Title: Measures for introduction of E10 fuel stream **IA No:** DfT00409 **Lead department or agency:** Department for Transport **Other departments or agencies:**	**Impact Assessment (IA)** **Date:** 08/01/2020 **Stage:** Consultation **Source of intervention:** Domestic **Type of measure:** Primary legislation **Contact for enquiries:** Tim Simon

Summary: Intervention and Options

RPC Opinion: Not applicable

Cost of Preferred (or more likely) Option (in 2016 prices)			
Total Net Present Social Value	**Business Net Present Value**	**Net cost to business per year**	**Business Impact Target Status**
-£460m	-£206m	£24m	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. However, industry has yet to introduce E10 given commercial concerns. 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 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 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 policy objectives. This is covered in more detail in the consultation document. 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:** +1.8		

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 SELECT SIGNATORY: -- Date: ----------------------------------

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: -170	**High:** -775	**Best Estimate: -473**

COSTS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Cost (Present Value)
Low	1.2	1	19	170
High	1.2		66	570
Best Estimate	**1.2**		**42**	**370**

Description and scale of key monetised costs by 'main affected groups'

Best estimate costs consist of: (1) decreased miles per gallon cause an increase in fuel supply costs of £200m 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) of £169m, and transition costs of fuel labelling and communications of £1m in year 1.

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.

BENEFITS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Benefit (Present Value)
Low	0	0	0	0
High	0		-24	-205
Best Estimate	**0**		**-12**	**-103**

Description and scale of key monetised benefits by 'main affected groups'

Without changes to the Renewable Transport Fuel Obligation (RTFO) targets, best estimate GHG savings are expected to fall by 1.6MTCO2e, giving a negative monetised benefit of -£103m. This is because the ethanol is expected to displace waste-derived biodiesel, which has higher greenhouse gas savings.

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 of fossil and biofuels. 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.

BUSINESS ASSESSMENT (Option 2)

Direct impact on business (Equivalent Annual) £m:			Score for Business Impact Target (qualifying provisions only) £m:
Costs: 23	**Benefits:** 0	**Net:** 23	103

[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: -269	**High:** -775	**Best Estimate: -522**

COSTS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Cost (Present Value)
Low	1.2	1	27	235
High	1.2		66	570
Best Estimate	**1.2**		**46**	**403**

Description and scale of key monetised costs by 'main affected groups'

Best estimate costs consist of: (1) decreased miles per gallon cause an increase in fuel supply costs of £200m 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) of £169m and transition costs of fuel labelling and communications of £1m in year 1.

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.

BENEFITS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Benefit (Present Value)
Low	0.0	0	-4	-34
High	0.0		-24	-205
Best Estimate	**0.0**		**-14**	**-120**

Description and scale of key monetised benefits by 'main affected groups'

Without changes to the RTFO targets, best estimate GHG savings are estimated to fall by 1.8MTCO2e, giving a negative monetised benefit of -£120m. This is because the ethanol is expected to displace waste-derived biodiesel, which has higher greenhouse gas savings.

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 of fossil and biofuels. 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.

BUSINESS ASSESSMENT (Option 3)

Direct impact on business (Equivalent Annual) £m:			Score for Business Impact Target (qualifying provisions only) £m:
Costs: 27	**Benefits:** 0	**Net:** -27	120

Contents

1 Executive summary

1. This impact assessment (IA) looks at options for introducing E10 petrol (i.e. petrol with up to 10% bioethanol) in the UK.
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. Moving from E5 to E10 is estimated to reduce GHG emissions from petrol cars by around 2%.
4. In order to meet future legally binding carbon budgets, additional emissions reducing policies are required. E10 represents a deliverable policy that could account for around 6% of the additional transport savings required under the fifth carbon budget (2028-2032)[2] and costs of the measure are also within the cost ranges expected for that carbon budget (see figure 3).
5. E10 is a recognised fuel blend that does not require adjustments to the majority of vehicles. A scenario where RTFO targets are increased to accommodate E10 is estimated to save around 0.7 to 0.8 megatons of CO2e[3] per year, which is the equivalent of taking around 350,000 cars off the road (more details on these calculations are in annex C).
6. Biofuel blending targets under the Renewable Transport Fuel Obligation (RTFO) are currently set out to 2032 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 would lead to a decrease in carbon savings compared to a “do nothing” scenario unless and until the targets are increased.
7. 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.
8. Increased demand for ethanol through the introduction of E10 could help also support the UK bioethanol industry, who have struggled to remain viable due to demand being lower than previously forecasted.
9. 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.
10. Introducing E10 will add to fuel costs paid by motorists. Moving from E5 to E10 is estimated to reduce pump price petrol costs by 0.2 pence per litre. 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 1.6% as a result of moving from E5 to E10. (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).
11. Commercial marketing pressures and 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.
12. We look at two options for removing the blend wall and enabling E10 supply in this assessment:
    1. Do nothing (baseline)
    2. All 95 Octane fuels required to be labelled as E10

[2] Based on 17MTCO2/year additional transport GHG savings required to meet carbon budget 5 target in 2032 (source: Decarbonising Transport: Setting the Challenge – published alongside this document) and 1.1MTCO2e/year E10 GHG savings in 2032 (carbon budget accounting) from figure A41 (annex C).

[3] Carbon Dioxide equivalent - see glossary for definition.

