Title: Measures for introduction of E10 petrol **IA No:** DfT00409 **Lead department or agency:** Department for Transport **Other departments or agencies:**	Impact Assessment (IA) **Date:** 25/02/2021 **Stage:** Final **Source of intervention:** Domestic **Type of measure:** Secondary legislation **Contact for enquiries:** Biofuels.Transport@dft.gov.uk

Summary: Intervention and Options

RPC Opinion: Green Rated

Cost of Preferred (or more likely) Option (in 2019 prices/2020 present value)			
Total Net Present Social Value	**Business Net Present Value**	**Net cost to business per year**	**Business Impact Target Status**
-£997.2m	-£100.0m	£11.6m	Qualifying Regulatory Provision Qualifying provision

What is the problem under consideration? Why is government intervention necessary?

Ethanol is a biofuel that can be blended into petrol to reduce greenhouse gas emissions. In the UK, petrol is currently blended with no more than 5% ethanol, a grade known as E5. Increasing this to 10%, a grade known as E10, has been permitted under fuel standards since 2013. While E10 could help reduce CO_2 emissions from petrol cars, a "first mover" risk has prevented fuel retailers from unilaterally introducing the new grade with concerns around competition law also potentially hindering a co-ordinated industry-led roll-out. This combination of factors means it is unlikely that E10 will be introduced in the UK without government intervention.

What are the policy objectives and the intended effects?

The aim of this policy is to support efforts to reduce greenhouse gas (GHG) emissions from transport. Currently, the Renewable Transport Fuel Obligation (RTFO) seeks to reduce GHG emissions by requiring fuel suppliers to meet specific targets for renewable fuels. These obligations have led to fuel suppliers moving towards blending 5% ethanol in petrol and 7% biodiesel in diesel. This policy looks to develop opportunities for higher ethanol blending levels, which should enable greater reductions in GHG emissions in the longer term provided they are accompanied by higher RTFO targets as part of further legislative change. It should also help support the UK bioethanol industry.

What policy options have been considered, including any alternatives to regulation? Please justify preferred option (further details in Evidence Base)

The options analysed in this IA look at two different routes to requiring E10 petrol to be introduced. The IA examines the impacts of either simply requiring the labelling of standard 95 octane petrol as E10 or setting a firm minimum ethanol content for the 95 octane petrol grade such that it must contain more than 5% ethanol. In both cases the higher octane "super" grade would remain E5. The options as reviewed in this Impact Assessment are:

- Option 1 – Do nothing
- Option 2 – All 95 octane fuels must be labelled as E10
- Option 3 – All 95 octane fuels must contain more than 5.5% ethanol and be labelled as E10 **(preferred option)**

Options 2 and 3 are assessed as being quite similar in terms of likely impacts, however option 3 is preferred as it is considered more likely to deliver the wider policy objectives. The rationale for intervention section (3.1) details why non-regulatory options have not been considered in the consultation.

Will the policy be reviewed? It will be reviewed. **If applicable, set review date:** 01/2025

Does implementation go beyond minimum EU requirements?		N/A			
Is this measure likely to impact on trade and investment?		No			
Are any of these organisations in scope?	**Micro** Yes	**Small** Yes	**Medium** Yes	**Large** Yes	
What is the CO_2 equivalent change in greenhouse gas emissions? (Million tonnes CO_2 equivalent)		**Traded:** 0.00	**Non-traded:** +2.4		

I have read the Impact Assessment and I am satisfied that, given the available evidence, it represents a reasonable view of the likely costs, benefits and impact of the leading options.

Signed by the responsible Minister: Rachel Maclean MP Date: 25/02/2021

Summary: Analysis & Evidence Policy Option 2

Description: Option 2 – All 95 Octane petrol must be labelled as E10

FULL ECONOMIC ASSESSMENT

Price Base Year 2019	PV Base Year 2021	Time Period Years 10	Net Benefit (Present Value (PV)) (£m)		
			Low: -173.6	**High:** -1307.0	**Best Estimate: -978.3**

COSTS (£m)	**Total Transition** (Constant Price)	Years	**Average Annual** (excl. Transition) (Constant Price)	**Total Cost** (Present Value)
Low	4.8	1	19.2	173.6
High	4.8		134.9	1168.9
Best Estimate	4.8		**101.4**	**880.2**

Description and scale of key monetised costs by 'main affected groups' – Total Costs (Present Value)

Best estimate costs consist of: (1) decreased miles per gallon cause an increase in fuel supply costs of £657m for fuel consumers (some of which are businesses) (2) costs to incompatible vehicle owners (from having to buy 'super' grade petrol meeting the E5 fuel spec) (some of which are businesses) of £169m, and (3) transition costs of fuel labelling and communications of £5m in year 1 borne by fuel retailers. There is also a cost to businesses in relation to fuel duty of £50m; these costs are treated as a transfer but included to ensure accurate business costs. This is added to the total of all costs mentioned so far to give the £880m (£880.2) total.

Other key non-monetised costs by 'main affected groups' Increased ethanol blending will displace other fuels from the fuel mix (e.g. petrol and biodiesel), possibly reducing profits for producers of those fuels. Increased fuel duty and VAT costs for fuel consumers (non-businesses) have not been monetised as these are treated as transfers for NPV modelling. Increased VAT costs have also not been included for business as this can be refunded**.**

BENEFITS (£m)	**Total Transition** (Constant Price)	Years	**Average Annual** (excl. Transition) (Constant Price)	**Total Benefit** (Present Value)
Low	0	0	0	0
High	0		-16.1	-138.1
Best Estimate	**0**		**-11.4**	**-98.1**

Description and scale of key monetised benefits by 'main affected groups' - Total Benefit (Present Value)

Without changes to the RTFO targets, best estimate GHG savings are estimated to be reduced by 2.2MTCO2e, giving a negative monetised benefit of -£148m. This is because to meet the pre-existing RTFO targets, the ethanol is expected to displace waste-derived biodiesel, which has higher greenhouse gas savings. There is also a transfer from businesses to government of fuel duty of £50m. Adding this to all benefits gives the -£98m (-£98.1).

Other key non-monetised benefits by 'main affected groups' A likely future RTFO target increase would allow E10 to deliver increased carbon savings compared to the current targets (as it would mean ethanol replaces fossil fuels instead of waste-derived biodiesel). The introduction of E10 would also lead to improved market conditions for domestic ethanol producers. Without such a change, there is a risk that UK domestic plants could be permanently closed. Losing these facilities now would impact the agricultural sector as ethanol production is a key feed-wheat market in the North East of England. The industry also supplies key by-products including high protein animal feed and stored CO2, which is classed as critical national infrastructure[1].

Key assumptions/sensitivities/risks **Discount rate** 3.5

Figures are sensitive to future prices and demand of fossil and biofuels, which could impact the volumes of ethanol / biodiesel supplied under this policy. Waste biodiesel is assumed to be the marginal fuel for the RTFO and its availability sufficient to meet the scenarios. GHG emission factors include Indirect Land Use Charge (ILUC) and are assumed constant over the period. Except where stated, taxes are excluded from these estimates (see Annex D)

BUSINESS ASSESSMENT (Option 2)

Direct impact on business (Equivalent Annual) £m:			Score for Business Impact Target (qualifying provisions only) £m (2019 prices, 2020 PV):
Costs: 11.3	**Benefits:** 0	**Net:** 11.3	54.8

[1] Critical National Infrastructure include facilities necessary for a country to function. It also includes functions, which are not critical for essential services, but which need protection due to the potential danger to the public (civil nuclear and chemical sites for example).

Summary: Analysis & Evidence — Policy Option 3

Description: Option 3 – All 95 Octane petrol must contain more than 5.5% bioethanol and be labelled as E10

FULL ECONOMIC ASSESSMENT

Price Base Year 2019	PV Base Year 2021	Time Period Years 10	Net Benefit (Present Value (PV)) (£m)		
			Low: -358.9	**High:** -1307.0	**Best Estimate: -1032.1**

COSTS (£m)	**Total Transition** (Constant Price)	Years	**Average Annual** (excl. Transition) (Constant Price)	**Total Cost** (Present Value)
Low	4.8	1	38.1	336.3
High	4.8		134.9	1168.9
Best Estimate	4.8		**106.8**	**927.5**

Description and scale of key monetised costs by 'main affected groups' – Total Costs (Present Value)

Best estimate costs consist of: (1) decreased miles per gallon cause an increase in fuel supply costs of £701m for fuel consumers (some of which are businesses) (2) costs to incompatible vehicle owners (from having to buy 'super' grade petrol meeting the E5 fuel spec) (some of which are businesses) of £169m; and (3) transition costs of fuel labelling and communications of £5m in year 1, borne by fuel retailers. There is also a cost to businesses in relation to fuel duty of £53m; these costs are treated as a transfer but included to ensure accurate business costs. Adding this to the total of all mentioned costs so far gives the £927m (£927.5) as presented directly in the box above.

Other key non-monetised costs by 'main affected groups' Increased ethanol blending will displace other fuels from the fuel mix (e.g. petrol and biodiesel), possibly reducing profits for producers of those fuels. Increased fuel duty and VAT costs for fuel consumers (non-businesses) have not been monetised as these are treated as transfers for NPV modelling. Increased VAT costs have also not been included for business as this can be refunded.

BENEFITS (£m)	**Total Transition** (Constant Price)	Years	**Average Annual** (excl. Transition) (Constant Price)	**Total Benefit** (Present Value)
Low	0.0	0	-2.6	-22.6
High	0.0		-16.1	-138.1
Best Estimate	**0.0**		**-12.2**	**-104.6**

Description and scale of key monetised benefits by 'main affected groups' – Total Benefit (Present Value)

Without changes to the RTFO targets, best estimate GHG savings are estimated to be reduced by 2.4MTCO2e, giving a negative monetised benefit of -£158m. This is because the ethanol is expected to displace waste-derived biodiesel, which has higher greenhouse gas savings. There is also a transfer from businesses to government of fuel duty of £53m. Adding this to the benefits mentioned so far gives the -£105m (-£104.6) as presented directly in the box

Other key non-monetised benefits by 'main affected groups'

A likely future RTFO target increase would allow E10 to deliver increased carbon savings compared to the current targets (as it would mean ethanol replaces fossil fuels instead of waste-derived biodiesel). The introduction of E10 would also lead to improved market conditions for domestic ethanol producers. Without such a change, there is a risk that UK domestic plants could be permanently closed. Losing these facilities now would impact the agricultural sector as ethanol production is a key feed-wheat market in the North East of England. The industry also supplies key by-products including high protein animal feed and stored CO_2, which is classed as critical national infrastructure.

Key assumptions/sensitivities/risks — **Discount rate** 3.5

Figures are sensitive to future prices and demand of fossil and biofuels, which could impact the volumes of ethanol / biodiesel supplied under this policy. Waste biodiesel is assumed to be the marginal fuel for the RTFO and its availability sufficient to meet the scenarios. GHG emission factors include Indirect Land Use Charge (ILUC) and are assumed constant over the period. Except where stated, taxes are excluded from these estimates (see Annex D).

BUSINESS ASSESSMENT (Option 3)

Direct impact on business (Equivalent Annual) £m:			Score for Business Impact Target (qualifying provisions only) £m (2019 prices, 2020 PV):
Costs: 12.0	**Benefits:** 0	**Net:** 12.0	58.1

Contents

1 Executive summary

1. This impact assessment (IA) assesses the options presented in the Department for Transport's March 2020 consultation, 'Introducing E10 Petrol'[2]. E10 is the term used to describe petrol with up to 10% ethanol. The consultation ran from 4 March to 3 May 2020 and was accompanied by a draft of this impact assessment.
2. Blending bioethanol into petrol can reduce transport greenhouse gas (GHG) emissions compared to fossil fuels, as bioethanol is typically produced from crops which capture carbon from the atmosphere while they are growing.
3. Standard grade petrol currently sold in the UK contains a blend of just under 5% bioethanol and around 95% petrol, known as E5. Increasing the bioethanol content of petrol from 5% to 10% is estimated to reduce GHG emissions from petrol cars by around 1.8%.
4. In order to meet future legally binding carbon budgets, policies to achieve additional emission reductions are required. E10 represents a deliverable policy, as it uses easily available biofuel and does not require adjustments to the majority of vehicles. The policy could account for around 7% of the additional transport savings required under the fifth carbon budget (2028-2032)[3]. The cost of the measure is also within the cost ranges expected for that carbon budget (see figure 3).
5. Biofuel blending targets under the Renewable Transport Fuel Obligation (RTFO) are currently set out to 2032 (continuing thereafter unless further changes are made) and can be delivered without introducing E10. Policies which increase ethanol blending could therefore displace other biofuels, such as biodiesel, with higher GHG saving from the fuel mix. This is because fuel providers have discretion over how they meet their targets, therefore if E10 fuel is introduced whilst the RTFO target remains fixed, the likely response of fuel providers would be to use more ethanol and less biodiesel than they currently use to meet their RTFO targets. This would likely lead to an overall decrease in carbon savings compared to a "do nothing" scenario unless and until the targets are increased.
6. The targets under the RTFO have been set as minimum targets and the introduction of E10 could create space for higher RTFO targets. These higher targets would ensure that instead of E10 displacing other biofuels, such as biodiesel, it would displace fossil fuels, meaning that higher GHG savings could be achieved than are currently expected under existing targets.
7. Increased demand for ethanol through the introduction of E10 could help also support the UK bioethanol industry, who have struggled to remain viable. Industry have claimed this is largely due to lower than anticipated E10 adoption across Europe, leading to lower than forecasted ethanol demand.
8. Producing ethanol for fuel blending also results in the production of valuable by-products such as high protein animal feed and stored CO_2. For their role in producing stored CO_2 (which is used in a range of sectors including the nuclear and food and drink industries), ethanol producers have been listed as critical national infrastructure. Increased demand for feed wheat could also provide a boost to local grain farmers by providing an increased domestic market. The ongoing viability of the UK bioethanol sector is also important for longer term decarbonisation strategy as we look towards sectors such as aviation and bioplastics.
9. Introducing E10 will add to fuel costs paid by motorists. Moving from 5% to 10% bioethanol content is not expected to change pump prices. However, as the energy content of the fuel will also decrease, motorists will have to buy more litres of fuel. Overall fuel costs for petrol cars are therefore estimated to increase by 2.3% as a result of moving from 5% to 10% bioethanol content. (More details on these calculations can be found in annex C; but note that the estimated GHG saving of 1.8% already takes into account the impact of the lower energy content).
10. Commercial marketing pressures and concerns around competition law have prevented fuel retailers from introducing E10 to date. The options presented would mitigate these issues and allow for a single co-ordinated communications campaign informing consumers of the change.

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[2] https://www.gov.uk/government/consultations/introducing-e10-petrol

[3] Based on 16MTCO2/year additional transport GHG savings required to meet carbon budget 5 target 2028-32 (source: Decarbonising Transport: Setting the Challenge - Chapter 4–) and 1.1MTCO2e/year E10 GHG savings in 2030 (carbon budget accounting) from figure A38 (annex C).

11. Two options for removing the blend wall and enabling E10 supply were reviewed in this assessment along with the "do nothing" baseline scenario:
    1. Do nothing (baseline)
    2. All 95 Octane fuels required to be labelled as E10
    3. All 95 Octane fuels required to contain a minimum of 5.5% bioethanol and be labelled as E10 **(chosen option)**.

	Option 2	Option 3
total cost (present value), £m	880	927
total benefit (present value), £m	-98	-105
net benefit (present value), £m	-978	-1032
GHG impact, MTCO2e (current RTFO levels)	+2.2	+2.4
GHG impact, MTCO2e (RTFO increased)	*-8.2*	*-8.1*
carbon cost effectiveness, £/tCO2e	n/a	n/a

Figure 1: Best estimate cost-benefit summary (covering 2021 to 2030), 2019 prices (monetised values discounted)

12. Under both options, costs increase, and benefits fall relative to the baseline scenario, giving an overall negative net present value for the policy over the appraisal period (2021 to 2030).
13. Increased costs are driven by three factors: (1) decreased miles per gallon cause an increase in fuel costs for fuel consumers (some of which are businesses); (2) drivers of E10 incompatible cars are assumed to switch to more expensive super grade petrol (some of which are businesses); and (3) fuel retailers are assumed to incur labelling and communications costs.
14. Under both options GHG savings are estimated to fall because the GHG savings from the additional ethanol that is supplied are lower than the GHG savings from the waste derived biodiesel which is displaced under the RTFO target. However, this assumes that RTFO targets remain at current levels and does not consider any uncertainties relating to the ongoing availability of sustainable feedstock supplies for waste biodiesel which could impact the ongoing biofuel supply.
15. Therefore, we prefer option 3 as we expect it will deliver GHG savings in the long-term, assuming an RTFO change is made in the future, and provides a better basis to ensure a smooth introduction of E10. However, as RTFO target changes are a separate policy decision, for the purposes of monetisation we have assumed this change does not happen, leading to a poorer net present value for our preferred option.
16. It is recognised that option 3 is modelled as costing slightly more whilst saving slightly less carbon. This is due to the relative displacement of biodiesel with ethanol within our modelling. These figures do not take into account certain limitations of assumptions particularly within the RTFO increase modelling. This is discussed in more detail from paragraph 156.

2 Background

2.1 Policy setting

17. In considering whether E10 should be introduced in the UK, it is important to outline the wider policy context that impacts on the decision-making. Part 2 of this document sets out a number of key developments and considerations that need to be taken into account in relation to E10.
18. It has not been possible for all these considerations to be included in developing the quantitative analysis within this IA but they are provided here to give a full overview of the policy and how it sits within the wider context.
19. This IA has been developed alongside a formal consultation on introducing E10 petrol, the outcome of which has also been published. Previously the Department for Transport also issued a "call for

evidence" on whether and how best to introduce E10[4]. We published the government response to that call for evidence in March 2020. This has helped inform our policy development for the new consultation and this impact assessment.

2.2 Transport decarbonisation

Overview

20. The transport sector is now the largest single source of GHG emissions in the UK and is acknowledged to be one of the more challenging sectors to decarbonise[5]. In the short and medium term, biofuels such as bioethanol and biodiesel will play an important role in decarbonising the vehicles currently on UK roads.
21. Moving forward, electrification will play an increasing role in decarbonising passenger vehicles and smaller vans, while biofuels will likely continue to be needed to fuel heavy goods vehicles and become increasingly important in other modes, such as aviation.
22. In addition, as the fuel efficiency and electrification of new passenger cars increases, demand for conventional fuels such as petrol, will fall[6]. Increasing blending rates therefore ensures that biofuel supply volumes do not also fall as a result. This allows progress to continue in emissions reductions across the transport energy space.
23. As a result, it will be important to set the right incentives to the biofuels industry if we are to achieve our future emissions reductions commitments under the Net Zero 2050 target. In March we published 'Decarbonising Transport: Setting the Challenge' which sets out our sector strategy, including the importance of biofuels.
24. While we are on track to hit our targets under the third carbon budget (2018-2022), the trajectory of emissions reductions indicate additional policies will be required to meet the reductions required by the fourth (2023-2027) and fifth carbon budget (2028-2032)[5]. It is therefore important we look to utilise opportunities to decarbonise transport where possible.

Renewable Transport Fuel Obligation (RTFO)

25. The Renewable Transport Fuel Obligation is one of the Government's main policies for reducing GHG emissions from fuels supplied for use in road vehicles, and non-road mobile machinery (e.g. tractors, construction machinery).
26. Under the RTFO, suppliers of road and non-road mobile machinery (NRMM) fuel supplying petrol, diesel, gas oil or renewable fuel totalling 450,000 litres or more in an obligation period have an obligation to supply a certain share of renewable fuels as specified for that year. Obligated suppliers may meet their obligation by redeeming Renewable Transport Fuel Certificates (RTFCs) or by paying a fixed sum for each litre of fuel for which they wish to 'buy-out' of their obligation. RTFCs are generated by supplying sustainable renewable fuels and can be traded on the open market.
27. One certificate may be claimed for every litre of sustainable renewable fuel supplied. Fuel derived from certain wastes or residues, fuel from dedicated energy crops, and renewable fuels of non-biological origin (RFNBOs) are incentivised by awarding double the RTFCs per litre or kilogram supplied.
28. In 2018, the Government introduced legislation that is doubling RTFO targets between 2018 and 2020 and sets minimum levels out to 2032 (but with no end date thereafter).

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[4] "E10 petrol, consumer protection and fuel pump labelling" published July 2018 - https://www.gov.uk/government/consultations/e10-petrol-consumer-protection-and-fuel-pump-labelling

[5] Decarbonising Transport: Setting the Challenge – https://www.gov.uk/government/publications/creating-the-transport-decarbonisation-plan

[6] Updated energy and emissions projections 2019. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/931323/updated-energy-and-emissions-projections-2019.pdf

RTFO, biofuels and fuel standards

29. Suppliers have flexibility in how they meet RTFO targets and can use a variety of different fuels. The majority of the obligation is met by either blending ethanol into petrol or biodiesel into diesel, with detailed statistics regularly published[7].
30. To date, RTFO annual statistics show most of the ethanol supplied under the RTFO is made from crop feedstocks such as feed wheat, sugar beet or corn, while most of the biodiesel is produced from waste cooking oil and other waste oils from biomaterial.
31. In the UK, biofuels can be blended into conventional road fuels including petrol and diesel provided they adhere to statutory fuel standards.
32. The petrol standard (BS EN 228) includes reference to two levels of ethanol blending, up to 5% (known as E5) and up to 10% (known as E10). To date, all petrol supplied in the UK has conformed to the E5 specification.
33. The diesel standard (BS EN 590) requires standard diesel to contain no more than 7% biodiesel (known as B7). High blend biodiesel such as B20, B30 or even B100 can be supplied, however vehicles (normally buses or HGVs) need to be approved by the manufacturer.
34. The RTFO target in 2020 can be met by fuel suppliers blending ethanol up to the 5% blendwall for E5 petrol and diesel up to the 7% blendwall for B7 diesel[8].

