline scenario, no development fuel is supplied under the current policy and all suppliers buy out of their development fuel obligation. When assessed against this baseline, all development fuel supplied as a result of the policy change is additional.

Baseline 2 – 100% road fuel from municipal solid waste (MSW)

In this 100% MSW baseline scenario, the entire development fuels target is assumed to be met using one 'typical' development fuel - a drop-in renewable diesel equivalent road fuel made from MSW with a carbon intensity of 32 gCO2e/MJ. This fuel was chosen because it is not subject to demand constraints - as much as can be produced would be usable in the market.

When assessed against this baseline, all fuel supplied as a result of the policy change displaces this baseline fuel. This means that whether there is an increase or decrease in GHG emissions savings from the policy change depends on whether the GHG emissions savings of the added fuel is higher or lower than that of the baseline fuel (i.e. road fuel from MSW).

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[5] This is true for development fuels except hydrogen, which is eligible to receive 9.16 dRTFCs per kg.

Policy changes

The two policy changes, outlined below, were assessed against each baseline above.

An increase in hydrogen eligibility

Following the consultation, we have decided to amend the RTFO so that renewable hydrogen used in maritime, rail and non-road mobile machinery applications is eligible for dRTFCs. Renewable hydrogen used in road vehicles is already eligible from dRTFCs, so this is not included in this analysis, and has not been included in the baselines for the reasons set out above.

Exactly how demand for, and supply of, renewable hydrogen will expand in the coming years is highly uncertain, but projections have been based on estimates received from the industry.

Introducing support for recycled carbon fuels (RCF) under the development fuel target of the RTFO

We have decided to make certain types of recycled carbon fuels eligible for dRTFCs. We have not yet decided how many dRTFCs RCFs will be eligible for.

For the purposes of this analysis, we have continued to use the proposed values from the consultation, i.e. RDFs produced from solid feedstocks (such as municipal solid waste (MSW)) are awarded 0.5 dRTFCs per litre, and RCFs produced from gaseous feedstocks (such as waste industrial gases) are awarded one dRTFC per litre.

RCFs produced from solid feedstocks (such as municipal solid waste (MSW)) are to be awarded 0.5 dRTFCs per litre, and RCFs produced from gaseous feedstocks (such as waste industrial gases) awarded one dRTFC per litre.

The amount of recycled carbon fuels supplied is likely to be primarily determined by the production capacity. Assumptions used in this analysis are based on views obtained from the industry. It is assumed that the RCFs which are produced are a mixture of road fuel (40%) and aviation fuel (60%). It is assumed that fuels produced from MSW are biofuel (60%) and RCF (40%). It is further assumed that some plants are not dependent on RCF eligibility to begin production i.e. these plants produce biofuels which are included in the development fuel baseline already.

Methodology

Total costs (under both baselines and our policy changes) are calculated by multiplying the assumed cost of development fuels (80 pence per litre) by the volume of fuels supplied.

The benefits of the policy changes were calculated by estimating the GHG emissions savings expected from a litre of the different development fuels supplied to meet the obligation, and then scaling up by the number of litres of each fuel we expect to be supplied under the different scenarios – both the baselines and as a consequence of the policy changes. As part of this, we accounted for the fact that development fuels receive two dRTFCs for every litre equivalent supplied.

The carbon saving benefits were then monetised and discounted in line with the HMT Green Book. This is done over the same time period of 2022-2032 that was used for appraising the costs and benefits of the changes to the main RTFO target.

Results

Table 10 summarises how the policies (hydrogen eligibility/RCF eligibility/both policies combined) have been assessed against the two baselines. This results in six different scenario outputs for development fuels. The additional benefits and costs of each of these six scenarios are presented and discussed further below.

Because supplier choices over hydrogen are assumed to be independent of their choices over RCFs (and vice-versa), the costs and benefits of the combined policies are simply the sum of the costs and benefits of the individual policies (e.g. the costs and benefits of scenario 3a are simply the sum of scenarios 1a and 2a).

	Proposal 1- hydrogen	**Proposal 2- RCF**	**Both proposals combined: hydrogen + RCF**
Baseline 1 (100% buy-out)	Scenario 1a	Scenario 2a	Scenario 3a (Scenario 1a + 2a)
Baseline 2 (100% road MSW)	Scenario 1b	Scenario 2b	Scenario 3b (Scenario 1b + 2b)

Table 9 - Summary labelling all six development fuels RTFO policy proposal options

Costs

Because the cost of supplying all development fuels is assumed to equal the buy-out price, the costs associated with both baselines are the same, and implementing either or both policy proposals results in no additional costs.

This conclusion that there are no additional costs from the policy changes stems from the specific assumptions made about the cost of development fuels, but is not an unreasonable outcome to expect. If the cost of hydrogen or RCFs was greater than the cost of buy-out or the cost of suppling alternative development fuels, then fuel suppliers could choose not to supply them. Providing that fuel suppliers will never choose to supply more expensive fuel options if cheaper alternatives are available, there should be no additional costs from amending eligibility of hydrogen and/or RCF in the dRTFO. These amendments simply widen the scope of development fuels available for dRTFCs under the RTFO.

Benefits

The GHG emissions savings that could be accrued by supplying additional quantities of hydrogen and/or introducing RCFs into the market are presented below. Figures 7-9 show the additional GHG emissions savings expected relative to what would be delivered by the existing development fuels RTFO policy under the two baseline scenarios.

The fact that the additional savings are positive in all three scenarios demonstrates the fact that hydrogen and RCFs are estimated to have lower GHG emissions than both (i) their fossil fuel equivalents (under the 100% buy-out baseline, where suppliers buy out of their development fuel obligations entirely and supply fossil fuels instead), as well as (ii) renewable fuel derived from MSW used in road transport (under the 100% road MSW baseline). Consequently, displacing either fossil fuels or road MSW fuel with hydrogen and/or RCFs is projected to result in higher emission savings under the RTFO.

As expected, the estimated additional benefits of the policies are always higher when assessed against the 100% buy-out baseline, compared to the 100% road MSW baseline. This is because the road MSW baseline already provides GHG emissions savings relative to fossil fuels, which are supplied at 100% within the buy-out baseline.

The additional GHG emissions savings arising from the dRTFO policies are seen to be relatively small. However, there may also be wider, indirect benefits that are not captured in these results, such as promoting an industry which could lead to an even greater production of development fuels. Benefits such as these have not been considered in this analysis.

Hydrogen eligibility change (scenarios 1a and 1b)

Extending support for hydrogen is projected to result in steadily rising GHG emissions savings from 2021 under both scenarios 1a and 1b, with a sharp increase in savings between 2024 and 2025 under the buy-out baseline.

This sharp increase in benefits reflects evidence from industry which suggests that there will be an approximate doubling of hydrogen dRTFCs for rail and non-road mobile machinery (NRMM) modes of transport between 2024 and 2025. Further industry expects new demand from the maritime sector and heavy goods vehicles for hydrogen especially from 2025 onwards.

There is expected to be comparatively modest increases in GHG emissions savings each year from 2025, with additional benefits plateauing from 2028 onwards. This reflects a lack of available evidence to suggest how hydrogen demand will change beyond 2028, therefore, there is high uncertainty over the appropriate values to use. In the absence of such evidence, it is judged that holding benefits constant past 2028 is the most appropriate assumption for the purposes of this CBA modelling, ensuring that we do not overstate the possible GHG benefits.