Future targets

35. Currently, the core RTFO target is maintained between 2020 and 2032 (and indefinitely beyond). This is intended as a minimum target, to give fuel suppliers long-term certainty that the RTFO scheme would continue through the 2020s. As specified in paragraph 34, the current targets can be met without moving to E10 petrol.
36. As the ‘Decarbonising Transport: Setting the Challenge’ publication indicates, we need to consider all reasonable policies for further reducing CO_2 emissions from road transport in order to meet our legally binding carbon budgets. Increasing RTFO targets above the current 2020-2032 level is one potential option. Targets beyond 2032 will also need to be considered as part of work in setting the sixth carbon budget (2033–2037).
37. Increasing overall targets will require suppliers to consider which renewable fuels to supply. As current blending levels are already close to the E5 and B7 blendwall[8], biofuel blending will face further commercial barriers. Fuel suppliers will have the following broad options:
    - Increasing ethanol blending which would require the sale of E10, and/or
    - Increasing supply of high blend biodiesel (B20/30/100) for use in commercial vehicles, and/ or
    - Increased supply of HVO[9] biodiesel as a drop-in fuel to regular diesel, and/or
    - Increased supply of biogas for use in commercial vehicles, and/or
    - Buy-out
38. From the above list, increasing ethanol blending is the only option for which there is a high level of understanding as to the availability, sustainability, costs and deliverability of the fuel. There is stable and sufficient supply of bioethanol to meet the extra demand E10 would create. E10 can be used in the majority of petrol vehicles and therefore the potential customer base is already established. In these respects, the technical, policy and consumer barriers to its introduction are low and well understood.
39. For the other options there are a number of significant uncertainties. First, the supply of sustainable waste-based feedstocks for biodiesel blending is currently unknown. Demand for used cooking oil for biodiesel production is increasing both across Europe and at a global scale. The year 2020 is a key measure for supply resilience as blending mandates across Europe are expected to peak in order to meet targets in the EU Renewable Energy Directive.

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[7] https://www.gov.uk/government/collections/renewable-fuel-statistics

[8] RTFO Government Response and Cost Benefit Analysis 2017 - https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/644843/renewable-transport-fuel-obligations-order-government-response-to-consultations-on-amendments.pdf

[9] Hydrotreated Vegetable Oil (HVO) is a type of renewable diesel that can be blended at higher concentrations with fossil diesel and still meet fuel standard specifications. It does not count towards the 7% limit for B7 diesel. HVO can be made from waste or crop feedstocks.

40. Second, for increased volumes of high blend biodiesel to be supplied there needs to be market demand to purchase the fuel. High-blend biodiesel is generally sold to fleet operators of commercial vehicles as it requires some adjustments to the vehicle and infrastructure. It's currently unclear just what enabling measures would be required to drive increased volumes of high blend biodiesel, and it is unlikely this could be delivered quickly, owing to the time needed for firms to invest in new or upgraded vehicles.
41. Responses to the call for evidence within the original consultation largely reaffirmed these points, however it is not expected that a detailed understanding of the picture in relation to biodiesel will be available until after the 2020 obligation has been delivered. Any changes to the RTFO would need to be consulted on separately and legislated for. The consultation would be accompanied by a cost-benefit analysis setting out the expected costs and GHG savings.
42. Regardless of the viability of increasing biodiesel blending and other low carbon fuel options, the viability and benefits of increasing ethanol blending are well understood. As a result, E10 is currently understood to be the only biofuel supply option that could be delivered via a "step change" to RTFO targets. The other options would likely require a slower, progressive increase in targets that allow suppliers time to develop supply routes to deliver higher obligation volumes. It is therefore clear that E10 can be an important part of decarbonising passenger cars in the short term in order to assist in meeting challenging carbon budgets.
43. It is also important to note that the work on introducing E10 will necessarily need to be on a faster timescale than decisions on overall RTFO targets. This is because there needs to be at least six months between any final decision on the introduction of E10, and its actual appearance at forecourts to allow for necessary communications to consumers and industry preparation. We also need to consider the needs of our domestic ethanol producers, as discussed in section 2.3.

Impacts of E10 on current and future targets

44. As this consultation did not formally propose higher RTFO targets, the main body of the impact assessment has modelled the effect of E10 on current targets against a "do nothing" baseline. Further analysis based on possible future target changes is included in annex C.
45. The "do nothing" baseline assumes that the current targets through the 2020s will be largely met by blending petrol with up to 5% ethanol and diesel with up to 7% biodiesel. Introducing E10 will therefore increase ethanol blending and have the effect of displacing some of the biodiesel that would have been blended into diesel as there is currently no incentive for fuel suppliers to go above and beyond the RTFO targets.
46. As ethanol delivers slightly lower carbon savings compared to waste derived biodiesel, and costs for consumers are slightly higher due to a lower energy density, the short-term impact of introducing E10 is likely to lead to reduced carbon savings at higher cost[10]. This is why the impact assessment indicates a negative cost benefit ratio.
47. However, introducing E10 would create headroom in the UK fuel supply sector to increase RTFO targets further. This would displace additional fossil fuel from the fuel mix and deliver higher carbon savings. These are estimated at around 0.7 to 0.8 megatons per year if targets were increased from the current B7/E5 level towards the B7/E10 level of blending. This is because the biodiesel originally displaced by increased ethanol blending is added back in under higher targets. The chart below shows the GHG impact of introducing E10 with and without increased RTFO targets. The blue bars represent a small emissions savings reduction if RTFO targets are not increased, however the red bar shows the potential emissions savings were targets to be increased following the introduction of E10.

[10] Annex B includes data on fuel prices, energy density and costs.

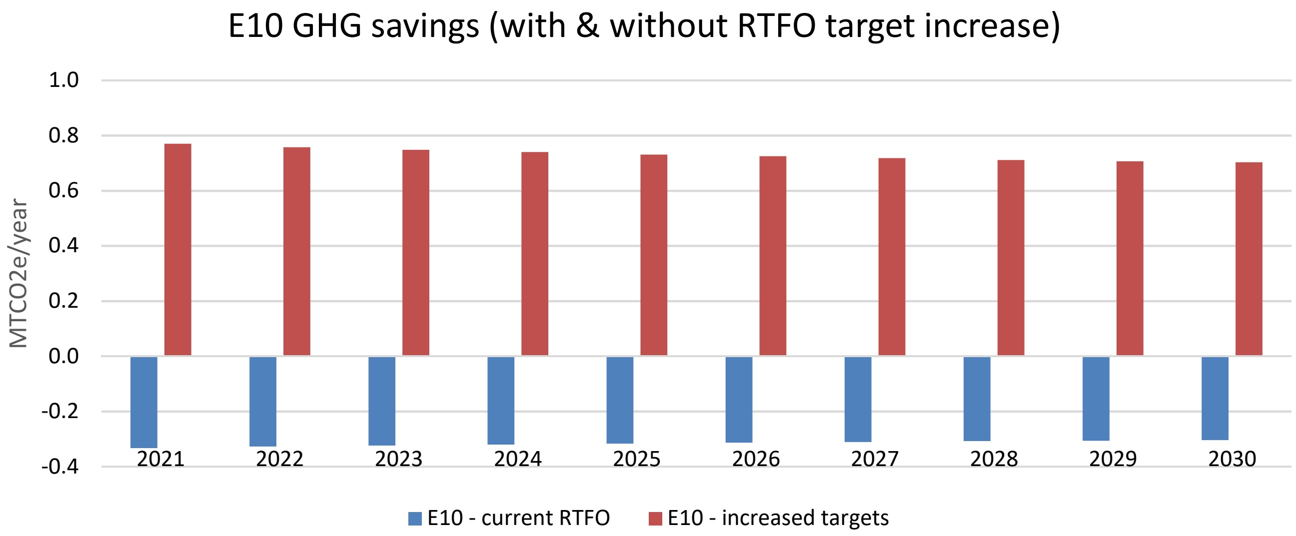

Figure 2: GHG impact of introducing E10 with and without increased RTFO targets - underlying data contained in cost-benefit analysis section (current RTFO) and annex C (increased targets) E9.8.

48. Changing the overall RTFO target will require a separate legislative process to the introduction of E10. As a result, keeping these two strands as separate but linked processes allows us to ensure both can be developed as robust individual policies. It is currently assumed unlikely targets would not be increased by at least the level afforded by the introduction of E10. If E10 is introduced the market is expected to be able accommodate a “step change” in targets equivalent to additional ethanol volume afforded by the move to E10. The main reason a step change target rise would not be implemented would be if the current assumed baseline within our modelling was incorrect such that the cost or availability of sustainable waste-based biodiesel became a significant limiting factor. Under such a scenario, a more gradual rise in targets may be required to ensure fuel suppliers can develop alternative biofuel blending options and markets to deliver higher obligation levels cost effectively.

Emissions reductions and carbon budgets

49. The Climate Change Act 2008 commits the UK to reducing greenhouse gas emissions to net zero by 2050 when compared to 1990 levels. To meet this aim, the Act implements a process of setting five-year caps on greenhouse gas emissions termed carbon budgets. While we have met our obligations under the first three carbon budgets, further action is required to ensure we can meet the fourth and fifth carbon budget.
50. The transport sector is the single biggest emitter accounting for over a quarter of emissions in the UK[5]. Recognising the need to scale up efforts in the transport industry, the UK’s first Transport Decarbonisation Plan is being developed and will bring together a programme of coordinated action needed for transport to play its part in reaching net zero emissions by 2050.
51. In terms of biofuels, we will need to maximise the potential of cost effective and deliverable measures through the 2020s and beyond. This will likely include increases to RTFO targets.
52. Analysis of a scenario where E10 is introduced and RTFO targets are increased shows that introducing E10 could help deliver around 0.7-0.8 megatons per year of CO_2 savings over the target periods at a cost of £349.50/tCO_2 (2019 prices). More detail on these calculations can be found in annex C.
53. Figure 3 shows a range of measures that could help meet future emissions reductions targets, and the associated estimated costs. E10 policy costs have been converted to carbon budget comparable figures to allow comparison with other policy measures to reduce GHG emissions. Costs are shown in £/tonne of CO_2e. The red line shows the level of emissions reductions required for carbon budget 5 with the blue line showing the E10 policy cost (£188/tCO_2), based on carbon budget accounting

(which attributes a 100% GHG saving to biofuels)[11]. This indicates that the costs associated with introducing E10 are within the expected range for measures required for carbon budget 5. More detail on these calculations can be found in annex C.

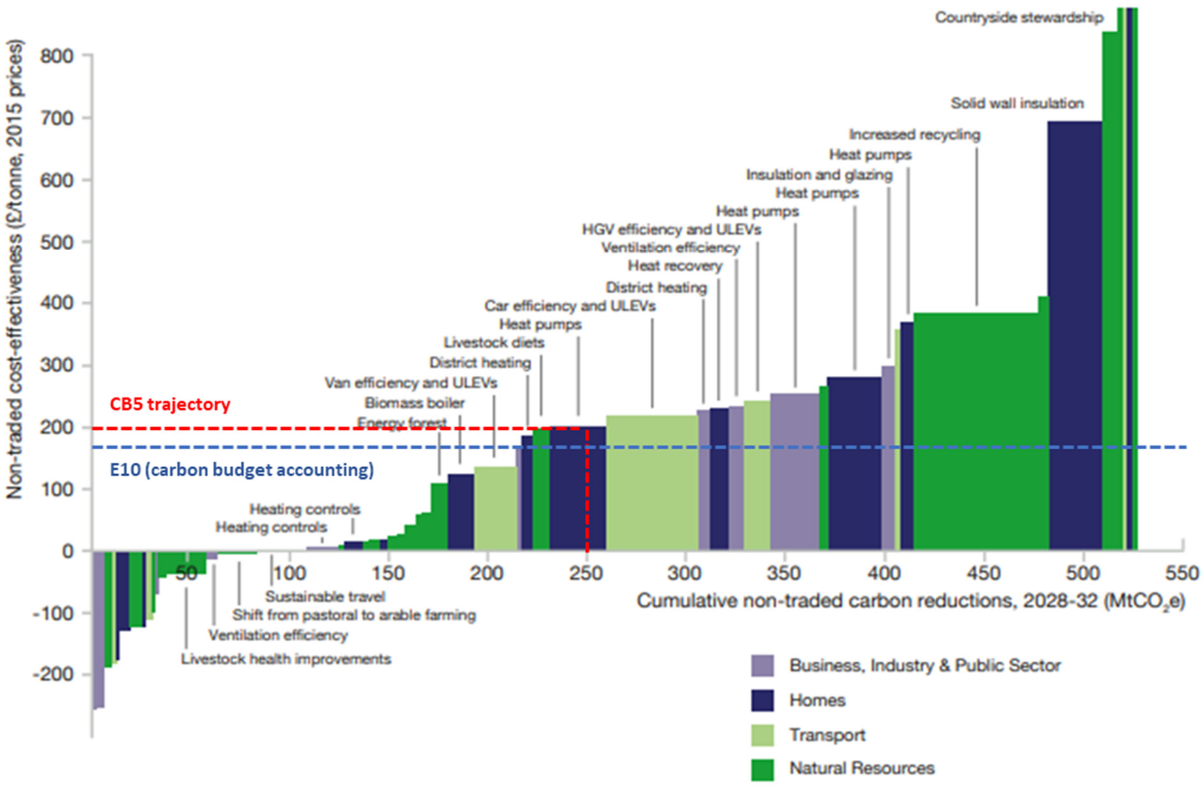

Figure 3: Marginal abatement cost curve showing the cost of carbon saving opportunities in the UK (for the heat and transport sectors). The red dotted line shows the level of carbon savings required by carbon budget 5 targets (central case). The blue dotted line shows the cost of carbon savings associated with the introduction of E10 (carbon budget accounting methodology) Source: The Clean Growth Strategy 2017, p. 147. (See annex C for more information on this chart)

2.3 UK bioethanol sector

Overview

54. The UK currently has a bioethanol production capacity of around 1 billion litres per year, with two large biorefineries based in Humberside and Teesside and one smaller facility in Norfolk. To date, industry have confirmed this capacity has regularly been underutilised. Currently, of the larger plants, one is operating at around half capacity, with the other mothballed due to poor market conditions.
55. Significant amounts of bioethanol supplied under the RTFO come from outside the UK. RTFO biofuel statistics 2017/18[12] indicate that UK feedstocks accounted for 217 million litres of the UK bioethanol supply (29% of the total UK bioethanol supply).
56. This trend is largely attributed by stakeholders to EU ethanol supply outstripping demand. The original investments made across Europe over the past decade were predicated on an assumption that ethanol demand would have increased more rapidly across the continent. As a result, in recent years, production capacity has outstripped demand creating challenging trading conditions in which UK plants have struggled to compete.

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[11] Lifecycle emissions savings includes subtracting emissions resulting from the production processes involved in producing the fuel. Carbon Budget accounting does not include this and therefore shows higher carbon savings. Both figures are provided to ensure they can be compared to other measures.

[12] https://www.gov.uk/government/statistics/biofuel-statistics-year-10-2017-to-2018-report-6 [accessed 17/12/19]

Improving market conditions

57. UK producers have been clear that were domestic demand to increase as a result of E10 introduction, it could help improve market conditions. With current blend levels constrained by the E5 blendwall, introducing E10 would approximately double the potential market for ethanol in the UK.
58. This should also be considered alongside wider EU upturns in demand. E10 is being introduced in a number of EU countries, with demand for ethanol increasing across the continent as nations seek to meet EU Renewable Energy Directive targets.
59. UK producers have cautioned that if the UK does not introduce E10 it is likely the domestic industry may not remain viable[13].

Wider benefits

60. UK ethanol production is beneficial to a number of related sectors and as such could help meet ambitious wider decarbonisation goals. UK ethanol is largely produced by processing feed-wheat. The two large plants in the North East of England have historically sourced their wheat locally, providing a stable market for farmers in the area.
61. The production of ethanol also results in valuable by-products. The high protein animal feed, Dried Distillers Grains with Solubles (DDGS) is a valuable commodity that is sold to livestock farmers. UK ethanol plants can produce around 850,000 tonnes per year[14], replacing e.g. more costly soya bean-based feed from South America[13]. This has a further net benefit in terms of GHG emissions reductions.
62. UK ethanol producers are also able to capture and store some of the CO_2 they create in producing ethanol. This stored CO_2 is a valuable resource in itself and is used in a number of industry sectors including nuclear and food and drink. This has led to one UK ethanol plant being listed as Critical National Infrastructure due to the importance of maintaining this supply domestically.

Future opportunities

63. Further into the future, ethanol, and the facilities that produce it, could play an important role in decarbonising other sectors such as aviation or the chemical industry. Existing production facilities could be adapted to meet future demand for these products but securing facilities in the short term is essential for these benefits to be realised in the future.
64. In the short term, if E10 is not introduced by 2021, we could lose our domestic industry. As we expect E10 will be needed to meet future carbon budgets, waiting significantly longer to introduce the new grade only jeopardises the ability of UK companies to benefit.

2.4 E10 Overview and Challenges

Overview

65. E10 is a blend of petrol with up to 10% bioethanol blended into fossil petrol.
66. Since 2012, the statutory petrol fuel standard has included two specifications for petrol that can be supplied in the UK. Petrol can either conform to the “E5” standard, with no more than 5% ethanol, or the E10 standard, with no more than 10% ethanol.
67. However, to date, no fuel retailer has stocked E10 petrol in the UK. A number of factors have dissuaded retailers from either a unilateral introduction, or a co-ordinated industry-led change.
68. There are two grades of petrol widely available in the UK distinguished by their octane rating (RON). Standard petrol, which is sold at every filling station, must have a RON of at least 95. Higher octane

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[13] The future of the British Bioethanol industry - APPG for British Bioethanol http://researchbriefings.files.parliament.uk/documents/CDP-2019-0004/CDP-2019-0004.pdf

[14] Ensus capacity around 350,000 tonnes. https://www.ensus.co.uk/Company/About_us/ – Vivergo around 500,000 tonnes https://vivergofuels.com/about/facts/

petrol with a RON of 97 or more is known as the “Super” grade and is available from many filling stations. Currently, both petrol grades qualify as “E5” as their ethanol content is no more than 5%.

69. All petrol vehicles can use high octane fuel, and most can use the standard grade. There are some high-performance vehicles that are advised by their manufacturer only to use the high-octane option, which performs better in engines that develop high compression.
70. The core reason for blending biofuels into road fuels is to reduce greenhouse gas emissions rather than air quality air related emissions. A range of studies have looked at the air quality implications of increased bioethanol blending with general consensus that a switch between E5 and E10 has minimal impact in either direction on emissions relating to air quality[15].

Barriers to industry-led E10 introduction

71. Ethanol is blended into petrol is to reduce GHG emissions from the fossil fuels traditionally used to power the nations cars and motorbikes as well as other petrol-powered equipment. While E10 has wider societal benefits in terms of helping to meet climate change related targets and obligations, there are no clear consumer advantages to choosing E10 fuel. Where individual’s incentives are not aligned with the socially optimal outcome (maximising value for society), there is a market failure.
72. There are three factors that act have contributed to this market failure and created a barrier to a commercially-led introduction of E10:
    - Vehicle compatibility and labelling requirements.
    - Slightly lower energy density of ethanol meaning a small decrease in fuel efficiency (and therefore higher per mile fuel costs).
    - Any new fuel grade would realistically need to replace an existing grade in the UK market.
73. These points are discussed in more detail in the sections below but have created a significant barrier to the market-led introduction of E10.
74. Fuel retailers have flagged their concern that in being the first to introduce E10, consumers could choose to fill up at a competitor’s forecourt if they are still supplying the standard E5 grade. This risk has prevented any retailer offering petrol blended above the 5% ethanol level. This has remained the case even though blending ethanol is understood to be the cheaper option for fuel suppliers to meet their RTFO targets cost effectively, the alternative being supplying more expensive biodiesel.
75. The difference between fuel retailers and fuel suppliers is an important factor in this respect. Fuel retailers are companies that operate filling stations while fuel suppliers are the companies that supply the fuel to filling stations. These are normally separate companies. The RTFO obligation sits with the fuel supplier. As a result, if a retailer does not want to supply E10 for commercial reasons, fuel suppliers cannot supply it. As a result, there is a risk that, even if suppliers cannot meet their obligation by supplying other biofuels, they may “buy-out” of their RTFO obligation before supplying E10. Buy-out of the RTFO will still impose a cost on the motorist, but the carbon savings of supplying renewable fuel will not be realised.

Commercial barrier: Vehicle compatibility and labelling

76. The vast majority of petrol vehicles are approved for use with E10. It has been the reference fuel for new car emissions and performance tests since 2016 and all cars since 2011 are approved to use E10.
77. There are no absolute rules for vehicle compatibility, but generally, cars produced since 2011 are approved for use with E10, with most from 2000 also listed as approved[16]. However, some older vehicles from the mid-2000s and older cherished and classic cars are not approved. Ethanol can be corrosive to some rubbers and alloys used in engine and fuel systems. The European vehicle

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[15] Impact of higher levels of bio components in transport fuels in the context of the Directive 98/70/EC of the European Parliament and of the Council of 13 October 1998, relating to the quality of petrol and diesel fuels and amending Council Directive 93/12/EEC https://op.europa.eu/en/publication-detail/-/publication/ec1f67bd-5499-11e7-a5ca-01aa75ed71a1/language-en/format-PDF

[16] ACEA have produced a car compatibility guide - https://www.acea.be/publications/article/e10-petrol-fuel-vehicle-compatibility-list

manufacturer trade associations have produced guides to vehicle compatibility to help owners identify the fuels their vehicles can use[17].