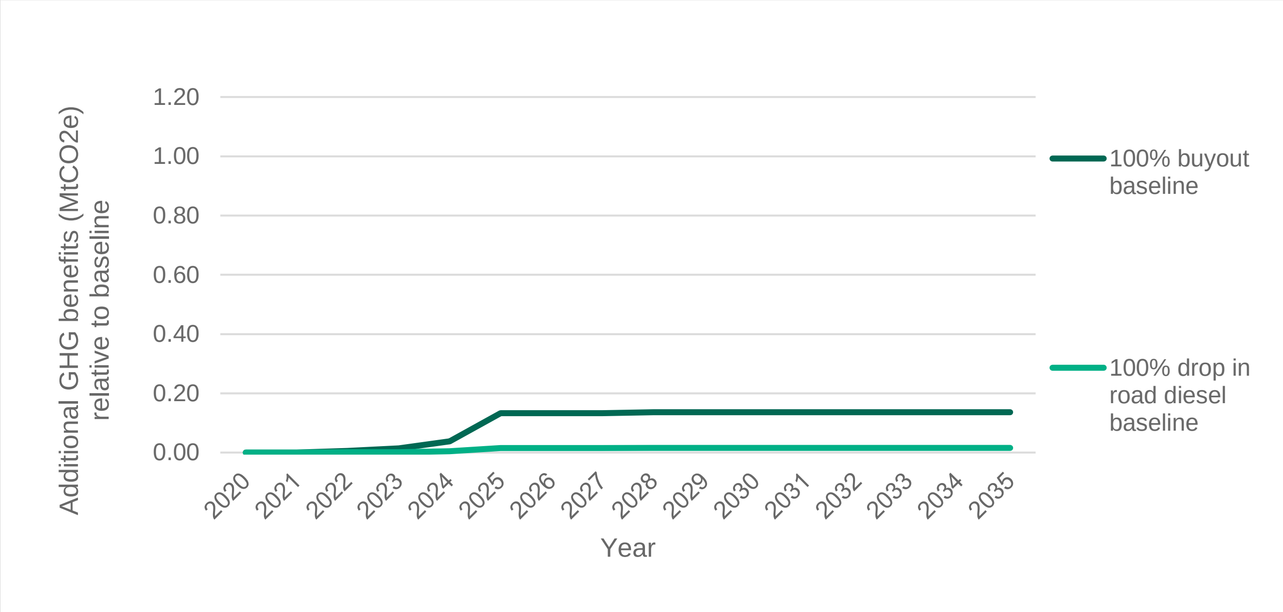

Figure 14 - Additional GHG emissions savings from scenarios 1a and 1b under option 1 hydrogen eligibility policy proposal presented relative to both baselines

RCF eligibility change (scenarios 2a and 2b)

The RCF eligibility policy change is expected to be introduced from 2023, with a steady increase in RCF dRTFCs being redeemed over the appraisal period. This results in additional savings which grow steadily over time.

It is assumed that there is an increase in RCF production capacity through the 2020s, estimated from projections which have been shared with us by industry. In addition, it is assumed that development fuel plants will deliver drop-in fuel for existing vehicles. As such, unlike hydrogen, RCFs are limited by production and not according to demand.

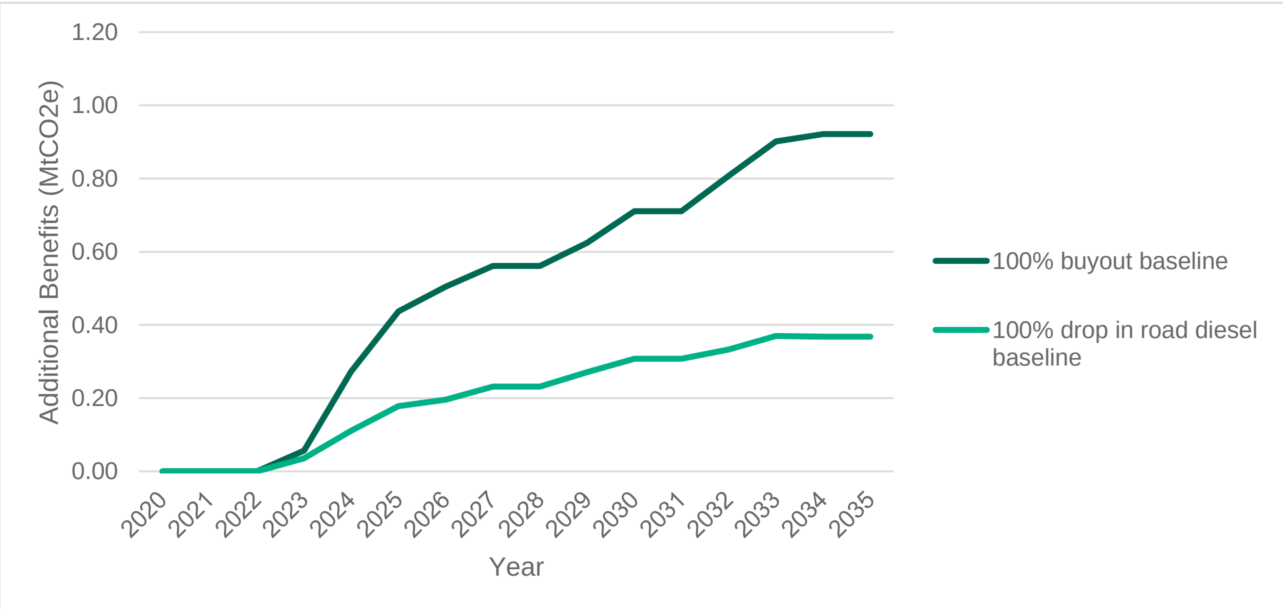

Figure 15 - Additional GHG emissions savings from scenarios 2a and 2b under option 2 RCF eligibility policy proposal relative to both baselines

Combined policy impact (options 3a and 3b)

The chart below shows the combined effect of both eligibility changes, assessed against both baselines. The profile of the estimated benefits closely mirrors what was shown for introducing support to RCFs - reflecting the fact this accounts for the majority of the estimated benefits, and the fact the benefits from the two proposals are assumed to be additive.

Combined, it is estimated that the two development fuel changes will lead to additional GHG emissions savings of between 2.3 and 6.4 MtCO2e. This is equivalent to benefits of £158 million to £434 million using discounted, central carbon values (see Table 12).

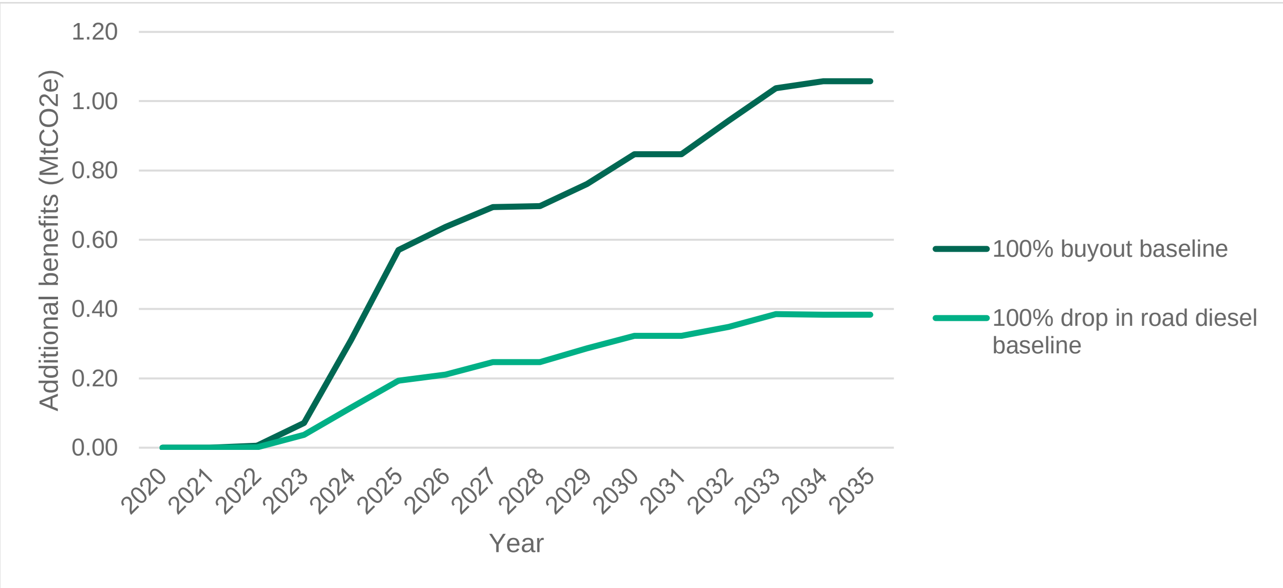

Figure 16 - Additional GHG emissions savings from scenarios 3a and 3b under option 3 of the combined development fuels policies (hydrogen and RCF eligibility) relative to both baselines

Year	**Additional Benefits (MtCO2e)**					
	100% buy-out baseline			100% Road MSW baseline		
	↑ Hydrogen eligibility	↑ RCF	Combined	↑ Hydrogen eligibility[6]	↑ RCF	Combined
2020	0.0	0.0	0.0	0.0	0.0	0.0
2021	0.0	0.0	0.0	0.0	0.0	0.0
2022	0.0	0.0	0.0	0.0	0.0	0.0

[6] GHG savings under this policy option are not technically zero, but are small in terms of MtCO2e. As GHG savings figures are presented to one decimal place, savings appear as if they are zero in our modelling when in fact they are not.