78. Estimates for 2019 show that 96.6%[18] of petrol cars in use in the UK are E10 compatible. 3.4%, around 700,000 cars, were classified incompatible, of which 25% are pre-1985 cars.
79. Based on scrappage rates ascertained from the DVLA database, by 2021 the number of incompatible cars is expected to fall to around 600,000 of which 50% are pre-1985 cherished vehicles. The total number of incompatible cars in the fleet continues to decline in the future to 279,000 incompatible cars by 2030 of which over 80% are pre-1985 cars.
80. As a number of vehicles and other petrol-powered machinery are not approved for use with E10, the ongoing supply of the current E5 grade will need to be maintained.
81. Because of the vehicle compatibility points, petrol classed as E10 must be labelled accordingly. The Biofuel (Labelling) Regulations 2004 set out a statutory consumer message to inform consumers that E10 is not suitable for use in all vehicles. This message will be updated in line with the proposals set out in the accompanying Government Response to the E10 consultation.
82. The need to communicate compatibility information to consumers, and the fact that some consumers would need to purchase an alternative petrol grade creates the barrier to a single commercial entity rolling the fuel out. The concern expressed by individual retailers are that they would need to shoulder the burden of this consumer education piece.

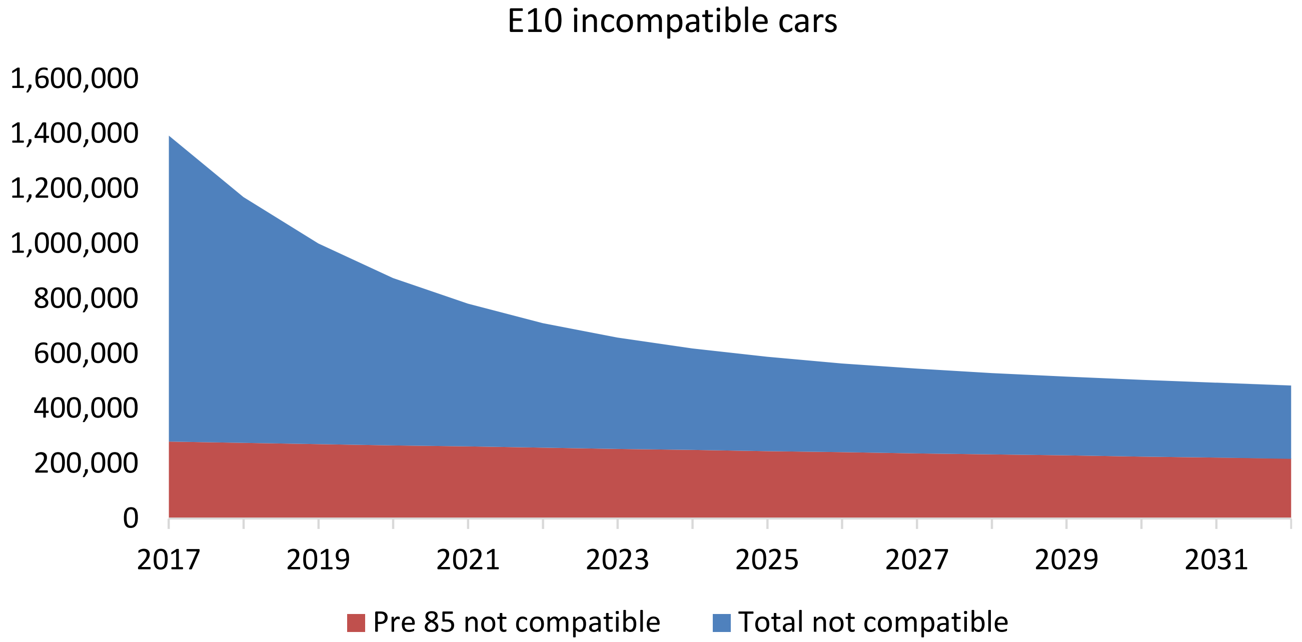

Figure 4: Number of incompatible vehicles with E10. Based on 2016 SMMT/DVLA E10 compatibility dataset

Commercial barrier: Energy density and costs

83. Bioethanol is less energy dense than petrol and contains only 65% of the energy content of fossil petrol (see annex B). This means, as more ethanol is blended into fossil petrol, less energy is contained in one litre of petrol.
84. Based on a direct relationship between energy and mileage, around 2% more litres of petrol with 10% ethanol (E10) are required to drive a given distance compared to petrol with 5% ethanol (E5) (see annex C for more detail).
85. This reduction in mileage is taken into account when calculating the GHG savings from E10. Overall CO_2 emissions when using petrol with 10% ethanol will still be 1.8% less than with 5% ethanol.

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[17] ACEM have produced a motorbike/scooter compatibility guide - https://www.acem.eu/component/content/article/2-non-categorise/33-e10

[18] Based on analysis of SMMT 2016 E10 compatibility dataset (the dataset is owned by SSMT and has not been published) combined with DVLA car scrappage rates https://www.gov.uk/government/statistical-data-sets/veh02-licensed-cars (table VEH0211)

86. Moving from 5% to 10% ethanol content is not expected to alter pump prices. However, as the energy content of the fuel will also decrease, overall fuel costs for petrol cars are therefore estimated to increase by 2.3% as a result of moving from 5% to 10% bioethanol content (more details on these calculations can be found in annex C).
87. It is important to consider that the energy density issue is likely a minor rather than major factor in determining why E10 has not been introduced in commercially. Ethanol has been blended up to the 5% level since around 2013, with the same energy density issue applying. However, as the move to E10 will require prominent advertisement, the link between ethanol and fuel efficiency can be more easily drawn for consumers. This increases the risk of a poor public reception should a single supplier or retailer chose to launch it. Expressed more simply, the energy density issue is only apparent due to the need to label the fuel and would likely not be widely noticed were blending to be increased without additional labelling.

Commercial barrier: E10 replacing an existing fuel grade

88. Following a call for evidence run by the Department for Transport in 2018 it is clear that fuel retailers are unlikely to be able offer E10 as an additional choice to the current fuel grades available on the UK market.
89. The UK petrol market is heavily optimised around supplying two grades of petrol – all forecourts sell a 95 octane standard petrol, while many forecourts also offer a higher octane "super" grade petrol at a higher price.
90. The whole supply chain, from refineries and blending facilities, through distribution and onto forecourts is designed around supplying two grades of petrol. Adding an additional grade would be costly at each stage of the supply line and could take multiple years to deliver to due to the require infrastructure changes.
91. Further, having E10 as an additional petrol option would likely create a more fractured petrol market, with possible low E10 uptake. Countries that have continued the sale of E5 95 and E10 95 alongside each other, most notably, France and Germany, have seen slow uptake in E10 fuel supply (~49%[19] and ~14% respectively[20]). This indicates that where consumers are given a choice, many continue to use E5 petrol. In both these countries significant tax incentives have been used to ensure E10 is cheaper than E5, however the many motorists still use the original E5 grade. This indicates that the "green" pull of a lower emission petrol, even when combined with a price incentive, is not sufficient to flip the petrol market to the mass uptake of E10.
92. On the other hand, countries that have only kept E5 available as the "super grade" fuel such as Finland (~68%), Belgium (~79%[21]) and the Netherlands[22], have seen much quicker and more comprehensive uptake.
93. As the main objective for the fuel sector in introducing E10 is to enable them to meet RTFO targets if the fuel only sells in low volumes it will not significantly help in meeting ongoing targets. As a result, the only viable route suggested by the fuel sector is for E10 to be introduced as a direct replacement for the standard petrol grade. This would mean the current E5 95 octane grade would become E10 95.

The market failure

94. The factors listed above have contributed to the overall market failure preventing the fuel sector from introducing E10. Currently, the only benefit to the fuel sector of introducing E10 would be slightly decreased costs associated with meeting RTFO obligations. The current obligation can be met by blending petrol at the E5 level, and diesel at the B7 level.
95. This limited benefit is not outweighed by the risks to a single fuel supplier or retailer. The need to convert the main and most popular fuel grade to one which must be advertised as not being suitable

[19] French market share data - https://www.bioethanolcarburant.com/actualite/bioethanol-data-7-septembre-2020/

[20] German market share data - https://www.bdbe.de/daten/marktdaten-deutschland

[21] Finland and Belgium - https://epure.org/media/1886/190509-def-pr-revised-epure-e10-leaflet_en_web.pdf

[22] E10 was introduced in October 19 and data has not been published on fuel trends, but anecdotal reports suggest a smooth transition.

for a selection of vehicles, whilst also delivering slightly lower MPG would be a high risk move for any company.

96. While consumers have shown willingness to purchase green alternatives in other markets, such as energy providers, these markets have significant consumer choice. The petrol market has very low levels of consumer choice and engagement. Few consumers actively support a single petrol brand and generally shop based on convenience and price.
97. For this reason petrol suppliers and retailers aim to serve as large a market as possible via their limited two petrol grade offering. A single retailer switching the most popular 95 grade to E10 is therefore high risk.
98. It is unlikely that those who prefer to purchase a greener fuel would outnumber those that are put off by the additional engagement needed to have confidence in their fuel purchase.
99. In short, the risks to a single fuel supplier switching to E10 outweigh the possible commercial benefits.

Need for Government-led introduction

100. To overcome these issues, a co-ordinated industry-wide roll out with accompanying single communications campaign is favoured by the fuel industry. This would remove the challenge of competing retailers supplying different grades. However, the fuel retail industry has stated that they are unable to organise this without government intervention due to concerns around competition law and whether all stakeholders within the sector would engage.
101. It is difficult to fully assess the concerns around competition law, as any co-operation between fuel suppliers could only be reviewed once the extent of the required co-operation became apparent. For this reason, fuel suppliers and retailers have indicated they would not be willing to risk infringing competition law by proceeding with an industry led co-ordinated introduction. There is also concern that unless such an industry led introduction was backed by all stakeholders, it would not achieve the aim of removing the commercial barrier that competitors may continue to sell E5 fuel in an effort to gain market share.
102. A government-led introduction also has clear benefits. A single nationwide introduction date with central communications and compatibility information would help keep consumer confusion to a minimum. This rectified information failures which are the current cause of market failure and under consumption of E10 petrol which is mentioned later. It removes competition concerns for fuel retailers and ensures consumers face the same choices at filling stations nationwide, as is currently the case.
103. This approach mirrors that of other European countries. In almost all cases, E10 has been introduced following government intervention, with the main objectives of meeting emissions targets and supporting domestic agriculture and bio-economies.
104. The communications campaign will be developed by government in a similar approach to that of the "know your fuel" campaign ahead of the introduction of new fuel labels in 2019. A campaign and accompany marketing material is developed by government, with assets shared with the fuel sector to use as necessary. It is not compulsory to participate in the communications campaign, but as the fuel sector will benefit from a smooth introduction of the fuel, it is expected that most will.

2.5 Keeping E5 available (Protection Grade)

105. In requiring E10 is introduced, we will also need to ensure that the current E5 grade is maintained as a choice on the market. A number of vehicles that are not approved for use with E10, as well as machinery and other petrol-powered equipment, will remain in use for the foreseeable future.
106. Accordingly, any introduction of E10 petrol also needs to consider how access to E5 is maintained.
107. The UK petrol market is already set up for the widespread distribution of two grades of petrol. Many petrol stations stock both a 95 octane "Premium" grade petrol, and a higher octane (97+) "Super" grade.
108. The Premium 95 grade accounts for around 95% of petrol sales, with the 97+ Super grade just 5%. As a result, for E10 to deliver any significant carbon savings it will need to be introduced in the Premium grade, with E5 maintained in the Super grade. This is the approach taken in other countries that have recently introduced E10 (Belgium and the Netherlands) and evidence suggests that this

approach has worked well, with smooth introductions of E10 and no reports of fuel or compatibility issues.

109. The higher octane super grade can be used in all types of petrol engine.

3 Problem under consideration and rationale intervention

3.1 Rationale for intervention

110. It is clear from our engagement with stakeholders throughout this and previous consultations that the fuel sector is unlikely to introduce E10 without Government intervention. The commercial barriers to an industry led introduction discussed in Chapter 2 mean there is no appetite within industry to lead on any introduction. As a result, if E10 is to be introduced it is reasonable to assume government intervention will be required.

111. In addition, a government led and co-ordinated introduction would create the best environment for a smooth UK wide E10 switch.

112. Government is keen to see E10 introduced for two main reasons:
- Facilitate the delivery of the RTFO and create favourable conditions for a future target increase.
- Ensure the UK ethanol sector can benefit from the introduction of E10 through its timely and smooth introduction.

3.2 Policy objective

113. The core policy objective is for E10 to be introduced across the UK in the standard petrol grade.

114. This will facilitate the effective delivery of the RTFO scheme by initially providing suppliers with increased flexibility in meeting their obligations while also providing a favourable environment for future target increases to be considered.

115. Effective delivery of the RTFO, and maximising opportunities for future target increases will be an important part of the UK's ability to meet carbon budgets 4 and 5 via emissions savings in the transport sector. The costs modelled in this IA indicate that E10 sits within the expected range for the level of carbon abatement required for carbon budget 5 as set out from paragraph 49 above.

116. Progressing a policy of E10 introduction in 2021 is also expected to foster the market conditions required to support the UK ethanol sector. Failure to do this in the short term could lead to one or both of the UK's major ethanol facilities closing permanently, with the loss of important investment in the UK's bioeconomy. These facilities have significant potential to help deliver on our bioeconomy strategy in the future.

117. This medium to long term view will help provide industry with a clear signal of the future direction of travel in this policy area. This is central to the rationale for introducing E10 now, rather than delaying a decision to later in the 2020s, alongside future RTFO target increases.

4 Description of options considered (including status-quo)

Options considered at Call for Evidence

118. A call for evidence on whether and how best to introduce E10 was published in July 2018. It asked whether E10 should be introduced as an additional grade of petrol alongside the current 95 E5 and 97+ E5 grades.

119. The Government response to that call for evidence was published alongside the consultation and draft Impact Assessment but is also summarised here. The "three-grade approach" of introducing E10 alongside the current two grade system was widely rejected by respondents across the fuel supply sector. There were three main reasons for this:

- First, respondents argued that, it would require significant infrastructure investment at all stages of the supply chain in order to accommodate a new grade. The UK fuel distribution system is reported to be heavily optimised around two grades of petrol and adding a third would be costly.
- Secondly, these upgrades would take time to plan and implement and would be subject to uncertain timelines in terms of permitting additional fuel storage at various supply chain points.
- Thirdly, by putting standard grade E5 and E10 alongside each other on the market, it was suggested that E10 uptake would remain low, as has been seen in other countries taking this approach. As a result, the carbon savings that E10 can deliver would be limited by its market penetration.

120. As a result, we did not proposed to require E10 to be introduced in this manner as part of the recent consultation. This is because it would represent the highest cost solution, would take time to implement and any carbon savings would be contingent on it gaining market share.

Non-legislative options

121. E10 has been permitted to be supplied by fuel retailers since 2013. The current commercial barriers have so far prevented its introduction, as described in section 3.1. We understand from anecdotal evidence that fuel suppliers are more likely to “buy out” of their RTFO target rather than unilaterally introducing E10.

122. As a result, further non-legislative initiatives, such as government encouragement via a central communications campaign, are considered unlikely to achieve the policy goal. In addition, this approach could lead to a partial E10 introduction which would still limit potential carbon savings and could lead to consumer confusion in a more complex petrol market.

123. Non-legislative options (other than the do-nothing approach) have therefore not been assessed in detail as part of this impact assessment.

Two-grade approach

124. Given the UK’s current petrol market is based around supplying two grades, E10 would need to be introduced either as an additional choice to motorists, thereby creating a three-grade petrol market, or as a replacement to one of the existing E5 grades (either the 95 octane Premium or the 97+ octane Super grade).

125. The three-grade approach has been ruled out following the 2018 Call for Evidence, as discussed from paragraphs 118.

126. Based on these factors, and the success of “two grade” introductions elsewhere in Europe (paragraph 108), a two-grade approach is the favoured route for E10 introduction in the UK. E10 would need to be introduced in the 95 octane Premium grade in order to deliver substantive carbon savings, with the 97+ Super grade retained as the E5 protection grade for those that need access to lower ethanol fuel. Introducing E10 in the 97+ Super grade would not be effective as it represents only a circa 5% share of the market. Doubling the ethanol content of this grade would therefore lead to only a small change in the capacity to blend ethanol in the UK.

127. To achieve the two-grade approach, each grade will need to meet different specifications. The Motor Fuel Composition and Content Regulations 1999 contain the current specifications for petrol sold in the UK. Amending these specifications to provide for a 95 octane Premium grade E10 and a 97+ octane Super grade E5 is the approach suggested in the consultation.

Ethanol as the “preferred fuel”

128. In meeting overall RTFO targets, fuel suppliers have two main options – biodiesel and bioethanol. Generally, blending bioethanol has represented better value to fuel suppliers in meeting overall obligations than biodiesel. As a result, since the RTFO was launched, ethanol blending increased up towards the E5 petrol blendwall in around 2013, before plateauing. Since then, further increases in RTFO targets have been met by increasing biodiesel blending towards the B7 blendwall. Current RTFO targets can be broadly met by blending to the E5 and B7 blendwall, with limited contributions from other areas such as biogas.

129. As a result, it is expected that, were suppliers to move above the 5% blendwall and label petrol as E10, as ethanol provides a more cost-effective route to RTFO compliance, they would proceed to

blend towards the 10% blendwall in petrol, and reduce the level of biodiesel blending. Further details on these assumptions are explained in the analysis of the options below.

130. As a result, our policy proposals aim to remove the 5% blendwall while providing fuel suppliers with flexibility in how they meet overall targets. This flexibility will permit them to take specific biofuel blending decisions based on cost, however based on historic price trends, we expect ethanol to remain the preferred fuel, while biodiesel will remain the marginal fuel. This is explored in more detail in the analysis of the options presented below.

131. The incentive to blend towards the 10% blendwall is also a product of the change in label. When more than 5% ethanol is blended into petrol, the label must be changed to E10. At this point the benefit of keeping ethanol content lower, i.e. not needing to label the fuel E10 and inform motorists of compatibility issues, no longer outweighs the benefits to the fuel sector of lower RTFO costs that supplying more ethanol could deliver.

132. It is also the case that under scenarios where E10 is introduced, the lower energy density of ethanol means more total litres of road fuel must be supplied to meet the same driving demand. As a result, where ethanol blending increases, fuel retailers will supply more litres of petrol, possibly leading to higher profits, though the mechanics of this are dependent on commercial decisions as to how costs are passed on.

133. These combined market factors have driven past blending ratios towards the 5% blendwall and are expected to drive future blending ratios towards the 10% blendwall when possible[23].

Option 1 – Do nothing

134. No change to minimum blend levels or fuel labelling. Under this option, the blend wall would remain in place and bioethanol blending would be expected to remain at its current level of E4.6. This 4.6% average blend level is understood to be towards the maximum that can be achieved over a calendar year whilst also remaining within the 5% figure for each litre of petrol. It is not possible / economic to blend exactly 5% into every litre of fuel. The 4.6% ethanol level is the baseline against which the other options are assessed.

Option 2 – All 95 Octane fuels required to be labelled as E10

135. Under this option, all 95 Octane fuels would be required to be labelled as E10. This would effectively remove the ‘blendwall’ as all petrol would be labelled as E10. As E5 and E10 fuel would have the same ‘E10’ label, it is assumed that any disadvantage associated with being the first retailers to shift to E10 would no longer be present as all fuel retailers would be rolling out E10 labelled fuel at the same time.

136. As ethanol is generally the preferred blending fuel for suppliers (see para 128 on), removal of the E5 blendwall would likely result in an increase of bioethanol blending towards the E10 blendwall.

137. Three different RTFO target scenarios have been considered when assessing this option. (1) a low scenario where ethanol blending rates remain unchanged at E4.6 (i.e. labelling changes only) (2) a high scenario where ethanol is blended into petrol at a 9.8% concentration (a theoretical maximum as blending exactly 10% across the petrol market would be challenging) (3) a central scenario at 8.3% concentration. This is weighted via historic biofuel certificate costs between the high and low scenarios.

Option 3 – All 95 Octane fuels required to contain a minimum of 5.5% bioethanol and be labelled as E10

138. Under this option, all 95 octane petrol is required to contain at least 5.5% bioethanol by volume. This would effectively remove the ‘blendwall’ as all 95 octane petrol would be labelled E10 as it would contain bioethanol in excess of the current E5 blending limit. The competitive disadvantage from being the first retailer to move to E10 would no longer be present as fuel retailers would be required to roll out E10 at the same time. 5.5% is the lowest minimum ethanol level that could be set whilst still being above the 5% E5 blendwall. In this respect it is the minimum legislative intervention that would entirely remove the E5 blendwall.

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[23] Data on blending levels and historic trends can be found in the RTFO annual statistics - https://www.gov.uk/government/collections/renewable-fuel-statistics

139. The key difference between this option and option 2 is that this option requires that all 95 octane petrol must contain at least 5.5% bioethanol by volume whereas option 2 is simply a requirement to change the labelling.

140. As with option 2, three different RTFO target scenarios have been considered when assessing this option. (1) a low scenario where ethanol blending rates remain unchanged at E5.5 (2) a high scenario where ethanol is blended into petrol at a 9.8% concentration (a theoretical maximum as blending exactly 10% across the petrol market would be challenging) and (3) a central scenario at 8.6% concentration. This is weighted via historic biofuel certificate costs between the high and low scenarios.

Why options were chosen

141. Option 2 is seen as the minimum regulatory intervention that could achieve the policy objective. By requiring the labelling of petrol as E10, this option removes the key barrier to a co-ordinated rollout of E10. However, while we would expect fuel suppliers to increase ethanol blending under this option, as it is the preferred fuel, it would not require that change. As a result it has some clear delivery risks, including that fuel retailers may attempt to continue to market the fuel as a low ethanol blend, notwithstanding the required E10 label. While this risk is unlikely, it could cause confusion were a single supplier or retailer to take this approach. In addition, by not requiring an increase in ethanol blending, the communications approach and messaging could be compromised.