Year	Additional Benefits (MtCO2e)					
	100% buy-out baseline			100% Road MSW baseline		
	↑ Hydrogen eligibility	↑ RCF	Combined	↑ Hydrogen eligibility[6]	↑ RCF	Combined
2023	0.0	0.1	0.1	0.0	0.0	0.0
2024	0.0	0.3	0.3	0.0	0.1	0.1
2025	0.1	0.4	0.6	0.0	0.2	0.2
2026	0.1	0.5	0.6	0.0	0.2	0.2
2027	0.1	0.6	0.7	0.0	0.2	0.2
2028	0.1	0.6	0.7	0.0	0.2	0.2
2029	0.1	0.6	0.8	0.0	0.3	0.3
2030	0.1	0.7	0.8	0.0	0.3	0.3
2031	0.1	0.7	0.8	0.0	0.3	0.3
2032	0.1	0.8	0.9	0.0	0.3	0.3
2033	0.1	0.9	1.0	0.0	0.4	0.4
2034	0.1	0.9	1.1	0.0	0.4	0.4
2035	0.1	0.9	1.1	0.0	0.4	0.4

Table 10 - Additional benefits for development fuel policies (2020-2035)

These benefits have been monetised using the government's current central carbon appraisal values, and a summary of the monetised benefits and costs for each policy, relative to the two alternative baselines can be found below (see Table 12). As highlighted, the changes are not expected to result in any additional costs.

Year	Additional costs of each scenario (£million)	Monetised additional benefits central estimate (£million)					
		100% buy-out baseline			100% Road MSW baseline		
		↑ Hydrogen eligibility	↑ RCF	Combined	↑ Hydrogen eligibility	↑ RCF	Combined
2020	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2021	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2022	0.0	0.4	0.0	0.4	0.1	0.0	0.1
2023	0.0	1.1	4.2	5.3	0.1	2.6	2.7
2024	0.0	2.7	19.6	22.4	0.3	8.0	8.3
2025	0.0	9.3	30.8	40.2	1.1	12.5	13.6
2026	0.0	9.2	34.8	44.0	1.1	13.5	14.6
2027	0.0	9.0	37.9	46.9	1.0	15.6	16.7
2028	0.0	9.1	37.6	46.7	1.1	15.5	16.6
2029	0.0	8.9	40.9	49.8	1.0	17.8	18.8
2030	0.0	8.7	45.5	54.3	1.0	19.7	20.7
2031	0.0	9.2	47.8	57.0	1.1	20.7	21.7
2032	0.0	9.7	57.3	67.0	1.1	23.6	24.7
Total (Appraisal Period 2022-2032)	**0.0**	**77.4**	**356.4**	**433.8**	**8.9**	**149.5**	**158.4**

Table 11 - Discounted additional benefits and costs for development fuel policies (2022-2032)

Combined impact of policies

In this section the costs and benefits of all the policies are combined, to show the overall effect of the RTFO amendments.

The central estimates of the impact of increasing the main RTFO target by 5 percentage points has been combined with the central estimate of the combined impact of widening eligibility for hydrogen and RCF in the dRTFO. Table 13 summarises the results.

Dev. fuel policy	Dev. fuels baseline	Main RTFO target Increase	Additional savings (MtCO2e)	Additional savings (£million)	Additional costs (£million)
Combined (Hydrogen and RCF eligibility)	100% buy-out	5%	26.1 - 30	2,039	3,894
Combined (Hydrogen and RCF eligibility)	100% Road MSW	5%	22 – 25.9	1,763	3,894

Table 12 - Central, discounted additional benefits and costs for the combined (hydrogen and RCF eligibility) development fuel policies and the 5 percentage point target increase to the main RTFO

Altogether, the policies are projected to lead to additional GHG emissions savings of between 22 to 30 MtCO2e. This amounts to a monetised benefit equal to £1,763 million to £2,039 million, and compares to additional costs from the combined reforms of £3,894 million. The 5 percentage point increase to the main RTFO is expected to deliver the bulk of the GHG emissions savings, although it is expected to result in higher fuel prices for motorists. It is estimated this will be equivalent to 1.6 pence per litre by 2032. Amendments to the dRTFO have the potential to generate additional GHG emissions savings at no cost.