142. Option 3 mitigates some of the issues that could arise under option 2, namely that fuel suppliers keep ethanol levels below 5% and market their fuel as a low ethanol option for incompatible vehicles, alongside the E10 label. Option 3 also means that ethanol blending levels must increase from their current point, meaning E10 will contain more ethanol than E5. This allows for stronger consumer messaging which is more likely to lead to a successful introduction of E10.

143. At the same time, the 5.5% minimum ethanol content will still allow suppliers flexibility in meeting overall RTFO mandates. While bioethanol is the main option in terms of biofuel blending into petrol, it is important individual suppliers maintain flexibility in meeting RTFO obligations. This flexibility ensures they are able to choose the cost-effective route to compliance. Were minimum ethanol levels set very high – towards the 10% maximum, suppliers would not be able to supply alternative biofuels, even if it was cost effect to do so.

144. While we expect fuel suppliers to blend more than 5.5%, due to it historically being the preferred fuel to meet targets, the 5.5% also allows them to vary blend levels over the year and geographically to ensure the RTFO is delivered cost effectively. It also allows suppliers to use other biocomponents in petrol, such as bio-methanol. If the minimum ethanol level was set higher, this flexibility would not be available to suppliers.

145. Setting the minimum ethanol level higher could preclude the use of other biofuels but would also reduce the ability of suppliers to react to price fluctuations. The 5.5% is deemed to present the best compromise between flexibility whilst still delivering the roll out of the new fuel grade.

146. The analysis looks at various different actual blend levels that could be delivered under both option 2 and 3. As a result, analysing a fourth option with a higher minimum blend would present little additional information and so has not been included in the Impact Assessment.

Consultation process and Government decision

147. These options were presented as part of the consultation on introducing petrol in the UK. A range of questions were included in the consultation impact assessment[24]. No additional data suitable to be update our modelling assumptions was presented at consultation stage. As such, we are not able to reasonably improve on any remaining evidence gaps, and no stakeholders raised significant concerns around these evidence gaps or the quality of analysis during the consultation.

148. Qualitative evidence from the overall consultation question responses have been considered as part of the decision-making process and where relevant the impact assessment has been updated.

[24] https://www.gov.uk/government/consultations/introducing-e10-petrol

149. Following the consultation process, Option 3, which requires a minimum 5.5% ethanol blend and the standards 95 octane petrol to be labelled E10, was chosen as the policy option to proceed with. The policy provides greater certainty for retailers and fuel suppliers, ensures a consistent and strong consumer message can be delivered via a communications campaign, and guarantees some increase in ethanol blending, whilst also opening up flexibility for a significant increase.
150. The detailed reasoning for the decisions can be found in the Government Response published alongside this IA.

5 Analytical approach and summary of outcomes

5.1 Analytical approach and assumptions

Core analysis

151. In this analysis we have assessed: (1) the costs associated with changes to biofuel blending (both biofuel and displaced fossil fuel); (2) the cost to owners of E10 incompatible vehicles who are assumed to switch to more expensive "super" grade petrol; and (3) the costs of fuel labelling for the new fuel stream. We have also assessed the benefits from GHG impacts which are presented as monetised benefits in the cost benefit analysis. We have also monetised additional fuel duty to accurately assess the costs to business. Further detail on the treatment of taxation in the IA is provided in Annex D.
152. The core part of the analysis, and that which is presented in the main summary sheets, is based on E10 being introduced under the current RTFO target regime.
153. We have assumed that waste biodiesel is the marginal fuel in the RTFO and ethanol the preferred fuel. This assumption is based on an analysis of current and past RTFO biofuel supply data and prices. This indicates that, in meeting targets, suppliers have supplied ethanol up to the E5 blend limit first (preferred fuel), and then used biodiesel to make up the remaining target (marginal fuel).
154. Therefore, any increase in the bioethanol supply results in reduced biodiesel supply according to our overall assumptions. This was explored further in the section above on ethanol as a preferred fuel.
155. We have not monetised the additional benefits that increased bioethanol production could bring to related sectors. This includes agricultural sector benefits through an increase in the feed-wheat market and benefits of increased domestic high protein animal feed supply and corresponding reductions in imported soy-based feed. We have not monetised the benefit of the supply of stored CO_2 and its wider contribution in terms of critical nation infrastructure. We have also not monetised the impact of reduced demand for fuels displaced by increased bioethanol blending (e.g. petrol and biodiesel).

Additional sensitivity analysis – RTFO target increase

156. The potential impacts of introducing E10 alongside increased RTFO targets (which have been assumed to be increased as a step change to accommodate the additional bioethanol, preventing a drop in biodiesel supply) have also been analysed and are presented as additional analysis against each option. While no decision on future targets has been made at this point, it is considered likely that, provided sufficient affordable feedstock to maintain current biodiesel blending levels remain available, RTFO targets would be increased by at least the level afforded by the introduction of E10 in the early 2020s. This additional analysis is therefore presented to show the likely costs and benefits of such an outcome.
157. This additional modelling includes an assumption that, were targets increased in the early 2020s, and E10 not introduced (RTFO target increase plus E10 "do nothing") suppliers would meet their additional target through further increased blending of biodiesel. The weakness of this assumption is that such a scenario is unlikely to be possible. As current targets are close to the B7 blendwall fuel suppliers would find it technically difficult to blend increasing levels of biodiesel, as is assumed in the modelling.

158. To blend further biodiesel to meet higher targets, as is assumed in the model, would require suppliers to sell increased volumes of "high blend" biodiesel to the commercial vehicle users. This is unlikely to be feasible in the short term.
159. In reality, it is unlikely targets would be increased as a step change in the early 2020's if E10 has not been introduced, as suppliers would find it difficult to meet these blending levels without E10. A more likely alternative is a gradual increase in targets that allows suppliers to grow alternative biofuel blending capabilities and markets. As a result, while the additional modelling is useful to understand the possible carbon savings and costs associated with an E10 roll out, there are limitations in how the detail presented would compare to real world blending options due to variability of possible policy scenarios. These questions will be covered in future consultations on overall RTFO policy.

	Monetised	Non-monetised
Costs	• Biofuel supply costs • Increased costs to owners of incompatible vehicles who may purchase super grade petrol as an alternative to E5 • Public communications and fuel pump labelling costs • Fuel duty costs to business	• Reduced demand for fossil petrol could impact profits at fuel refineries
benefits	• GHG savings from biofuel blending • Fuel duty transfer from business to government	• Increasing ethanol demand will reduce the likelihood of ethanol refinery closure • Increased domestic ethanol production would provide a boost to UK feed-wheat growers as well as provide additional domestic production of high protein feed and stored CO_2.

Non-monetised factors

160. A range of costs and benefits have not been monetised in this IA. The main un-monetised cost is the possible impact introducing E10 would have on refiners and suppliers of fossil petrol, as ethanol would displace petrol in the current road fuel market. This has not been monetised due to insufficient data on the mechanics of profits and possible export options for these companies. Their profits are also affected by how RTFO targets are met. This means any effort to include forecast of the impact on this policy on this area would be highly challenging.
161. The main un-monetised benefits are those related to increased profits at domestic ethanol producers and the agricultural sector supplying those producers with feedstocks. Again, due to insufficient information and the high level of uncertainty towards future predictions of these trends, these benefits have not been monetised. However, UK ethanol producers has been vocal in their support for the introduction of E10 linking it directly to the ongoing viability of the sector.
162. We have also not monetised the possible increased profits for fuel retailers / suppliers as a result of the increased volumes of total fuel that will need to be supplied when E10 is introduced. The relationship between the increased fuel volumes and various other mechanics of fuel sector profitability make this challenging.
163. We have also not included analysis related to impacts on air quality as it is generally considered changing biofuel blend levels within existing fuel standards will have a negligible impact either way in terms of air quality impacts. This is discussed more in para 70. We have also not monetised the possible impact of more frequent refuelling due to the lower energy density of E10 petrol. The possible small change in fuel economy coupled with the most motorists not filling tanks to the brim at each opportunity means any assumptions in this regard would be marginal in terms of cost and be subject to significant uncertainty.

95 E10 market adoption assumption

164. The UK petrol market is currently shared between the 95-octane standard grade and the 97+ super grade. The split is around 95% standard and 5% super.
165. While a small number of motorists with incompatible vehicles are expected to need to switch to the super grade we do not expect the overall market share of the two grades to change significantly and this has not been modelled within the IA.
166. The majority of incompatible vehicles in 2021 will be classic and cherished cars. Owners of these vehicles are assumed to already make up a significant proportion of those already using the Super grade, as it generally considered preferable for older cars. We expect therefore for relatively few drivers to need to switch to the Super grade, and some may switch from using the Super to using the standard due to the increased ethanol content and "green" impact of reduced emissions.
167. It is unlikely that demand will shift based on concerns over reduced MPG, as any reduction experienced due to increased ethanol content (1%-2%) would not be offset by the increased cost of the super grade (8%).
168. There is limited published evidence for how petrol markets in different countries have been effected by introducing E10 in the standard grade and keeping E5 in the super grade, however anecdotal evidence from Belgium and the Netherlands, who have proceeded with the most recent similar introductions, suggest no major changes in market share.
169. As a result, the analysis in this impact assessment has assumed that market share of the standard and super grade will not change after E10 introduction. To do so would have significantly complicated the analysis for limited benefit in terms of assessing overall costs.

5.2 Option 1 – Do nothing

170. There are no monetised costs or benefits associated with this option. However, not introducing E10 could potentially lead to the closure of one or more UK bioethanol refineries
171. In a do-nothing scenario we assume that standard grade petrol would continue to be sold as 95 octane E4.6 during the period 2021 – 2030.
172. In the table below we show predicted RTFO fuel supply volumes for biodiesel, bioethanol, diesel and petrol. This table has simplified for readability with certain niche fuels aggregated into the totals for the main fuels. The full table is provided in Annex C. This aggregation means that directly comparing the figures in the tables below to calculate the outputs will not yield the results presented in the IA – the full tables in the annex are required to reproduce some of the results presented in analysis.

Fuel	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Biodiesel	1,984	2,008	2,023	2,036	2,044	2,058	2,073	2,084	2,097	2,111
Bioethanol	672	661	652	645	637	631	625	619	615	611
Total Biofuel	**2,657**	**2,669**	**2,675**	**2,681**	**2,681**	**2,689**	**2,698**	**2,703**	**2,712**	**2,722**
Fossil Diesel	27,647	27,438	27,282	27,094	26,838	26,661	26,515	26,307	26,113	25,935
Fossil Petrol	13,964	13,726	13,553	13,403	13,226	13,109	12,980	12,861	12,773	12,699
Total fossil fuel	**41,611**	**41,164**	**40,834**	**40,498**	**40,064**	**39,770**	**39,495**	**39,169**	**38,886**	**38,634**
Total Fuel	**44,267**	**43,834**	**43,510**	**43,179**	**42,744**	**42,459**	**42,192**	**41,872**	**41,598**	**41,356**

Figure 5: Baseline fuel supply volumes (million litres)

173. In the do-nothing scenario, the bioethanol supply is projected to fall over time from 672 million litres in 2021 to 611 million litres by 2030. This fall is due to the overall energy demand for fuels falling over the period (resulting from increased fuel efficiency and electrification of the fleet). This trend is shared across all other fuels. Renewable fuels do not fall as quickly as fossil fuels due to continual increases in the RTFO target[25]. More detail on fuel supply projections can be found in annex B.

[25] https://www.legislation.gov.uk/ukdsi/2018/9780111164242

174. To calculate the cost of the fuel supply we used the following fuel price projections. Fossil fuel price projections are based on standard government values and biofuel prices are based on an analysis of historical price trends. More detail on fossil fuel and biofuel price projections can be found in annex B.

	£/litre, 2019 prices			
	petrol	diesel	crop ethanol	UCO biodiesel
2021	0.42	0.45	0.69	0.99
2022	0.42	0.46	0.70	1.00
2023	0.43	0.46	0.70	1.00
2024	0.43	0.47	0.71	1.01
2025	0.44	0.47	0.71	1.01
2026	0.45	0.49	0.72	1.02
2027	0.45	0.49	0.73	1.03
2028	0.45	0.50	0.73	1.03
2029	0.46	0.51	0.74	1.04
2030	0.47	0.51	0.74	1.05

Figure 6: biofuel and fossil fuel price projections (£/litre, 2019 prices, undiscounted, excluding tax)

175. The overall cost of the fuel supply is then calculated by multiplying projected supply volumes by projected prices. The table below has been calculated using the full fuels projection and prices shown in Annex B.

Fuel	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Biodiesel	2,031	2,101	2,148	2,194	2,235	2,292	2,340	2,384	2,440	2,486
Bioethanol	518	513	510	508	504	506	505	503	506	506
Total Biofuel	**2,549**	**2,613**	**2,658**	**2,702**	**2,740**	**2,799**	**2,845**	**2,887**	**2,946**	**2,992**
Fossil Diesel	12,556	12,603	12,673	12,728	12,747	12,942	13,009	13,045	13,221	13,266
Fossil Petrol	5,845	5,807	5,796	5,793	5,776	5,844	5,846	5,851	5,927	5,950
Total fossil fuel	**18,401**	**18,410**	**18,469**	**18,520**	**18,523**	**18,786**	**18,855**	**18,896**	**19,148**	**19,216**
Total Fuel	**20,950**	**21,023**	**21,127**	**21,222**	**21,263**	**21,584**	**21,700**	**21,783**	**22,093**	**22,208**

Figure 7: Baseline fuel supply costs (£m, 2019 prices, undiscounted, excluding tax)

176. The costs of supplying blended petrol and diesel is estimated at £21bn in 2021 increasing to £22bn in 2030.

177. Carbon impacts are also examined in this analysis. Carbon emission factors are based on reported carbon data from the RTFO statistics with the addition of carbon emissions from indirect land use change (ILUC). Where the historical emissions factors fall below the recently implemented 60% RTFO minimum GHG saving threshold, GHG emissions have been reduced to comply with the threshold (therefore we assume that crop ethanol and crop biodiesel GHG emissions are lower in the future than they have been in the past, as this is required by the minimum GHG saving threshold).

178. A 12gCO2e/mj emissions factor to take into account emissions from indirect land use change (i.e. changes in land use (e.g. deforestation) resulting from increased demand for agricultural crops) has been added to the crop bioethanol emissions factor and a 55gCO2e/mj indirect land use change (ILUC) factor has been added to crop biodiesel (ILUC values sourced from the Renewable Energy Directive26). A breakdown of emissions for the main fossil fuels and biofuels is shown in the table below. More information on emissions assumptions can be found in annex B.

[26] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32015L1513, Annex V

	petrol	diesel	crop ethanol	waste biodiesel	crop biodiesel
well to tank	17	17	31	10	34
tank to wheel	71	75	0	0	0
ILUC	0	0	12	0	55
total	88	92	43	10	89

Figure 8: breakdown of emissions factors for main fossil fuels and biofuels covered in the analysis (gCO2e/mj) (underlying sources can be found in annex B)

179. Multiplying fuel supply volumes by fuel emissions factors gives total GHG emissions
180. Total baseline GHG emissions are calculated by multiplying projected fuel supply by their emissions factors. Overall GHG emissions from road transport are estimated to fall from 132 million tonnes of CO2e in 2021 (MtCO2e) to 123 million tonnes in 2030.

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Total Emissions	132	131	130	129	127	126	125	124	124	123

Figure 9: total road transport GHG emissions (MTCO2e, lifecycle GHGs)

5.3 Option 2 – All 95 Octane fuels required to be labelled as E10

Under this option all 95 Octane fuels would be required to be labelled as E10. This would effectively remove the 'blendwall' as all petrol would be labelled as E10. As E5 and E10 fuel would have the same 'E10' label, it is assumed that any disadvantage associated with being the first supplier to shift to E10 would no longer be present and all fuel suppliers would be rolling out E10 labelled fuel at the same time.

Three different RTFO target scenarios have been considered when assessing this option. (1) a low scenario where ethanol blending rates remain unchanged at E4.6 (i.e. labelling changes only) (2) a high scenario where ethanol is blended into petrol at a 9.8% concentration and (3) a central scenario where ethanol is blending into petrol at a 8.3% which is a weighted average based on the probability of a full E10 deployment (E9.8) and the low scenario (E4.6).

Cost: Fuel supply impacts (excluding taxes)

Low scenario (E4.6)

181. Relative to the counterfactual (option 1 – 'do nothing'), there is no change in the fuel supply in the low scenario as bioethanol blending is assumed to remain at E4.6. Therefore, the low scenario has no additional costs to fuel suppliers.

High scenario (E9.8)

182. In the high scenario we assume a blend rate of E9.8 in standard 95 octane petrol, which reflects a successful widespread introduction of E10. This would give the following change in the fuel supply. As above, this table has simplified for readability with certain niche fuels aggregated into the totals for the main fuels.

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Biodiesel	-409	-402	-397	-393	-388	-385	-381	-378	-375	-373
Bioethanol	818	805	795	787	777	770	763	756	751	747
Fossil Diesel	375	369	364	360	356	353	350	346	344	342
Fossil Petrol	-537	-528	-522	-516	-510	-505	-500	-496	-493	-490
Total Fuel	247	243	240	238	235	233	230	228	227	226

Figure 10: Change in fuel supply moving between the baseline and E9.8 (million litres)

183. An increase in supply of crop bioethanol is expected to displace waste biodiesel from the fuel supply (as waste biodiesel is assumed to be the marginal biofuel supplied under the RTFO). As waste biodiesel is double rewarded under the RTFO, and contains slightly more energy, just over two litres of bioethanol are supplied for every litre of waste biodiesel displaced.

The fossil petrol supply decreases to accommodate the increased bioethanol supply and fossil diesel increases to offset the fall in the biodiesel supply. Overall, the fuel supply increases by around 235 million litres per year. This happens because bioethanol has a relatively low energy content, so more litres of fuel are required to meet the same energy demand.

184. Multiplying the change in fuel supply by projected fuel prices gives the following cost profile. As above, this table has simplified for readability with certain niche fuels aggregated into the totals for the main fuels.

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Biodiesel	-406	-401	-398	-396	-393	-394	-392	-391	-392	-392
Bioethanol	568	562	559	557	553	555	554	552	555	556
Fossil Diesel	170	169	169	169	169	171	172	172	174	175
Fossil Petrol	-225	-223	-223	-223	-223	-225	-225	-226	-229	-230
Total Fuel	108	107	107	107	106	108	108	108	109	109

Figure 11: Change in cost of fuel supply moving between the baseline and E9.8 (£m, 2019 prices, undiscounted, excluding taxes)

185. Bioethanol costs increase by £568m in 2021 falling to £556m in 2030. The decrease in waste biodiesel leads to a cost saving of £406m in 2021 falling to £392m in 2030.
186. Fossil petrol costs decrease by £225m in 2021 decreasing further to £230m in 2030. The increase in fossil diesel leads to a cost of £170m in 2021 to £175m in 2030.
187. Overall, the total fuel supply cost increases by £108m in 2021 falling to £109m in 2030.

Cost: Incompatible vehicles

188. In this assessment, drivers of vehicles that are incompatible with E10 are assumed to purchase "super unleaded" grade petrol which will not be labelled as E10 under this proposal. Drivers of compatible vehicles are assumed to switch to E10 when it is introduced.
189. To estimate vehicle compatibility, we have taken data from the SMMT[27] on vehicles that are incompatible with E10 and applied estimated vehicle scrappage rates going forward. DfT has standard assumptions about the rate at which cars are scrapped dependent on age. However, this does not account for classic cars, which are significantly less likely to be scrapped.
190. To estimate scrappage rates for the E10 unsuitable fleet we categorised cars into two categories by year of production: 1985 or newer or pre-1985 (a proxy for classic cars). A "survival rate" was then applied to estimate the number of incompatible cars leaving the fleet in each year. This gives the following projection of non-E10 suitable cars by year:

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Total not compatible	**519,110**	**453,193**	**404,978**	**369,643**	**343,449**	**323,583**	**308,339**	**296,327**	**286,614**	**278,619**
Pre- 85 not compatible	262,109	257,782	253,515	249,303	245,142	241,062	237,091	233,198	229,368	225,607
% pre 85	50%	57%	63%	67%	71%	74%	77%	79%	80%	81%

Figure 12: Number of incompatible vehicles split by pre-1985 and post-1985, SMMT compatibility dataset 2016 [37]

[27] Vehicle compatibility data was supplied by the Society of Motor Manufacturers & Traders (SMMT). A summary of this data can be found in figure 4

191. The current 12-month average retail price[28] of "premium unleaded" petrol at the time of this analysis was 125 pence per litre and "super unleaded" was 135 pence per litre 10 pence price differential.
192. Assumptions were made on the fuel efficiencies and average mileage of incompatible vehicles. Fuel efficiency data was taken from historic fuel efficiencies from DfT Energy and Environment data tables[29]. The data only goes as far back as 1997 which is taken as a proxy for all incompatible vehicles which gives an efficiency of 34.0 miles per gallon. DfT's car fleet model[30] provided estimates for vehicle mileage with the oldest vehicles in the fleet averaging 4700 miles per year.
193. Combining the vehicle data with the assumptions above gives us the costs to incompatible vehicles who would have to switch to "super unleaded" fuel. Combining the efficiency and mileage assumptions gives an estimated 629 litres of petrol consumed per incompatible vehicle.
194. The analysis looks at both costs to all incompatible vehicles and those that were made before 1985, these are considered as classic cars. Multiplying the super cost premium by the demand from incompatible vehicles gives the following cost profile.

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
£m/year	33	29	26	24	22	21	20	19	19	18

Figure 13: Cost to incompatible vehicle owners (£m, 2019 prices, undiscounted)

195. Cost to incompatible vehicles would be £33m in 2021 falling to £18m in 2030 as the size of the incompatible fleet decreases over the period.
196. This cost differential would also include the increased VAT paid as the base cost of the fuel is higher. To avoid double counting because taxation costs are considered a transfer for the purposes of this analysis we have used the costs excluding the additional VAT for the final cost to incompatible vehicles. Any additional fuel VAT paid by businesses could still be claimed back under standard VAT rules, so has not been included in any additional business costs. There is no change in fuel duty costs to incompatible vehicles as it is paid per litre, which will be unchanged (further details on the treatment of tax is provided in Annex D).

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
£m/year	28	24	22	20	18	17	17	16	15	15

Figure 14: Cost to incompatible vehicle owners excluding VAT (£m, 2019 prices, undiscounted)

197. This gives a cost of £28m in 2021 to £15m in 2030.
198. These costs are expected to occur independent of the fuel blend of E10 as consumers are expected to avoid E10 labelled fuel if their vehicle is not compatible. As a result, the same costs are anticipated for low and high scenarios as fuel choice decisions are based on label and not actual biofuel blending level, which would be unknown to the consumer.

Cost: Communication Campaign and Fuel labelling

199. Fuel filling stations will be required to re-label all their petrol pumps to account for the new E10 fuel. This cost has already been calculated in the recent Alternative Fuel Labelling Regulations Impact Assessment[31].
200. It is assumed that the labelling exercise would have to be replicated by fuel pump station once again to apply the E10 labels. It is possible the fuel pump stations could incorporate the costs of these new labels as part of their own regular branding campaigns so there would no extra cost faced by stations from this. Alternatively, this may not coincide with fuel pump stations branding and labelling timeline and so would be an additional cost. These were treated as low and high cost

[28] https://www.gov.uk/government/statistical-data-sets/oil-and-petroleum-products-weekly-statistics

[29] https://www.gov.uk/government/statistical-data-sets/energy-and-environment-data-tables-env

[30] DfT car fleet model uses mileage and vehicle age information gathered for MOT recording

[31] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/781677/alternative-fuel-labelling-impact-assessment.pdf

scenarios respectively. This is shown in the table below with the costs taken from the Alternative Fuel Labelling Regulations Impact Assessment.

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Cost of fuel labelling (£m)	£1.20	-	-	-	-	-	-	-	-	-
Cost of communications	*£3.6*	-	-	-	-	-	-	-	-	-
Total (£m)	*£4.8*	-	-	-	-	-	-	-	-	-

Figure 15: Fuel labelling costs to fuel filling stations (£m, 2019 prices, undiscounted)

201. It is assumed that, following an additional outlay for the initial labelling, replacement labels would be factored into branding maintenance schedules with marginal additional costs is also taken for this analysis.
202. These costs are expected to occur independent of the fuel blend of E10 as the labels on fuel pumps would be E10 regardless of the true blend of petrol.
203. Based on the £1.2million base cost of fuel labelling, this is then tripled and added to the labelling costs to give an overall cost of £4.8 million (1.2m of fuel labelling cost and £3.6 million of communication campaign cost). The decision to triple these costs comes from the rationale that literature which form the communication campaign such as posters, adverts etc. could cost roughly three times the amount of labels to print. This is an assumption which has been shared with industry. Generally, industry were unable to verify or provide more detailed costs, but agreed that it would be more than the base labelling costs incurred for previous fuel labelling requirements and industry were content with these projections. The overall total amount of £4.8m encompasses overall fuel labelling and communication costs. The development and design of the communications assets (posters / leaflets etc.) will be provided by Government (these costs have not been included in the analysis and will be drawn from existing DfT budget), with industry only needing to procure printing and distribution of these assets to forecourts.
204. We have not conducted a sensitivity analysis on the on the labelling and communications costs as it is founded on an unevidenced assumption. Adding sensitivity to this would therefore add no additional insight on proportionality grounds.

Benefit: GHG savings

Low scenario (E4.6)

205. There are no additional GHG savings in the low scenario as the fuel supply is the sme as the baseline.

High scenario (E9.8)

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
MTCO2e/year	-0.33	-0.33	-0.32	-0.32	-0.32	-0.31	-0.31	-0.31	-0.31	-0.30

Figure 16: GHG savings impact of moving from the baseline to E9.8 (MTCO2e/year)

206. This decrease in GHG savings is mainly because the biofuel displaced by ethanol (waste biodiesel is assumed to be displaced) gives a slightly higher carbon saving.

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
£m/year	-24	-24	-24	-24	-24	-24	-24	-25	-25	-25

Figure 17: Monetised GHG savings benefit of moving from the baseline to E9.8 (£m, 2019 prices, undiscounted)

207. The monetised value of this decrease in GHG savings is valued at -£24m in 2021 rising to -£25m by 2030. Non-traded carbon values have been used to monetise the emissions (these values can be found in annex B).

Delivery Risks

208. Option 2 – which is a requirement to simply change the labels on fuel pumps from E5 to E10 – is considered to carry a higher delivery risk than option 3 (which requires ethanol blending above the E5 blendwall). As suppliers can theoretically choose to continue to sell E5 there is a risk that retailers could label the fuel as E10 but continue to market it separately as a low ethanol option, therefore undermining the smooth consumer roll out of E10.
209. This could cause confusion amongst consumers hindering the acceptance of the new fuel grade. The lack of a requirement to blend more ethanol could lead the public to question whether compatibility issues are correct and generally sew distrust in the communications campaign.
210. Overall biofuel supply will still be controlled by the RTFO, so carbon saving risks remain low, but consumer confidence in biofuels could be hit, limiting appetite for further RTFO increases.

Probability of full E10 deployment

211. Biofuel and fossil fuel market prices can be used to estimate the cost of generating a Renewable Transport Fuel Certificates (RTFC). The cost of generating a certificate by supplying bioethanol is estimated by taking the difference between the cost of supplying a litre of bioethanol and the cost of supplying a litre of petrol (which is displaced from the fuel mix by bioethanol).

£/certificate (bioethanol) = bioethanol price (£/litre) – petrol price (£/litre)

212. The cost of generating a certificate by supplying used cooking oil derived biodiesel (UCOME) is estimated by taking the difference between the cost of supplying a litre of UCOME and the cost of supplying a litre of diesel (which is displaced from the fuel mix by biodiesel). As supplying a litre of UCOME generates two certificates, the difference in prices is divided by two to produce the certificate cost estimate.

£/certificate (UCOME) = (UCOME price (£/litre) – diesel price (£/litre))/2

213. Looking at market price data from the past 5 years (from April 2015 to April 2020), we can see that the estimated cost (to the fuel supplier) of generating a renewable transport fuel certificate using UCOME has been on average 24% higher than the cost of generating certificates using bioethanol. For 71% of this period, the cost of generating a certificate from supplying bioethanol has been the lower of the two. In addition, suppliers will also sell more litres under a scenario where E10 is introduced which could lead to higher profits (assuming that profit is a function of volume sold). For these reasons, we conclude that suppliers are likely choose to supply more bioethanol if the E10 blend wall is effectively removed by this policy change.
214. As the price differential between biodiesel and bioethanol can fluctuate, including flexibility into the policy proposals ensures suppliers can balance their blending between the two main biofuel options as dictated by the market.

Cost-benefit summary for Option 2

215. The table below shows a summary of monetised costs and benefits for the central scenario (E8.3), the low scenario (E4.6) and the high scenario (E9.8) for the appraisal period of 2021 to 2030. The central scenario has been calculated by a weighted average calculation which attributes a 71% probability to E9.8 and a 29% probability to E4.6 (see 'probability of full E10 deployment' section directly above for explanation of the probabilities weightings). For the calculation of the low and high scenarios within the EANCB calculator, the methodology has been adjusted such that the NPV values of the high and low scenarios have been calculated by subtracting high costs from high benefits and low costs from low benefits.
216. In the central scenario, total costs of £880m are made up of (1) £657m of additional fuel costs; (2) £169m of costs to incompatible vehicles; (3) £5m communication campaigns and fuel pump labelling

costs; and (4) £50m fuel duty costs. GHG savings are estimated to fall by 2.2 MTCO2e which is valued at -£148m (a negative benefit). There is also a transfer of £50m in the form of fuel duty benefits, giving total benefits of £98m. Overall this gives a policy net present value of -£978m. £/tCO2e is not given as there are no GHG savings under this scenario.

217. In the low scenario, the fuel supply is assumed to remain unchanged. However, as standard grade petrol fuel pumps are all labelled as E10 under the scenario, it is assumed that owners of incompatible vehicles will buy super grade petrol, incurring a cost of £169m in addition to £5m communications campaign and fuel labelling costs. Overall this gives a policy net present value of -£174m. £/tCO2e is not given as there are no GHG savings under this scenario.

218. In the high scenario, total costs of £1169m are made up of (1) £925m of additional fuel costs; (2) £169m of costs to incompatible vehicles; (3) £5m communication campaign and fuel pump labelling costs; and (4) £70m of fuel duty costs. GHG savings are estimated to fall by 3.2 MTCO2e which is valued at -£209m (a negative benefit). There is also a transfer of £70m in the form of fuel duty benefits, giving total benefits of £138m. Overall this gives a policy net present value of -£1307m. £/tCO2e is not given as there are no GHG savings under this scenario.

	Central (E8.3)	low deployment (E4.6)	high deployment (E9.8)
Cost of communication campaign and fuel labelling	5	5	5
Cost to incompatible vehicles	169	169	169
Fuel costs	657	0	925
Fuel duty cost	50	0	70
Total Costs	880	174	1169
Carbon benefits	-148	0	-209
Fuel duty benefit	50	0	70
Total Benefits	-98	0	-138
NPV	-978	-174	-1307

Figure 18: Option 2 summary cost-benefit data covering appraisal period 2021 to 2030 (£m, 2019 prices, discounted)

	central (E8.3)	low deployment (E4.6)	high deployment (E9.8)
GHG savings (MTCO2e)	-2.2	0.0	-3.2
£/tCO2e	n/a	n/a	n/a

Figure 19: Option 2 GHG savings impact covering appraisal period 2021 to 2030 (MTCO2e)

Cost distribution (excluding tax)

219. In assessing who is likely to bear the costs of this policy change we look at 4 different groups: fuel suppliers; (2) fuel retailers; (3) individual fuel consumers; and (4) business fuel consumers.

220. **Communication Campaign and Labelling costs** - the cost of the communication campaign and labelling pumps is assumed to fall 100% on fuel retailers.

221. **Incompatible vehicle costs -** owners of E10 incompatible vehicles are assumed to purchase more expensive super grade (E5) petrol instead of standard grade (E10) petrol. We estimate that petrol consumed by incompatible vehicles is split between 98% individual fuel consumers and 2% business fuel consumers (see table in annex D for how this has been calculated).

222. **Fuel costs** – As bioethanol contains less energy than the fuel it displaces, total fuel volumes increase. The cost of the increased volume of fuel is borne by consumers of petrol. We estimate that

94% of petrol is consumed by individual members of the public and 6% is consumed by business fuel consumers[32].

223. The tables below show how policy costs are estimated to be spread across these groups.

	Total (E8.3 – central scenario)	fuel suppliers	fuel retailers	consumers (individuals)	consumers (companies)
Cost of fuel labelling	5	0	5	0	0
Cost to incompatible vehicles	169	0	0	165	3
Fuel costs	657	0	0	617	39
Total Costs	830	0	5	783	43

Figure 20: costs split into fuel consumer groups covering appraisal period 2021 to 2030 (£m, 2019 prices, discounted) (central scenario) (excluding taxes)

	companies	individuals
Total Costs	48	783

Figure 21: costs split into companies and individuals covering appraisal period 2021 to 2030 (£m, 2019 prices, discounted) (central scenario) (excluding taxes)

224. These costs have been expressed net of any additional tax costs. Tax costs are treated as transfers for this impact assessment and calculating the net present value of the policy. The section below includes a summary of the costs to businesses, including those relating to increased tax costs.

Business costs including fuel duty

225. Under option 2, total costs for businesses will include the costs listed above, plus the additional value of the fuel duty incurred because of purchasing more litres of E10 compared to E5 (see Annex D for further details of the approach to taxation).

226. This was calculated by apportioning the increased fuel consumption of business consumers via the method in the "cost distribution section" and applying a 57.95p/l duty rate, then discounted across the appraisal period.

227. This cost represents an additional £50m over the appraisal period for the central scenario. For the low scenario, there is no change in fuel duty and for the high scenario this amounts to £70.4m. These costs do not count towards the NPV of the policy but will be borne by business.

Business costs (£m)			
	central (E8.3)	low deployment (E4.7)	high deployment (E9.8)
Cost of fuel labelling	4.8	4.8	4.8
Cost to incompatible vehicles	3.4	3.4	3.4
Fuel costs	39.4	0	55.5

[32] DVLA ownership data - https://www.gov.uk/government/statistics/vehicle-licensing-statistics-2019

Additional fuel duty	50	0	70.4
Total Costs	**97.6**	**8.2**	**134.1**

Figure 22. Total costs to businesses including fuel duty, covering appraisal period 2021 to 2030 (£m, 2019 prices, discounted)

Additional modelling - *RTFO target increase sensitivity analysis (excluding taxes)*

228. Introducing E10 will create space for future RTFO target increases which will generate additional GHG savings. Monetised costs and benefits for a scenario where targets are raised to accommodate E10 in 2021 is shown in the tables below. Detail on the assumptions that underpin this analysis can be found in para's 152 on.
229. In the central scenario (E8.3), the target increase is assumed to be met through a mixture of bioethanol and waste biodiesel. Total costs of £2,667m are made up of (1) £2,494m of additional fuel costs; (2) £169m of costs to incompatible vehicles; and (3) £5m communication campaign and fuel pump labelling costs. GHG savings are estimated to increase by 8.2 MTCO2e which is valued at £542m. Overall this gives a policy net present value of -£2,225m. Carbon cost effectiveness[33] under the central scenario is £271/tCO2e.
230. In the low scenario, the ethanol supply is assumed to remain unchanged and the RTFO target increase is assumed to be met through increased blending of waste biodiesel. However, as standard grade petrol fuel pumps are all labelled as E10 under the scenario, it is assumed that owners of incompatible vehicles will choose to buy super grade petrol. Total costs of £1,765m are made up of (1) £1,592m of additional fuel costs; (2) £169m of costs to incompatible vehicles; and (3) £5m communication campaign and fuel pump labelling costs. GHG savings are estimated to increase by 10.5 MTCO2e which is valued at £690m. Overall this gives a policy net present value of -£1,421m. Carbon cost effectiveness under the low scenario is £136/tCO2e.
231. In the high scenario, the target increase is assumed to be met entirely through increased bioethanol blending. Total costs of £3,036m are made up of (1) £2,862m of additional fuel costs; (2) £169m of costs to incompatible vehicles; and (3) £5m communication campaign and fuel pump labelling costs. GHG savings are estimated to increase by 7.3 MTCO2e which is valued at £482m. Overall this gives a policy net present value of -£2,554m. Carbon cost effectiveness under the high scenario is £350/tCO2e.

	central (E8.3)	low deployment (E4.6)	high deployment (E9.8)
Cost of communication campaign and fuel labelling	5	5	5
Cost to incompatible vehicles	169	169	169
Fuel costs	2,494	1,592	2,862
Total Costs	**2,667**	**1,765**	**3,036**
Carbon benefits	542	690	482
Total Benefits	**542**	**690**	**482**
NPV	**-2,225**	**-1,421**	**-2,554**

Figure 23: Option 2 summary cost-benefit data covering appraisal period 2021 to 2030 – with increased RTFO targets (£m, 2019 prices, discounted)

	central (E8.3)	low deployment (E4.6)	high deployment (E9.8)

[33] £/tCO2e carbon cost effectives is presented net of monetised GHG savings in line with the Government's GHG valuation guidance (p.25) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/794737/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal-2018.pdf

GHG savings (MTCO2e)	8.2	10.5	7.3
£/tCO2e	271	136	350

Figure 24: Option 2 GHG savings impact covering appraisal period 2021 to 2030 – with increased RTFO targets (MTCO2e)

High Carbon Price Sensitivity (excluding taxes)

232. In recent years, fossil fuel prices have been lower than anticipated. This has the effect of increasing the cost of saving carbons across the economy. To reflect increase in the cost of carbon abatement, we look at a sensitivity where the current high carbon price is used to value GHG savings. In the scenario where current targets are maintained (which lowers GHG savings relative to the baseline), monetised carbon savings fall from -£148m to -£222m. In the scenario where RTFO targets are increased to accommodate the additional supply of bioethanol (which lowers GHG savings relative to the baseline), monetised carbon savings rise from £542m to £813m.

	current RTFO targets		increased RTFO targets	
	central carbon price	high carbon price	central carbon price	high carbon price
Total Costs	830	830	2,667	2,667
Carbon benefits	-148	-222	542	813
Total Benefits	-148	-222	542	813
NPV	**-978**	**-1,052**	**-2,225**	**-1,954**

Figure 25: Option 2 (E8.3) NPV components with central and high carbon prices (£m, 2019 prices, discounted, excluding taxes)

	current RTFO targets		increased RTFO targets	
	central carbon price	high carbon price	central carbon price	high carbon price
GHG savings (MTCO2e)	-2.2	-2.2	8.2	8.2
£/tCO2e	n/a	n/a	270	238

Figure 26: Option 2 (E8.3) GHG savings with central and high carbon prices (MTCO2e). Cost figures for current targets are not shown as there is a negative carbon saving.

5.4 Option 3 – All 95 Octane fuels required to contain a minimum of 5.5% bioethanol and be labelled as E10 (Chosen option)

233. Under this option all 95 octane petrol is required to contain at least 5.5% bioethanol by volume. This would effectively remove the 'blendwall' as all 95 octane petrol would be labelled as E10 and would contain bioethanol in excess of the current E5 blending limit. The competitive disadvantage from being the first supplier to move to E10 would no longer be present as fuel suppliers would be required to roll out E10 at the same time.

234. The key difference between with this option and option 2 is that option 3 requires that all 95 octane petrol must contain at least 5.5% bioethanol by volume whereas option 2 is simply a requirement to change the labelling.

235. As with option 2, three different RTFO target scenarios have been considered when assessing this option. (1) a low scenario where ethanol blending rates remain unchanged at E5.5 (i.e. labelling changes only) (2) a high scenario where ethanol is blended into petrol at a 9.8% concentration and (3) a central scenario where ethanol is blending into petrol at a 8.6% which is a weighted average based on the probability of a full E10 deployment (E9.8) and the low scenario (E5.5).

Cost: Fuel supply (excluding taxes)

Low scenario (E5.5)

236. Under this scenario the ethanol blend increases to E5.5 in 2021. This gives rise to the fuel supply changes. As above, this table has simplified for readability with certain niche fuels aggregated into the totals for the main fuels.

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Biodiesel	-67	-66	-65	-64	-63	-63	-62	-62	-61	-61
Bioethanol	134	132	130	129	127	126	125	123	123	122
Fossil Diesel	61	60	60	59	58	58	57	57	56	56
Fossil Petrol	-88	-86	-85	-84	-83	-83	-82	-81	-80	-80
Total Fuel	41	40	39	39	38	38	38	37	37	37

Figure 27: Change in fuel supply moving between the baseline and E5.5 (million litres)

237. An increase in supply of crop bioethanol is expected to displace waste biodiesel from the fuel supply (as waste biodiesel is assumed to be the marginal biofuel supplied under the RTFO). As waste biodiesel is double rewarded under the RTFO, and contains slightly more energy per litre, slightly more than two litres of bioethanol are supplied for every litre of waste biodiesel displaced.
238. The fossil petrol supply decreases to accommodate this bioethanol increase and fossil diesel increases to offset the fall in the biodiesel supply. Overall, the fuel supply increases by around 38 million litres per year. This happens because bioethanol has a relatively low energy content, so more litres are required to meet the same energy demand.
239. Multiplying the change in fuel supply by projected fuel prices gives the following cost profile. As above, this table has simplified for readability with certain niche fuels aggregated into the totals for the main fuels.

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Biodiesel	-67	-66	-65	-65	-64	-64	-64	-64	-64	-64
Bioethanol	93	92	92	91	90	91	90	90	91	91
Fossil Diesel	28	28	28	28	28	28	28	28	28	29
Fossil Petrol	-37	-37	-37	-36	-36	-37	-37	-37	-37	-37
Total Fuel	18	18	17	17	17	18	18	18	18	18

Figure 28: Change in cost of fuel supply moving between the baseline and E5.5 (£m, 2019 prices, undiscounted, excluding taxes)

240. The increase in crop bioethanol costs £93m in 2021 falling to £91m in 2030. The decrease in waste biodiesel leads to a cost saving of £67m in 2021 falling to £64m in 2030.
241. The decrease in fossil petrol from the increase in crop bioethanol costs £37m over the appraisal period. The increase in fossil diesel leads to a cost of around £28m over the appraisal period.
242. Overall, the total fuel supply cost is estimated to increase by £17m to £18m per year over the appraisal period.

High scenario (E9.8)

243. In the high scenario we assume a blend rate of E9.8 in standard 95 octane petrol, which reflects a successful widespread introduction of E10. This would give the following change in the fuel supply. As above, this table has simplified for readability with certain niche fuels aggregated into the totals for the main fuels.

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Biodiesel	-409	-402	-397	-393	-388	-385	-381	-378	-375	-373
Bioethanol	818	805	795	787	777	770	763	756	751	747
Fossil Diesel	375	369	364	360	356	353	350	346	344	342

Fossil Petrol	-537	-528	-522	-516	-510	-505	-500	-496	-493	-490
Total Fuel	247	243	240	238	235	233	230	228	227	226

Figure 29: Change in fuel supply moving between the baseline and E9.8 (million litres)

244. An increase in supply of crop bioethanol is expected to displace waste biodiesel from the fuel supply (as waste biodiesel is assumed to be the marginal biofuel supplied under the RTFO). As waste biodiesel is double rewarded under the RTFO, and contains slightly less energy, just over two litres of bioethanol are supplied for every litre of waste biodiesel displaced.
245. The fossil petrol supply decreases to accommodate the increased bioethanol supply and fossil diesel increases to offset the fall in the biodiesel supply. Overall, the fuel supply increases by around 235 million litres per year. This happens because bioethanol has a relatively low energy content, so more litres of fuel are required to meet the same energy demand.

246. Multiplying the change in fuel supply by projected fuel prices gives the following cost profile. As above, this table has simplified for readability with certain niche fuels aggregated into the totals for the main fuels.

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Biodiesel	-406	-401	-398	-396	-393	-394	-392	-391	-392	-392
Bioethanol	568	562	559	557	553	555	554	552	555	556
Fossil Diesel	170	169	169	169	169	171	172	172	174	175
Fossil Petrol	-225	-223	-223	-223	-223	-225	-225	-226	-229	-230
Total Fuel	108	107	107	107	106	108	108	108	109	109

Figure 30: Change in fuel supply costs between the baseline and E9.8 with increased target (£m, 2019 prices, undiscounted, excluding taxes)

247. Bioethanol costs increase by £568m in 2021 falling to £556m in 2030. The decrease in waste biodiesel leads to a cost saving of £406m in 2021 falling to £392m in 2030.
248. Fossil petrol costs decrease by £225m in 2021 falling further to £230m in 2030. The increase in fossil diesel leads to a cost of £170m in 2021 rising to £175m in 2030.

249. Overall, the total fuel supply cost increases by £108m in 2021 falling to £109m in 2030.

Cost: E10 incompatible vehicles

250. Costs to owners of incompatible vehicles are the same as described in option 2. This is because, under both options, the labelling of the standard grade changes to E10, with owners of incompatible vehicles needing to purchase the more expensive super grade. The cost implications are therefore the same for both option 2 and 3.

Cost: Communication Campaign and Fuel labelling

251. Costs of fuel labelling is the same as described in option 2.

Benefit: GHG savings

Low scenario (E5.5)

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
MTCO2e/year	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05

Figure 31: GHG savings impact of moving from the baseline to E5.5 (MTCO2e/year)

252. The introduction of E5.5 leads to a reduction in GHG savings of 50,000 tonnes of CO2e per year from 2021 to 2030. This increase is CO2e is mainly because the biofuel displaced by ethanol gives a slightly higher carbon saving.

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
£m/year	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4

Figure 32: Monetised GHG savings benefit of moving from the baseline to E5.5 (£m, 2019 prices, undiscounted)

253. The monetised value of these carbon emissions is of £4m per year. Non-traded carbon values have been used to monetise the emissions (these values can be found in annex 2).

High scenario (E9.8)

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
MTCO2e/year	-0.33	-0.33	-0.32	-0.32	-0.32	-0.31	-0.31	-0.31	-0.31	-0.30

Figure 33: GHG savings impact of moving from the baseline to E9.8 (MTCO2e/year)

254. The introduction of E9.8 leads to a reduction in GHG savings of 330,000 tonnes of CO2e in in 2021 which falls to 300,000 tonnes of CO2e by 2030.
255. This decrease in GHG savings is mainly because the biofuel displaced by ethanol (waste biodiesel is assumed to be displaced) gives a slightly higher carbon saving.

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
£m/year	-24	-24	-24	-24	-24	-24	-24	-25	-25	-25

Figure 34: Monetised GHG savings benefit of moving from the baseline to E9.8 (£m, 2019 prices, undiscounted)

256. The monetised value of this decrease in GHG savings is valued at -£24m in 2021 falling to -£25m by 2030. Non-traded carbon values have been used to monetise the emissions (these values can be found in annex B).

Delivery Risks

257. Option 3 – which is a requirement to require fuel retailers to ensure the 95 grade contains at least 5.5% ethanol carries a relatively low delivery risk. As suppliers are required to supply petrol which is technically E10, consumers will see a nationwide switch to the new grade.
258. As the fuel has more than 5% ethanol, fuel retailers would not be able to market it as a low ethanol option. The compatibility concerns for older vehicles only arise when the blend moves above 5%, so consumers would need to be adequately informed, and could not reasonably be advised that the fuel remains compatible with all vehicles.
259. This means we can be assured that communications from all fuel retailers will be consistent, laying the basis for a successful communications campaign and smooth roll out.
260. There is a risk that overall ethanol supply is only marginally increased under this option, as the 5.5% requirement is only slightly above the level currently blended into the 95 grades. However, as overall biofuel supply is governed by the RTFO, carbon emissions savings will still be broadly achieved. In a scenario where ethanol blending initially remains low, around the 5.5% minimum, future increases to the RTFO would result in ethanol blending rates moving higher to meet increased obligations. Equally, should ethanol blending levels run towards the high scenario, with a corresponding drop in biodiesel blending, future RTFO target increases could be used to return blending to current levels.

Probability of full E10 deployment

261. Biofuel and fossil fuel market prices can be used to estimate the cost of generating a Renewable Transport Fuel Certificates (RTFC). The cost of generating a certificate by supplying bioethanol is estimated by taking the difference between the cost of supplying a litre of bioethanol and the cost of supplying a litre of petrol (which is displaced from the fuel mix by bioethanol).

£/certificate (bioethanol) = bioethanol price (£/litre) – petrol price (£/litre)

262. The cost of generating a certificate by supplying used cooking oil derived biodiesel (UCOME) is estimated by taking the difference between the cost of supplying a litre of UCOME and the cost of supplying a litre of diesel (which is displaced from the fuel mix by biodiesel). As supplying a litre of UCOME generates two certificates, the difference in prices is divided by two to produce the certificate cost estimate.

£/certificate (UCOME) = (UCOME price (£/litre) – diesel price (£/litre))/2

263. Looking at market price data from the past 5 years (from April 2015 to April 2020), we can see that the estimated cost (to the fuel supplier) of generating a renewable transport fuel certificate using UCOME has been on average 24% higher than the cost of generating certificates using bioethanol. For 71% of this period, the cost of generating a certificate from supplying bioethanol has been the lower of the two. In addition, suppliers will also sell more litres under a scenario where E10 is introduced which could lead to higher profits (assuming that profit is a function of volume sold). For these reasons, we conclude that suppliers are likely to choose to supply more bioethanol if the E10 blend wall is effectively removed by this policy change.

264. As the price differential between biodiesel and bioethanol can fluctuate, including flexibility into the policy proposals ensures suppliers can balance their blending between the two main biofuel options as dictated by the market.

Cost-benefit summary for option 3

265. The table below shows a summary of monetised costs and benefits for the central scenario (E8.6), the low scenario (E5.5) and the high scenario (E9.8) for the appraisal period of 2021 to 2030. The central scenario has been calculated by a weighted average calculation which attributes a 71% probability to E9.8 and a 29% probability to E5.5 (see 'probability of full E10 deployment' section directly above for explanation of the probabilities weightings). For the calculation of the low and high scenarios within the EANCB calculator, the methodology has been adjusted such that the NPV values of the high and low scenarios have been calculated by subtracting high costs from high benefits and low costs from low benefits.

266. In the central scenario, total costs of £927m are made up of (1) £701m of additional fuel costs; (2) £169m of costs to incompatible vehicles; (3) £5m communication campaign and fuel pump labelling costs; and (4) £53m fuel duty costs. GHG savings are estimated to fall by 2.4 MTCO2e which is valued at -£158m (a negative benefit). There is also a transfer of £53m in the form of fuel duty benefits, giving total benefits of -£105m. Overall this gives a policy net present value of -£1,032m. £/tCO2e is not given as there are no GHG savings under this scenario.

267. In the low scenario, total costs of £336m are made up of (1) £151m of additional fuel costs; (2) £169m of costs to incompatible vehicles; (3) £5m communication campaign and fuel pump labelling costs; and (4) £12m fuel duty costs. GHG savings are estimated to fall by 0.5 MTCO2e which is valued at -£34m (a negative benefit). There is also a transfer of £12m in the form of fuel duty benefits, giving total benefits of -£23m. Overall this gives a policy net present value of -£359m. £/tCO2e is not given as there are no GHG savings under this scenario.

268. In the high scenario, total costs of £1,169m are made up of (1) £925m of additional fuel costs; (2) £169m of costs to incompatible vehicles; (3) £5m communication campaign and fuel pump labelling costs; and (4) £70m fuel duty costs. GHG savings are estimated to fall by 3.2 MTCO2e which is valued at -£209m (a negative benefit). There is also a transfer of £70m in the form of fuel duty benefits, giving total benefits of -£138m. Overall this gives a policy net present value of -£1,307m. £/tCO2e is not given as there are no GHG savings under this scenario.

	central (E8.6)	low deployment (E5.5)	high deployment (E9.8)

Cost of communication campaign and fuel labelling	5	5	5
Cost to incompatible vehicles	169	169	169
Fuel costs	701	151	925
Fuel duty	53	12	70
Total Costs	927	336	1169
Carbon benefits	-158	-34	-209
Fuel duty	53	12	70
Total Benefits	-105	-23	-138
NPV	-1032	-359	-1307

Figure 35: Option 3 summary cost-benefit data covering appraisal period 2021 to 2030 (£m, 2019 prices, discounted)

	central (E8.6)	**low deployment (E5.5)**	**high deployment (E9.8)**
GHG savings (MTCO2e)	-2.4	-0.5	-3.2
£/tCO2e	n/a	n/a	n/a

Figure 36: Option 3 GHG savings impact covering appraisal period 2021 to 2030 (MTCO2e)

Cost distribution (excluding tax)

269. In assessing who is likely to bear the costs of this policy change we look at 4 different groups: fuel suppliers; (2) fuel retailers; (3) individual fuel consumers; and (4) business fuel consumers.
270. **Communication Campaign and Labelling costs** - the cost of communication campaign and labelling pumps is assumed to fall 100% on fuel retailers.
271. **Incompatible vehicle costs -** owners of E10 incompatible vehicles are assumed to purchase more expensive super grade (E5) petrol instead of standard grade (E10) petrol. We estimate that petrol consumed by incompatible vehicles is split between 98% individual fuel consumers and 2% business fuel consumers.
272. **Fuel costs** - As bioethanol contains less energy than the fuel it displaces, total fuel volumes increase. The cost of the increased volume of fuel is borne by consumers of petrol. We estimate that 94% of petrol is consumed by individual members of the public and 6% is consumed by business fuel consumers.
273. The tables below show how policy costs are estimated to be spread across these groups.

	Total (E8.6 – central scenario)	**fuel suppliers**	**fuel retailers**	**consumers (individuals)**	**consumers (companies)**
Cost of communication campaign and fuel labelling	5	0	5	0	0
Cost to incompatible vehicles	169	0	0	165	3
Fuel costs	701	0	0	659	42
Total Costs	874	0	5	824	45

Figure 37: costs split into fuel consumer groups covering appraisal period 2021 to 2030 (£m, 2019 prices, discounted, excluding taxes) (central scenario)

	companies	**individuals**
Total Costs	50	824

Figure 38: costs split into companies and individuals covering appraisal period 2021 to 2030 (£m, 2019 prices, discounted, excluding taxes) (central scenario)

Business costs including fuel duty

274. Under option 3, total costs for businesses will include the costs listed above, plus the additional value of the fuel duty incurred because of purchasing more litres of E10 compared to E5.
275. This was calculated by apportioning the increased fuel use for business fuel consumers via the methodology above and applying the 57.95p/l duty rate then discounted across the appraisal period.
276. This cost represents an additional £53.3m over the appraisal period for the central scenario. For the low scenario this amounts to £11.5m and for the high scenario this amounts to £70.4m. Total business costs including fuel duty are therefore £104m in the central scenario (further details on the treatment of tax in this IA are in annex D):

Business costs (£m)			
	central (E8.6)	**low deployment (E5.5)**	**high deployment (E9.8)**
Cost of fuel labelling	4.8	4.8	4.8
Cost to incompatible vehicles	3.4	3.4	3.4
Fuel costs	42.0	9.1	55.5
Additional fuel duty	53.3	11.5	70.4
Total Costs	**103.5**	**28.8**	**134.1**

Figure 39. Total costs to businesses including fuel duty, covering appraisal period 2021 to 2030 (£m, 2019 prices, discounted)

Additional modelling - RTFO target increase sensitivity analysis (excludes tax)

277. Introducing E10 will create space for future RTFO target increases which will generate additional GHG savings. Monetised costs and benefits for a scenario where targets are raised to accommodate E10 in 2021 is shown in the tables below. Detail on the assumptions that underpin this analysis can be found in para's 152 on.
278. In the central scenario, the target increase is assumed to be met through a mixture of bioethanol and waste biodiesel. Total costs of £2,812m are made up of (1) £2,638m of additional fuel costs; (2) £169m of costs to incompatible vehicles; and (3) £5m communication campaign and fuel pump labelling costs. GHG savings are estimated to increase by 8.1 MTCO2e which is valued at £532m. Overall this gives a policy net present value of -£2,279m. Carbon cost effectiveness[34] under the central scenario is £282/tCO2e.
279. In the low scenario, the ethanol supply is assumed to remain unchanged and the RTFO target increase is assumed to be met through increased blending of waste biodiesel. However, as standard

[34] £/tCO2e carbon cost effectives is presented net of monetised GHG savings in line with the Government's GHG valuation guidance (p.25) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/794737/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal-2018.pdf

grade petrol fuel pumps are all labelled as E10 under the scenario, it is assumed that owners of incompatible vehicles will choose to buy super grade petrol. Total costs of £2,262m are made up of (1) £2,089m of additional fuel costs; (2) £169m of costs to incompatible vehicles; and (3) £5m communication campaign and fuel pump labelling costs. GHG savings are estimated to increase by 10.0 MTCO2e which is valued at £656m. Overall this gives a policy net present value of -£1,606m. Carbon cost effectiveness under the low scenario is £161/tCO2e.

280. In the high scenario, the target increase is assumed to be met entirely through increased bioethanol blending. Total costs of £3,036m are made up of (1) £2,862m of additional fuel costs; (2) £169m of costs to incompatible vehicles; and (3) £5m communication campaign and fuel pump labelling costs. GHG savings are estimated to increase by 7.3 MTCO2e which is valued at £481m. Overall this gives a policy net present value of -£2,554m. Carbon cost effectiveness under the high scenario is £350/tCO2e.

	central (E8.6)	low deployment (E5.5)	high deployment (E9.8)
Cost of fuel labelling	5	5	5
Cost to incompatible vehicles	169	169	169
Fuel costs	2,638	2,089	2,862
Total Costs	**2,812**	**2,262**	**3,036**
Carbon benefits	532	656	481
Total Benefits	**532**	**656**	**481**
NPV	**-2,279**	**-1,606**	**-2,554**

Figure 40: Option 3 summary cost-benefit data covering appraisal period 2021 to 2030 – with increased RTFO targets (£m, 2019 prices, discounted, excluding taxes)

	central (E8.6)	low deployment (E5.5)	high deployment (E9.8)
GHG savings (MTCO2e)	8.1	10.0	7.3
£/tCO2e	282	161	350

Figure 41: Option 3 GHG savings impact covering appraisal period 2021 to 2030 – with increased RTFO targets (MTCO2e)

High Carbon Price Sensitivity (excludes tax)

281. In recent years, fossil fuel prices have been lower than anticipated. This has the effect of increasing the cost of saving carbons across the economy. To reflect increase in the cost of carbon abatement, we look at a sensitivity where the current high carbon price is used to value GHG savings. In the scenario where current targets are maintained (which lowers GHG savings relative to the baseline), monetised carbon savings fall from -£158m to -£237m. In the scenario where RTFO targets are increased to accommodate the additional supply of bioethanol (which lowers GHG savings relative to the baseline), monetised carbon savings rise from £532m to £799m.

	current RTFO targets		increased RTFO targets	
	central carbon price	high carbon price	central carbon price	high carbon price
Total Costs	874	874	2,812	2,812
Carbon benefits	-158	-237	532	799
Total Benefits	-158	-237	532	799
NPV	**-1,032**	**-1,111**	**2,279**	**2,013**

Figure 42: Option 3 (E8.6) NPV components with central and high carbon prices (£m, 2019 prices, discounted, excluding taxes)

	current RTFO targets		increased RTFO targets	
	central carbon price	high carbon price	central carbon price	high carbon price
GHG savings (MTCO2e)	-2.4	-2.4	8.1	8.1
£/tCO2e	n/a	n/a	282	249

Figure 43: Option 3 (E8.6) GHG savings with central and high carbon prices (MTCO2e)

6 Annex

Annex A: Glossary of Terms

Fuel terminology

E5 – a blended fuel consisting of up to 5% bioethanol and 95% mineral petrol

E10 - a blended fuel consisting of up to 10% bioethanol and 90% mineral petrol

Bioethanol – a biofuel which can be used as a petrol substitute. It can be made from a range of biogenic feedstocks (e.g. sugar cane, wheat, woody biomass, black bag waste)

Biodiesel – a biofuel which can be used as a diesel substitute

Waste biodiesel – a biodiesel which can be made from waste oil feedstocks such as used cooking oil

UCO biodiesel – a biodiesel made from used cooking oil (UCO)

Tallow biodiesel – a biodiesel made from animal fat (tallow)

FAME biodiesel – Fatty acid methyl ester (FAME) biodiesel is a type of biodiesel which is made by combining vegetable oils and methanol. Can be blended into the standard diesel fuel stream up to 7% (B7). This is the most common type of biodiesel currently supplied.

HVO biodiesel – hydrogenated vegetable oil biodiesel

Biomethane – gas produced from biogenic feedstock. Used as a substitute for natural gas (methane)

Biomethanol – a biofuel which can be used as a petrol substitute. It can be made from a range of biogenic feedstocks

Double counted bioethanol – bioethanol made from waste feedstocks

95 octane petrol – standard grade petrol.

98 octane petrol – super grade petrol. Typically sold at a price premium over 95 octane petrol.

Blend wall – a regulatory threshold which prevents blending of biofuel into fossil fuel above a certain concentration, for example FAME biodiesel is not permitted to be blended into mineral diesel at a concentration above 7%. This is known as the B7 blend wall.

RFNBO – renewable fuel of non-biological origin is a type of low carbon fuel which is made from non-biogenic sources (e.g. hydrogen from renewable electricity)

NRMM – non-road mobile machinery (e.g. tractors, combine harvesters, construction vehicles, trains, boats on inland waterways).

Energy density – the energy content of a fuel for a given unit of volume or mass (e.g. megajoule per litre or megajoule per kilogram).

Price spread – the difference between two prices. For example, the fossil fuel-biofuel price spread is the difference in price between a biofuel and the fossil fuel which it has displaced from the fuel mix (e.g. the bioethanol petrol price spread).

Low carbon fuel targets & policy

RTFO – the Renewable Transport Fuel Obligation is a regulation requiring that fuel suppliers supply biofuel as a certain proportion of their fuel supply. The RTFO target specifies the proportion of fuel which has to be supplied as biofuel

RTFC – a renewable transport fuel certificate is a certificate that is issued (to fuel suppliers) by the Government to demonstrate compliance with the RTFO target. RTFCs can be traded amongst fuel suppliers.

Buy-out – fuel suppliers can opt to pay a price (currently 30 pence per RTFC) to buy out of their obligation to supply biofuel under the RTFO. The 30 pence per RTFC payment is known as the buyout price.

Greenhouse gases (GHGs)

GHG – a greenhouse gas is a type of gas which is thought to cause the atmosphere to heat up. There are a large range of GHGs e.g. carbon dioxide (CO2) and methane (CH4). Some gases have a higher warming potential than others. For example, a gram of methane has 25x the potential to warm the atmosphere compared to a gram of CO2.

CO2e – carbon dioxide equivalent is a measure which shows greenhouse gas emissions from a range of fuels as the equivalent weight of CO2.

Emissions factor – a number which gives the GHG emissions per energy unit of fuel (e.g. X grams of CO2e per megajoule).

Well to tank (GHG emissions) – GHG emissions from fuel production (e.g. oil extraction and refining)

Tank to wheel (GHG emissions) – GHG emissions from combustion within the vehicle

ILUC – indirect land use change GHG emissions are second order emissions associated with an increase in demand for a commodity (e.g. an increase in demand for vegetable oil could result in emissions from deforestation if tropical rainforest is cleared to make way for new palm oil plantations required to meet the increased demand for vegetable oil).

Annex B: Modelling Input Assumptions

Energy densities

Energy density values for both biofuel and fossil fuel have been sourced from the Renewable Energy Directive[35] (Annex III, p.49). These are expressed as lower calorific values.

	mj/litre
bioethanol	21
FAME biodiesel	33
HVO biodiesel	34
petrol	32
diesel	36

Figure A1: fuel energy densities

35 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0028&from=EN [accessed 16/12/2019]

Greenhouse gas emissions – fossil fuels

Fossil fuel greenhouse gas emissions have been taken from the Government's Greenhouse gas reporting: conversion factors 2019 dataset[36] (full set).

		kgCO2e/kWh	gCO2e/mj
petrol	well to tank	0.06	17.3
	tank to wheel	0.25	70.5
	total	0.32	87.8
diesel	well to tank	0.06	17.4
	tank to wheel	0.27	74.7
	total	0.33	92.1

Figure A2: fossil fuel GHG emissions factors

Greenhouse gas emissions - biofuels

Biofuel greenhouse gas emissions are based upon the latest full year (year 10) RTFO statistics[37] (sheet RTFO_05) and ILUC factors are taken from DIRECTIVE (EU) 2015/1513[38] (Annex V)

Crop bioethanol and crop biodiesel emissions factors have been adjusted upwards to reflect the recently introduced 60% minimum GHG saving sustainability criteria. For crop bioethanol, non-compliant biofuel supplied in year 10 was dropped from the dataset to produce an adjusted average of compliant fuels. All crop biodiesel supplied in year 10 was non-compliant with the latest GHG saving criterial, so the minimum value allowed under the criteria (33.5gCO2e/mj) has been used as a proxy.

Crop bioethanol

		gCO2e/mj
crop bioethanol (pre-adjustment)	well to tank	32.9
	tank to wheel	0
	ILUC	12
	total	44.9
crop bioethanol (post-adjustment)	well to tank	31
	tank to wheel	0
	ILUC	12
	total	43

Figure A3: crop bioethanol GHG intensities

36 https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2019 [accessed [16/12/19]

37 https://www.gov.uk/government/statistics/biofuel-statistics-year-10-2017-to-2018-report-6 [accessed [16/12/19]

38 https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32015L1513&from=EN [accessed 16/12/19]

Crop biodiesel

		gCO2e/mj
crop biodiesel (FAME) (pre-adjustment)	well to tank	39.3
	tank to wheel	0
	ILUC	55
	total	94.3
crop biodiesel (post-adjustment)	well to tank	33.5
	tank to wheel	0
	ILUC	55
	total	88.5

Figure A4: crop biodiesel GHG intensities

Used cooking biodiesel

		gCO2e/mj
Used Cooking Oil biodiesel (FAME)	well to tank	10.4
	tank to wheel	0
	ILUC	0
	total	10.4

Figure A5: used cooking oil biodiesel GHG intensities

Tallow biodiesel

		gCO2e/mj
Tallow biodiesel (FAME)	well to tank	10.9
	tank to wheel	0
	ILUC	0
	total	10.9

Figure A6: tallow biodiesel GHG intensities

HVO biodiesel (waste derived)

		gCO2e/mj
HVO biodiesel (waste-derived)	well to tank	7.1
	tank to wheel	0
	ILUC	0
	total	7.1

Figure A7: HVO biodiesel (waste derived) biodiesel GHG intensities

Fuel Costs

Fossil fuels

Fossil fuel costs are based upon standard Government fuel price projections taken from the Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal[39] (data table 13)

	£/litre, 2019 prices		£/mj, 2019 prices	
	petrol	diesel	petrol	diesel
2020	0.42	0.45	0.013	0.013
2021	0.42	0.45	0.013	0.013
2022	0.42	0.46	0.013	0.013
2023	0.43	0.46	0.013	0.013
2024	0.43	0.47	0.013	0.013
2025	0.44	0.47	0.014	0.013
2026	0.45	0.48	0.014	0.013
2027	0.45	0.49	0.014	0.014
2028	0.45	0.5	0.014	0.014
2029	0.46	0.51	0.014	0.014
2030	0.47	0.51	0.015	0.014

Figure A8: fossil fuel price projections, excluding tax

Biofuels

Biofuel price projections are based upon analysis of price trends in biofuel markets. The figures in table A9 are based on 5 year average price trends reported by Argus Biofuels[40] market information. Forward projections are calculated using a GDP deflator. Price per megajoule is calculated by taking the energy density in figure A1 divided by the price in A9.

	£/litre, 2019 prices				
	crop ethanol	crop biodiesel	UCO biodiesel	tallow biodiesel	HVO biodiesel
2020	0.69	0.80	0.99	0.99	1.19
2021	0.69	0.80	0.99	0.99	1.19
2022	0.70	0.81	1.00	1.00	1.20
2023	0.70	0.81	1.00	1.00	1.20
2024	0.71	0.82	1.01	1.01	1.21
2025	0.71	0.82	1.01	1.01	1.21
2026	0.72	0.83	1.02	1.02	1.22
2027	0.73	0.84	1.03	1.03	1.23
2028	0.73	0.84	1.03	1.03	1.23
2029	0.74	0.86	1.04	1.04	1.24
2030	0.74	0.86	1.05	1.05	1.25

Figure A9: Central biofuel price projections, £/litre, excluding tax

[39] https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal [accessed 16/12/19]

[40] https://www.argusmedia.com/en/bioenergy/argus-biofuels

	£/mj, 2019 prices				
	crop ethanol	crop biodiesel	UCO biodiesel	tallow biodiesel	HVO biodiesel
2020	0.03	0.02	0.03	0.03	0.04
2021	0.03	0.02	0.03	0.03	0.04
2022	0.03	0.02	0.03	0.03	0.04
2023	0.03	0.02	0.03	0.03	0.04
2024	0.03	0.02	0.03	0.03	0.04
2025	0.03	0.02	0.03	0.03	0.04
2026	0.03	0.03	0.03	0.03	0.04
2027	0.03	0.03	0.03	0.03	0.04
2028	0.03	0.03	0.03	0.03	0.04
2029	0.04	0.03	0.03	0.03	0.04
2030	0.04	0.03	0.03	0.03	0.04

Figure A10: Central biofuel price projections, £/mj, excluding tax

GHG Abatement Costs

Using projected biofuel price spreads and GHG emissions values for crop ethanol and crop biodiesel, we get the following £/tCO2e abatement cost values.

	£/tCO2e
crop ethanol	448.30
crop biodiesel	3,153.46
used cooking oil biodiesel	209.12
tallow biodiesel	210.41
HVO biodiesel	259.80

Figure A11: projected biofuel abatement costs (2020 prices)

The formula for calculating £/tCO2e is:

(fossil fuel price – biofuel price) (£/mj) / biofuel GHG saving (gCO2e/mj)

where biofuel GHG saving is:

fossil fuel GHG emissions factor (gCO2e/mj) – biofuel emissions factor (gCO2e/mj)

and biofuel price spread is:

displaced fossil fuel price (£/mj) - biofuel price (£/mj)

Carbon prices

Short-term non-traded carbon values have been used to monetise GHG savings. These have been sourced from the Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal[41] (data table 3). Since the latest carbon values were given for the year 2018, these have been inflated to the 2019 year using the official government GDP deflator[42].

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Low	35	36	36	37	38	38	39	39	40	40	41
Central	70	72	73	74	75	76	77	79	80	81	82
High	106	107	109	111	113	114	116	118	120	121	123

Figure A12: carbon price projections

Fuel supply volumes and costs – full tables

Road transport fuel demand values have been taken from the Government's 2018 Energy & Emission projections[43] (annex F: Final energy demand, reference scenario sheet). These energy values are converted to litres using the energy density factors in annex B. Non Road Mobile Machinery (NRMM) fuel demand is based upon reported values taken from 2018 RTFO statistics[44].

Total fuel demand (road petrol and diesel plus NRMM fuel) is then multiplied by RTFO target value to generate the number of certificates fuel suppliers will have to generate to comply with the RTFO target.

		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
diesel	m litres	29,456	29,270	29,127	28,951	28,702	28,538	28,405	28,208	28,026	27,860
petrol	m litres	14,384	14,139	13,960	13,806	13,623	13,502	13,369	13,247	13,155	13,079
NRMM	m litres	5,258	5,258	5,258	5,258	5,258	5,258	5,258	5,258	5,258	5,258
total	m litres	49,099	48,667	48,345	48,015	47,583	47,298	47,033	46,714	46,440	46,198
target	%	9.60%	9.60%	9.60%	9.60%	9.60%	9.60%	9.60%	9.60%	9.60%	9.60%
certificates	million	4,713	4,672	4,641	4,609	4,568	4,541	4,515	4,484	4,458	4,435

Figure A13: fuel demand & RTFO certificate demand projections

In the analysis presented above the tables have been simplified for readability. The tables presented below show the full range of fuels required to ensure accurate analysis consistent with other fuel / biofuel demand modelling.

For biomethanol, biomethane, double counted bioethanol, HVO (waste) and crop biodiesel and tallow biodiesel supply volumes have been set in line with volumes reported under the RTFO statistics. Crop bioethanol is set in line with the blending level implied by the scenario (e.g. E4.6, E5.5 E9.8). UCO biodiesel – which is assumed to be the marginal fuel – makes up the difference until sufficient biofuel is supplied to generate the number of certificates implied by the RTFO target.

In the simplified tables, biomethanol, crop bioethanol and double counted bioethanol are combined to provide the "bioethanol" total. Biomethane, tallow biodiesel, development road fuel and UCO biodiesel have been combined to provide a "biodiesel" total.

E4.6

These are the projected fuel volumes under the baseline (E4.6). Different fuels within the table have been aggregated together which overall provide figure 5. Through multiplying the figures within this table

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41 https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal [accessed 16/12/19]

42 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/793632/data-tables-1-19.xlsx [accessed 01/12/20]

43 https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2018 [accessed 17/12/19]

44 https://www.gov.uk/government/statistics/renewable-fuel-statistics-2018-april-to-december-final-report [accessed 17/12/19]

by the corresponding prices given in figure A17, costs can be calculated. The aggregated costs are shown in figure 7 within the main analysis.

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
UCO biodiesel	1,846	1,831	1,820	1,808	1,791	1,781	1,771	1,758	1,747	1,738
tallow biodiesel	61	61	61	61	61	61	61	61	61	61
crop bioethanol	483	471	463	456	447	442	436	430	426	422
double counted bioethanol	158	158	158	158	158	158	158	158	158	158
Biomethane	10	10	10	10	10	10	10	10	10	10
Biomethanol	32	32	32	32	32	32	32	32	32	32
Development road fuel	67	106	132	157	182	206	231	255	279	302
Fossil Diesel	27,647	27,438	27,282	27,094	26,838	26,661	26,515	26,307	26,113	25,935
Fossil Petrol	13,964	13,726	13,553	13,403	13,226	13,109	12,980	12,861	12,773	12,699

Figure A14: biofuel and fossil fuel demand projections with E4.6 petrol/ethanol blend (million litres)

E5.5 supply volumes

These supply volumes are used to compare the E5.5 scenario to the baseline E4.6. Costs can be calculated using table A17. The figures are then aggregated as discussed above when presented in the analysis.

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
UCO biodiesel	2,188	2,168	2,152	2,137	2,116	2,103	2,090	2,075	2,062	2,050
Tallow biodiesel	61	61	61	61	61	61	61	61	61	61
Crop bioethanol	617	603	593	585	574	568	560	553	548	544
Double counted bioethanol	158	158	158	158	158	158	158	158	158	158
Biomethane	10	10	10	10	10	10	10	10	10	10
Biomethanol	32	32	32	32	32	32	32	32	32	32
Development road fuel	67	106	132	157	182	206	231	255	279	302
Fossil Diesel	27,333	27,130	26,977	26,793	26,540	26,366	26,222	26,017	25,825	25,648
Fossil Petrol	13,876	13,640	13,467	13,319	13,143	13,026	12,898	12,780	12,692	12,619

Figure A15: biofuel and fossil fuel demand projections with E5.5 petrol/ethanol blend (million litres)

E9.8 supply volumes

These supply volumes are used to compare the E9.8 scenario to the baseline E4.6. Costs can be calculated using table A17. The figures are then aggregated as discussed above when presented in the analysis.

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030

UCO biodiesel	1,846	1,831	1,820	1,808	1,791	1,781	1,771	1,758	1,747	1,738
Tallow biodiesel	61	61	61	61	61	61	61	61	61	61
Crop bioethanol	1,301	1,276	1,258	1,242	1,224	1,212	1,198	1,186	1,176	1,169
Double counted bioethanol	158	158	158	158	158	158	158	158	158	158
Biomethane	10	10	10	10	10	10	10	10	10	10
Biomethanol	32	32	32	32	32	32	32	32	32	32
Development road fuel	67	106	132	157	182	206	231	255	279	302
Fossil Diesel	27,647	27,438	27,282	27,094	26,838	26,661	26,515	26,307	26,113	25,935
Fossil Petrol	13,427	13,198	13,031	12,887	12,716	12,603	12,480	12,365	12,280	12,209

Figure A16: biofuel and fossil fuel demand projections with E9.8 petrol/ethanol blend (million litres)

Fuel costs

The table below shows the full fuels cost projections used to calculate the totals in the cost analysis of the different scenarios.

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
UCO biodiesel	0.99	1.00	1.00	1.01	1.01	1.02	1.03	1.03	1.04	1.05
Tallow biodiesel	0.99	1.00	1.00	1.01	1.01	1.02	1.03	1.03	1.04	1.05
Crop bioethanol	0.69	0.70	0.70	0.71	0.71	0.72	0.73	0.73	0.74	0.74
Double counted bioethanol	0.96	0.97	0.97	0.98	0.98	0.99	0.99	1.00	1.01	1.01
Biomethane	1.27	1.28	1.29	1.30	1.31	1.31	1.32	1.32	1.33	1.34
Biomethanol	0.96	0.97	0.97	0.98	0.98	0.99	0.99	1.00	1.01	1.01
Development road fuel	1.88	1.89	1.89	1.90	1.90	1.91	1.92	1.92	1.93	1.94
Fossil Diesel	0.45	0.46	0.46	0.47	0.47	0.49	0.49	0.50	0.51	0.51
Fossil Petrol	0.42	0.42	0.43	0.43	0.44	0.45	0.45	0.45	0.46	0.47

Figure A17 biofuel and fossil fuel price projections,£/l, excluding tax

GDP deflator

GDP deflator values have been used to historical monetary values into 2019 prices. The deflator series was sourced from the Office for Budget Responsibility (OBR)[45]

[45] https://www.gov.uk/government/statistics/gdp-deflators-at-market-prices-and-money-gdp-september-2019-quarterly-national-accounts [accessed 16/12/2019]

	GDP deflator (2018 = 100)	adjustment factor (from 2019)
2015	94	0.925
2016	96	0.944
2017	98	0.962
2018	100	0.981
2019	102	1
2020	104	1.018

Figure A18: GDP deflator series

Annex C: Cost & Energy Calculations

The assumptions below regarding cost and energy changes from moving from E5 to E10 petrol are based on full switch to E10 (i.e. 10% ethanol) that an individual fuel consumer could experience because of a market shift to E10 petrol were that petrol blended with 10% ethanol. This is different to the cost benefit analysis, which looks at market wide aggregate blend levels to model overall costs, however the same energy density principles have been used in the CBA for the different blend levels assessed.

E5 to E10 energy impact

Energy content values (mj/litre) for this calculation have been taken from annex B. Multiplying petrol and ethanol blending concentration by their respective energy contents gives us the petrol and energy content of each component of the blended fuel. Adding the energy content of each component gives us total blend energy content.

	mj/litre
petrol	32
ethanol	21

Figure A19: energy content values for petrol & ethanol

E5	volume (%)	blended fuel energy content (mj/litre)	energy content (%)
Petrol	95%	30.4	97%
Ethanol	5%	1.1	3%
Total	100%	31.5	100%

Figure A20: E5 energy content breakdown

E10	volume (%)	blended fuel energy content (mj)	energy content (%)
Petrol	90%	28.8	93%
Ethanol	10%	2.1	7%
Total	100%	30.9	100%

Figure A21: E10 energy content breakdown

E5 to E10 energy difference	-1.7%

Figure A22: E5 to E10 energy difference

E5 to E10 GHG impact

GHG emissions factor values (gCO2e/mj) for this calculation have been taken from annex B. Multiplying petrol and ethanol blending concentration by their respective GHG factors gives us the GHG emissions for each component of the blended fuel. Summing the GHG emissions of each component gives us total blend GHG emissions.

	gCO2e/mj
Petrol	87.8
Ethanol	43

Figure A23: GHG emissions factors for petrol & ethanol

E5	% energy	gCO2e/mj
Petrol	97%	84.9
Ethanol	3%	1.4
Total		86.3

Figure A24: GHG emissions factor for E5

E10	% energy	gCO2e/mj
Petrol	93%	81.8
Ethanol	7%	2.9
Total		84.8

Figure A25: GHG emissions factor for E10

% GHG saving (E0 to E5)	1.7%

Figure A26: GHG saving moving from E0 to E5

% GHG saving (E5 to E10)	1.8%

Figure A27: GHG saving moving from E5 to E10

% GHG saving (E0 to E10)	3.5%

Figure A28: GHG saving moving from E0 to E10

E5 to E10 pump price & driving cost impact

These calculations below estimate the cost the fuel cost impacts (for motorists driving petrol cars) of moving from E5 to E10 in 2021.

RTFO costs are made up of (1) direct fuel costs and (2) RTFO certificate costs to cover any shortfall

Fuel prices from Annex B have been used in the following calculations.

Certificate price calculation

The RTFO certificate price has been calculated by subtracting the UCO biodiesel price (annex B) from the diesel price (annex B) and dividing the result by 2. The UCO biodiesel price spread is used because UCO biodiesel is assumed to be the marginal biofuel supplied under the RTFO, which determines the certificate price. The difference is then divided by 2 as each litre of UCO biodiesel receives 2 certificates under the RTFO.

2021 UCO biodiesel price	£/litre	0.99
2021 diesel price	£/litre	0.45
2021 certificate price	£/certificate	0.27

Figure A29: RTFO certificate price calculation

Fuel cost calculation - moving from E5 to E10

Individual blend components have been costed by multiplying their share of the fuel blend by the £/litre costs in annex B. The difference between the RTFO target 9.75% and the volume of biofuel in the blend is assumed to be made up by certificate purchases. In the case of E5, there is a 4.75% gap between the target which is made up by purchasing 4.75% of a certificate – 0.0475 * 0.27 = 0.013. Supply + margin costs (unevidenced assumption) fuel duty (£0.58/litre) and VAT (levied at 20%) are then added to calculate the final retail fuel cost.

The energy adjusted E10 price is calculated by dividing the £/litre E10 price by the E10 energy content and then multiplying by the E5 energy content (both calculated above).

A driving cost increase of 2.3% is calculated by dividing the energy adjusted E10 price by the E5 price (£1.31 / £1.28).

	£/litre
2021 petrol price	£0.42
2021 ethanol price	£0.69
2021 certificate price	£0.27

Figure A30: 2021 petrol, ethanol and RTFO certificate prices

E5	% volume	£/litre
Petrol	95%	£0.40
Ethanol	5%	£0.03
certificates	4.75%	£0.01
supply + margin		£0.05
Duty		£0.58
Vat		£0.21
Total		£1.28

Figure A31: E5 pump price calculation

E10	% volume	£/litre	£/litre (energy adjusted)
Petrol	90%	£0.38	£0.38
Ethanol	10%	£0.07	£0.07
certificates	-0.25%	£0.00	£0.00
supply + margin		£0.05	£0.05
Duty		£0.58	£0.59
Vat		£0.21	£0.22
Total		£1.28	£1.31

Figure A32: E10 pump price calculation

Fuel cost calculation - moving from E5 (standard grade) to E5 (super grade)

To calculate the difference in price between standard grade petrol and super grade petrol a 12-month average of prices between 03/18 and 04/19 was taken. Price statistics were sourced from the 'Monthly and annual prices of road fuels and petroleum products' statistical series[46]

standard grade	super grade	difference	difference (%)
135.2	124.9	10.3	8.2%

Figure A33: petrol prices (average of prices between 03/18 and 04/19)

'Cars off the road' calculation

The average car is assumed to emit 2.17 tonnes CO2/year (2017 average) which was sourced from a recent DfT biofuels statistical release[47] (page 4).
The number of cars equivalent to policy GHG savings is then calculated by dividing policy GHG savings by average car GHG emissions.

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
CO2e savings	0.77	0.76	0.75	0.74	0.73	0.72	0.72	0.71	0.71	0.7
cars off road	354,709	348,891	344,655	340,999	336,660	333,793	330,647	327,747	325,573	323,768

Figure A34: GHG savings (MTCO2e) and equivalent 'cars off the road' figure (# cars) for E9.8 and increased RTFO targets

Carbon Budget 5 marginal abatement cost curve (MACC)

In order to assess the cost of an E10 roll out with the cost against other carbon abatement policies from across the economy, we have compared the £/tCO2e cost of an E10 roll out with the marginal abatement cost curve (MACC) published in the Government's Clean Growth Strategy (p.147) which was published in 2017. The red dotted line shows the level of GHG savings requires to meet carbon budget 5 targets (248MTCO2e from 2028 to 2032[48]). According to the MACC, an additional 250MTCO2e of GHG savings in the carbon budget 5 period equates to a marginal abatement cost of around £200/tCO2e.

[46] https://www.gov.uk/government/statistical-data-sets/oil-and-petroleum-products-monthly-statistics [accessed 17/12/19]

[47] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/845349/renewable-fuel-statistics-2018-final-report.pdf [accessed 17/12/19]

[48] The 248MT is taken from the 2032 Pathway emissions reductions for CB5. Table 7 page 149 of the Clean Growth Strategy - https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700496/clean-growth-strategy-correction-april-2018.pdf

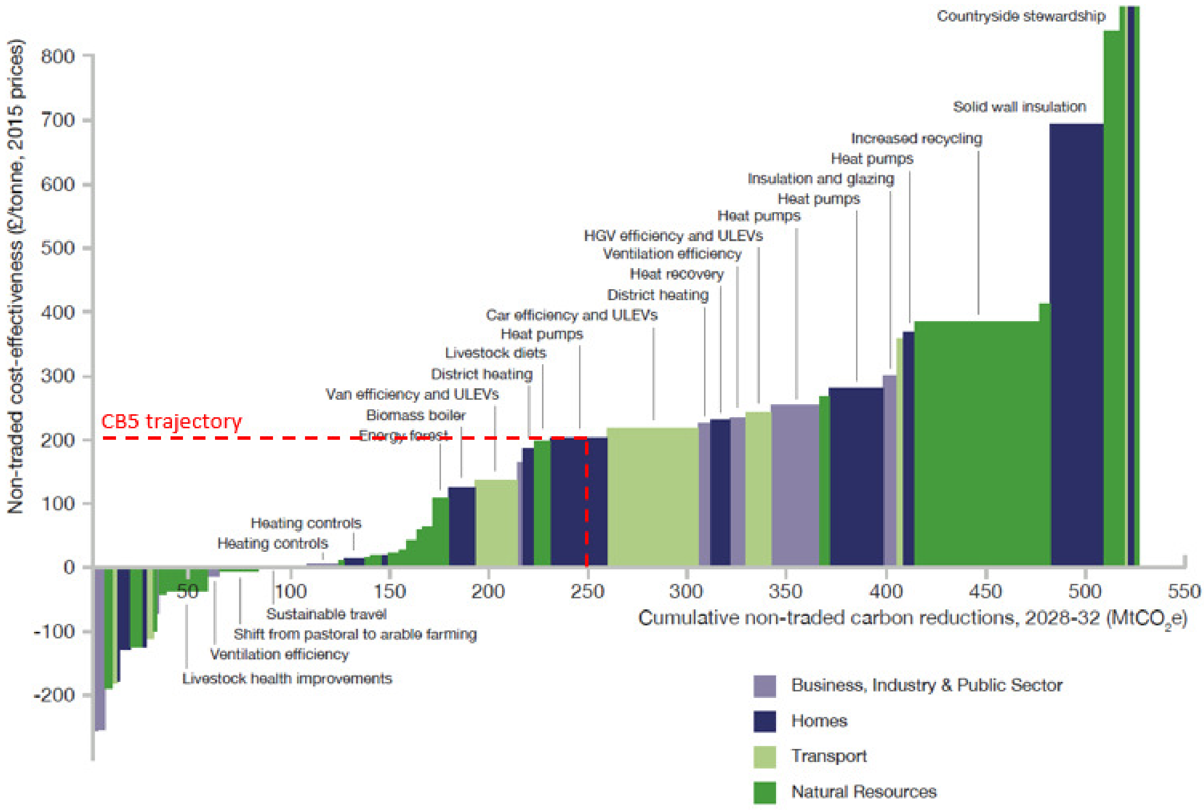

Figure A35: Carbon budget 5 marginal abatement cost curve with carbon budget 5 GHG savings target shown by red line

For consistency, the £349.5/tCO2e average abatement cost (2019 prices) from the RTFO target increase analysis (E9.8, the high scenario from both options 2 and 3) is converted into 2015 prices (using the deflator series in annex B) so that it can be compared consistently. The figure will then need to be converted for the different carbon accounting methodology, as described below.

E9.8 £/tCO2e (2019 prices)	349.5
E9.8 £/tCO2e (2015 prices)	331.1

Figure A36: estimated abatement cost for E9.8 and increased RTFO targets (£/tCO2e, discounted and net of monetised GHG benefits)

Carbon budget GHG accounting

For carbon budgets, a different system of carbon accounting is used. Carbon budget accounting assigns 100% GHG savings to biofuels in the transport sector (whereas lifecycle accounting, which is used elsewhere in this impact assessment, also takes into account emissions from biofuel production).

We can calculate the carbon budget accounting £/tCO2e value by following the same process as above but instead using the amended GHG input assumptions which are shown in the following table:

All biofuels	gCO2/mj	0
Fossil Diesel	gCO2/mj	74.3
Fossil Petrol	gCO2/mj	70.3

Figure A37: biofuel and fossil fuel GHG emission factors under carbon budgets GHG accounting methodology

As GHG savings are higher under carbon budget accounting (as no GHG emissions are attributed to biofuels) and costs remain unchanged, the average abatement cost under carbon budget accounting is significantly lower under lifecycle accounting. We use the deflator series from the BEIS carbon values[49] to calculate the equivalent value in 2015 prices which is also added to the chart below.

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
lifecycle accounting	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
carbon budget accounting	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1

Figure A38: estimated GHG savings for E9.8 and increased RTFO targets under both lifecycle and carbon budgets GHG accounting methodology (MTCO2e)

	lifecycle accounting	carbon budget accounting
E9.8 £/tCO2e (2019 prices)	349.5	199.9
E9.8 £/tCO2e (2015 prices)	331.1	188.3

Figure A39: estimated abatement cost for E9.8 and increased RTFO targets under both lifecycle and carbon budgets GHG accounting methodology (£/tCO2e, discounted and net of monetised GHG benefits)

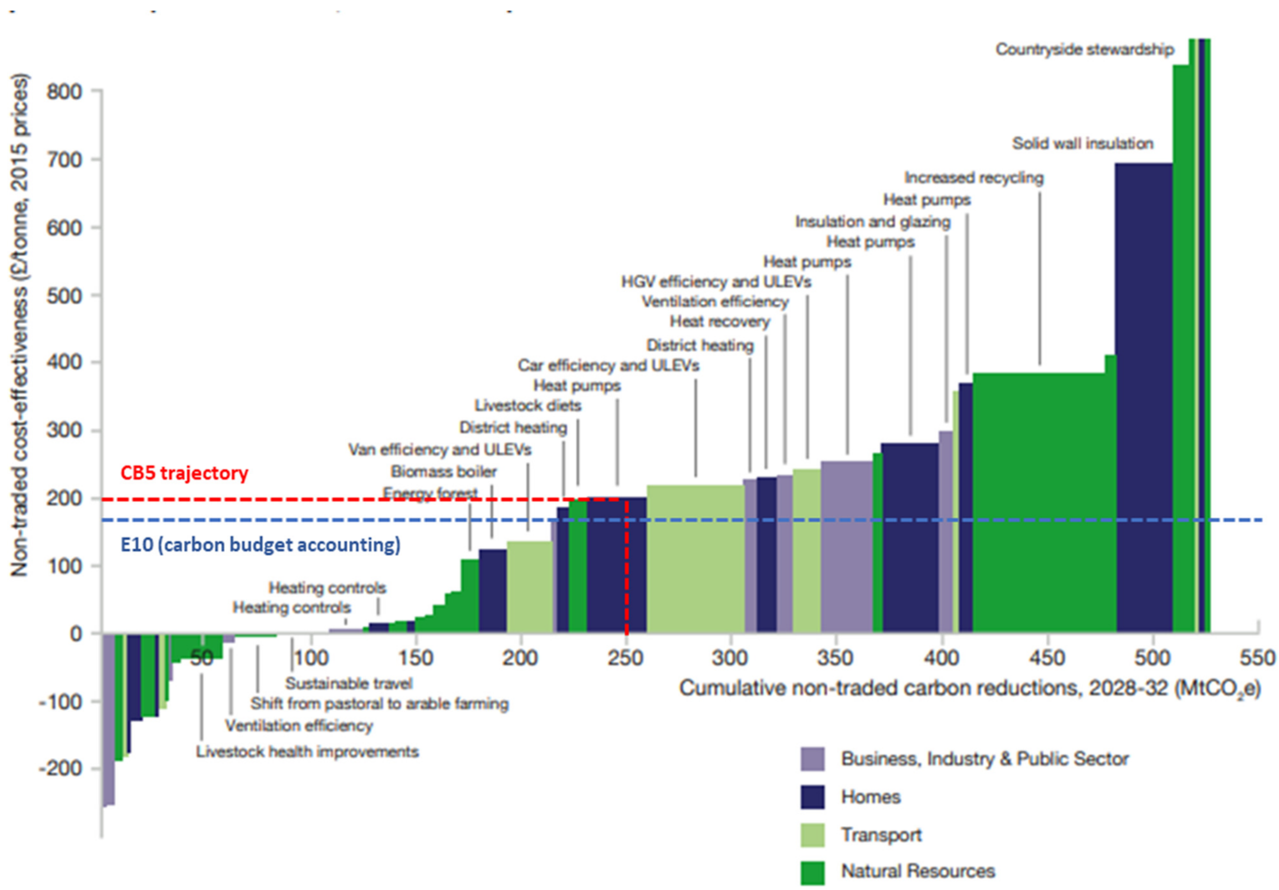

Figure A40: Carbon budget 5 marginal abatement cost curve with carbon budget 5 GHG savings target (red dotted line) and E9.8 abatement cost (carbon budget accounting)

49 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/793632/data-tables-1-19.xlsx

Sensitivity - crop biodiesel as marginal fuel (excluding taxes)

A key assumption in the main cost-benefit analysis is that waste biodiesel is the 'marginal fuel' supplied under the RTFO. This assumption means that introducing E10 (increasing the supply of bioethanol) results in less waste biodiesel is supplied.

In this sensitivity we look at an alternative state of the world where crop biodiesel is the marginal fuel. As crop biodiesel has significantly lower GHG savings than waste biodiesel (see annex B for fuel GHG factors), changing this assumption increases the benefits resulting from the introduction of E10. Summary results are shown below for the central scenario for policy option 3 alongside results from the central scenario where used cooking oil biodiesel is assumed to be the marginal fuel.

In the scenario where crop biodiesel is the marginal fuel in the RTFO, the cost of introducing E10 is lower (as crop biodiesel a more expensive option for meeting RTFO targets than waste biodiesel) and there are more GHG savings. Therefore, the net present value of the policy is higher under this scenario.

	total monetised values (2021 to 2030)	
	crop biodiesel marginal fuel	**UCO biodiesel marginal fuel**
Cost of communication campaign and fuel labelling	£5	£5
Cost to incompatible vehicles	£169	£169
Fuel costs	£213	£701
Total Costs	£387	£874
Carbon benefits	£301	-£158
Total Benefits	£301	-£158
Net Cost	£86	£1032

Figure A41: cost & monetised benefits for option 3 central scenario (E8.6), discounted [showing both crop biodiesel and UCO biodiesel as marginal biofuel] (excludes taxes)

Annex D: Small and Micro Business, Trade and Innovation assessments.

Small and Micro Business Assessment

Small businesses are defined in the better regulation framework guidance as those employing between 10 and 49 full-time equivalent (FTE) employees. Microbusinesses are those employing between 1 and 9 employees[50].

There are a number of routes through which the introduction of E10 could potentially impact small and micro businesses. We have identified the following impacts for assessment:

- Increased fuel costs
- Small filling stations with limited fuel tank capacity
- Fuel suppliers
- Labelling costs

Increased fuel costs

As a result of moving from 5% to 10% bioethanol content, fuel costs for owners of E10 compatible petrol cars could increase by around 2.3% due to the decreased energy content of E10. Owners of incompatible cars who are assumed to purchase the more expensive E5 'super grade' petrol as an alternative to E10 would see an increase of around 8% (see annex C for more information on these numbers).

Small and micro businesses which operate modern petrol vehicles are therefore expected to experience up to a 2.3% rise in fuel costs as a result of this legislation along with all other operators of petrol vehicles. Small businesses operating older, incompatible vehicles would be expected to experience an 8% increase in fuel costs as they will have to buy a premium grade E5 fuel. However, the number of businesses operating these vehicles is thought to be very small. DfT vehicle statistics show that 1.6% of pre-2005 petrol vehicles are owned by companies[51]. Vehicles operated by small and micro businesses would therefore form a sub-set of this group.

Body Type	Male Private Ownership	Female Private Ownership	Unknown Ownership	Company Ownership	Between Keepers	All Vehicles
SPECIAL PURPOSE	0.3	0.0	0.0	0.1	0.0	0.4
GOODS - HEAVY	0.6	0.0	0.0	0.1	0.0	0.8
TRICYCLES	7.3	0.6	0.3	0.2	0.1	8.4
GOODS - LIGHT	67.0	10.7	3.4	5.6	0.7	87.4
CARS	2122.2	1156.1	187.4	49.2	61.7	3576.7
OTHERS	5.0	0.5	0.3	1.5	0.1	7.3
BUSES & COACHES	2.2	0.4	0.1	0.4	0.0	3.2
TAXIS	0.1	0.0	0.0	0.0	0.0	0.1
AGRICULTURAL	8.5	0.5	0.3	2.3	0.1	11.7
MOTORCYCLES, MOPEDS & SCOOTERS	408.3	16.1	11.0	4.9	3.4	443.7
NOT RECORDED	0.8	0.1	0.0	0.1	0.0	1.1
TOTAL (% of total)	2622.4 (63.3)	1185.0 (28.6)	202.9 (4.9)	64.5 (1.6)	66.0 (1.6)	4140.8 (100)

50 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/827960/RPC_Small_and_Micro_Business_Assessment__SaMBA___August_2019.pdf

51 DfT vehicle statistics extracted from DVLA vehicle ownership data

Figure A45: pre-2005 petrol vehicles split by body type and ownership category ('000s) (source: DfT vehicle statistics)

We do not believe costs will be incurred due to needing to refuel more regularly, as the small drop in fuel economy would be unlikely to lead significant additional trips to filling stations. Any fuel customer not currently filling their fuel tank fully at each trip to a forecourt could increase the volume purchased to mitigate the drop-in energy content. If a business fuel user does fill their tank each time, it could result in perhaps one or two additional visits to filling stations per year and is therefore difficult to quantify in terms of cost impact for businesses. Such time pressure would likely be absorbed into normal day to day operational activities.

Small filling stations with limited fuel tank capacity

This legislation could have an additional impact on small fuel retailers who only have capacity to run two fuel streams (i.e. sites which only have two fuel tanks – one for petrol and one for diesel). In cases where retailers only have one petrol stream, they are likely to lose the ability to supply drivers of E10 incompatible vehicles who would require E5 'protection grade fuel'. We do not have data on the number of fuel tanks in use at individual filling stations. However, we have been able to access data on the number of pumps at fuelling stations which is used as a rough proxy. The following table shows the numbers of stations with a given number of pumps and % exempt under the 1,000,000 litre per year threshold.

	total sites	# sites exempt	# sites not exempt	market share exempt	market share not exempt
1	182	182	0	0.1%	0.0%
2	1013	685	328	0.9%	1.7%
3	1487	303	1184	0.5%	10.8%
4	3694	199	3495	0.4%	40.0%
>=5	2009	12	1997	0.0%	45.5%
All Total	8385	1381	7004	1.9%	98.1%

Figure A46: filling stations split by number of pumps and % exempt (equal to or less than the 1 million litre E10 exemption threshold) (source: Experian - privately held data)

E10 incompatible vehicles are expected to make up a small and shrinking share of the future petrol market. In 2021, around 600,000 cars (out of around 19 million in total[52]) are expected to be E10 incompatible. We estimate fuel consumption of 629 litres of petrol consumed per incompatible vehicle (see section 5.3 for more information on this assumption), which gives a total annual fuel consumption from incompatible vehicles of 377 million litres. Multiplying by £1.25/litre[53], the projected 2021 petrol price gives a value for incompatible vehicle fuel demand of £471m/year. Taking the number of sites and estimated fuel supply from the dataset in figure A47, we can estimate the market share of sites with either 2 pumps or less (low scenario), 3 pumps or less (medium scenario) or 4 pumps or less (high scenario). Multiplying the value for incompatible vehicle fuel demand by these market shares allows us to estimate total revenue loss for sites which are unable to supply both E5 and E10 and dividing by number of affected sites gives us an estimate for a single fuel retailer. Finally, we assume a profit margin[54] of 2% to 5% which gives an estimate of lost profit per site in 2021. Going forward from 2021, losses of revenue and profit would be expected to decline as incompatible vehicles leave the fleet.

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52 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/812632/Road_fuel_consumption_and_the_UK_motor_vehicle_fleet.pdf.

53 Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal – table 8 https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal [accessed 07/01/2020]

54 Unevidenced assumption

	low (non-exempt sites with 2 pumps or less)	medium (non-exempt sites with 3 pumps or less)	high (non-exempt sites with 4 pumps or less)
petrol demand - incompatible vehicles (litres/year, 2021)	377	377	377
retail petrol price (£/litre)	1.25	1.25	1.25
fuel value – incompatible vehicles (£m/year, 2021)	471	471	471
number of sites	328	1,184	3,495
non-exempt market share	1.7%	10.8%	40%
revenue loss - all non-exempt sites (£m/year)	8.0	50.9	188.5
revenue loss - single site (£000/year)	24.4	43.0	53.9
profit margin	2% to 5%	2% to 5%	2% to 5%
lost profit per site (£/year)	£22 to £576	£1,018 to £2,545	£1,079 to £2,697

Figure A47: estimation of revenue and profit loss from E10 introduction at non-exempt fuel retail sites

Fuel suppliers

It is assumed that none of the fuel suppliers supplying petrol into the UK market meet the definition of a small or micro business. No feedback on this assumption was provided during consultation, so has been retained.

Labelling costs

Fuel filling stations will be required to relabel all their petrol pumps to account for the new E10 fuel. This cost has already been calculated in the recent Alternative Fuel Labelling Regulations Impact Assessment[55]. In this assessment, labelling for a smaller fuel station is estimated to cost £100 per station.

Treatment of Taxation (VAT and Fuel Duty)

There are two distinct types of tax relevant to the introduction of E10: (i) VAT (applied to the cost of fuel at 20%) and (ii) Fuel Duty (applied to each litre of fuel at 57.95 pence per litre). The fuel duty is applied first and then is uplifted by 20% to account for VAT. Taxes are treated as transfers from individuals/businesses to the government. As a result, they have no material net impact on the calculation of overall NPV figures. However, for the IA there is some application of taxes depending on the party concerned:

a) **Consumers** – both VAT and fuel duty are applicable.

   For the consumption of E10 fuel, both VAT and fuel duty are applied to the costs borne to consumers. However, due to the fact that these taxes would have no material impact on the overall NPV figures within the IA, we have not factored these costs into the cost-benefit analysis

[55] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/781677/alternative-fuel-labelling-impact-assessment.pdf

modelling. Where costs have been expressed as a percentage increase in the analysis in Annex C, this is inclusive of all relevant taxes.

b) **Businesses** – only fuel duty is applicable.

VAT registered businesses are able to claim VAT back, which for the purposes of proportionality as this area of the policy has a relatively low cost to business, we assume all businesses are VAT registered and they do claim it back. Any business with a taxable turnover of over £85,000 is required to be VAT registered, and any company turning over less than this can also choose to be VAT registered. For any business where fuel is a significant cost, there is a clear and strong incentive to be VAT registered and save 20% on the cost of fuel. Therefore, we believe this simplifying assumption will be largely accurate.

As such, any impact of VAT on business fuel use has not been included in the modelling.

We have also not monetised any administration/familiarisation time for the recovery of VAT, as we have assumed that businesses will be reclaiming VAT in the 'Do Nothing' scenario. As this policy only increases fuel costs by up to 2.3% (based on moving from a 5% to a 10% blend), we don't believe this will significantly change the incentives to begin or end claiming VAT back on fuel compared to the baseline.

Fuel duty costs are applicable to businesses. We account for a 57.95 ppl additional cost accrued to businesses within our modelling. These are accounted for as a direct cost to business, factored in to the EANDCB and Business Impact Target Score. However, as tax is a transfer from business to government, this will have no material impact on overall Net Present Value figures as there is an exactly equal benefit to government from the fuel duty costs paid for by business.

Covid-19 impacts

The impact of Covid-19 is not considered to have a material effect on our decision making in relation to this policy area. While the pandemic has impacted the fuel and biofuel sectors, we expect significant recovery towards normal pre-covid volumes to have returned by the proposed introduction date of September 2021.

Introducing E10 opens up flexibility in the fuel sector to use different biofuels to meet their RTFO targets. It also provides an increased market for domestic ethanol producers. As a result, E10 should have a positive effect on supporting the whole fuel sector as we progress through the 2020's and beyond.

Monitoring and evaluation plan

The policy will be monitored closely via the existing reporting mechanism within the RTFO scheme. This requires fuel suppliers to report quarterly volumes of supplied road fuels and includes detailed information in relation to carbon savings. An annual report is also compiled by the department to assess the overall costs of the scheme. As the introduction of E10 will directly impact the carbon savings and costs of delivery of the RTFO, this existing reporting mechanisms will remain the best tool to assess the impact of this policy[56].

[56] RTFO statistics and reports - https://www.gov.uk/government/collections/renewable-fuel-statistics

The initial roll out of E10 will be monitored via our existing engagement with the fuel sector and industry trade associations. We will also work closely with BEIS downstream oil team to understand any relevant changes in consumer habits which we need to be aware of.

Biofuels policies are regularly reviewed as we are challenged to keep up with accelerating targets for decarbonisation. The efficacy of our policies around bioethanol and all other biofuels will always be under scrutiny as part of these regular reviews to ensure maximum carbon savings and cost effectiveness are being realised. The legislation will also include a 5-year review clause for public consultation.

Trade statement

The policy is not expected to have a material impact on international trade. While the volumes of traded ethanol and other related commodities may change due to the impact of the policy, there are no significant changes to market access or investment as a result of policy.

Petrol is generally traded as a base fuel and not a blended finished product. As a result, changing the requirements for the UK standard petrol grade will not impact the UK's ability to import or export base petroleum grades.

International impacts

The policy is not expected to have international impacts. Those travelling into the UK by petrol car will likely have arrived from a country that already uses E10 (most of northern Europe). E5 petrol will still be available as the protection grade, and E10 is approved for all recent petrol vehicles built to European and US standards.

Innovation statement

The regulations proposed are not expected to have significant impact on innovation in the biofuel sector or on wider policy related to transport decarbonisation. For the biofuel sector, the RTFO already includes a separate "Development Fuel" obligation aimed at driving innovation in the fuel industry. This policy area will be unaffected by the proposed E10 policy. In addition, the regulatory options assessed in this impact assessment have been designed to remove the current barriers to supplying E10 but are not overly prescriptive in how suppliers then meet their wider obligation. The chosen option, which would set minimum ethanol content for the 95-octane grade at 5.5%, still permits fuel suppliers to use other bio components permitted under the relevant fuel standard and which could count towards RTFO targets.

The requirement for a minimum 5.5% ethanol in the 95-octane grade will be kept under review to ensure it still best meets wider decarbonisation policy objectives and does not stifle innovation opportunities that would better meet these goals.

On the wider subject of decarbonising road transport, changes to biofuel policy should have no knock-on impact to other policy goals such as accelerating the role out of electric vehicles and the corresponding infrastructure. Developments and capacity for biofuel production will also be an important stepping stone for moving these fuels into harder decarbonise sectors, such as aviation. As a result, policies that encourage biofuel production will help enable further future biofuel use.