3. All 95 Octane fuels required to contain a minimum of 5.5% bioethanol and be labelled as E10 **(preferred option)**.

	Option 2	Option 3
net present cost, £m	-370	-403
net present benefit, £m	-103	-120
net present value, £m	-473	-522
GHG impact, MTCO2e	-1.6	-1.8
carbon cost effectiveness, £/tCO2e	n/a	n/a

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

13. 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).
14. Increased costs are driven by three factors: (1) The additional ethanol that is supplied costs more than the waste derived biodiesel which is displaced under the RTFO target; (2) drivers of E10 incompatible cars are assumed to switch to more expensive super grade petrol; and (3) fuel retailers are assumed to incur labelling costs.
15. 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.

2 Background

2.1 Policy setting

16. 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.
17. 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.
18. This IA accompanies a new consultation on introducing E10 petrol. Previously the Department for Transport issued a “call for evidence” on whether and how best to introduce E10[4]. We have also published the government response to that call for evidence, which has helped inform our policy development for the new consultation and this impact assessment.

2.2 Transport decarbonisation

Overview

19. The transport sector is now the largest 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.

[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 – published alongside this document.

20. 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.
21. 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. The recently published Decarbonising Transport: Setting the Challenge sets out our sector strategy, including the importance of biofuels.
22. 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). It is therefore important we look to utilise opportunities to decarbonise transport where possible.

Renewable Transport Fuel Obligation (RTFO)

23. The Renewable Transport Fuel Obligation is one of the Government's main policies for GHG emissions from fuels supplied for use in road vehicles, and non-road mobile machinery (e.g. tractors, construction machinery).
24. 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.
25. 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.
26. In 2018, the Government introduced legislation that is doubling RTFO targets between 2018 and 2020 and sets minimum levels out to 2032.

RTFO, biofuels and fuel standards

27. 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[6].
28. To date, 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.
29. In the UK, biofuels can be blended into conventional road fuels including petrol and diesel provided they adhere to statutory fuel standards.
30. 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.
31. 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.
32. 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.

Future targets

33. Currently, the core RTFO target is maintained between 2020 and 2032. 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 31, the current targets can be met without moving to E10 petrol.

---

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

34. As the 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).
35. 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, 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[7] biodiesel as a drop-in fuel to regular diesel, and/or
    - Buy-out
36. 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.
37. 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.
38. 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. Commercial operators are more likely to invest both in vehicles that are compatible with the fuel and ensuring supply of high-blend biodiesel instead of regular diesel.
39. The call for evidence within the consultation begins to seek stakeholder feedback on 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.
40. Regardless of the viability of increasing biodiesel blending, the viability and benefits of increasing ethanol blending are well understood. As a result, it is clear that E10 can be an important part of decarbonising passenger cars in order to assist in meeting challenging carbon budgets.
41. 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

42. As this consultation is not formally proposing 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.
43. 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.
44. 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

[7] 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.

is likely to lead to reduced carbon savings at higher cost. This is why the impact assessment indicates a negative cost benefit ratio.

45. 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.

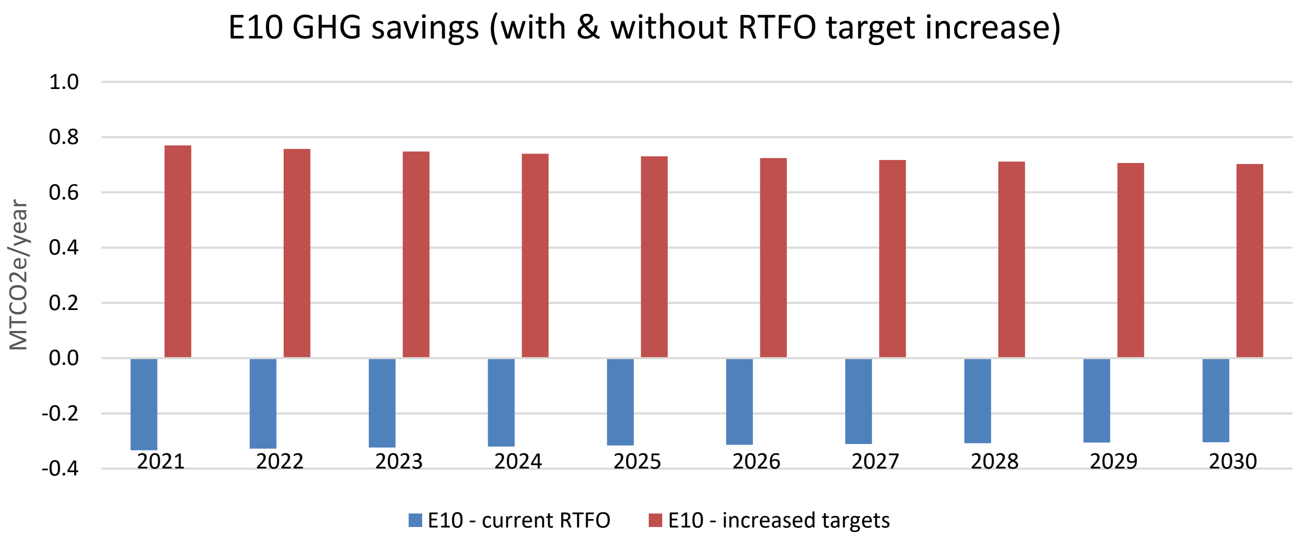

Figure 2: GHG impact of introducing E10 with and without increased RTFO targets - underlying data contained in cost-benefit analysis section (current RTFO) and annex C (increased targets)

46. 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.

Emissions reductions and carbon budgets

47. 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.
48. The transport sector is the single biggest emitter accounting for over a quarter of emissions in the UK. 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.
49. 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. The consultation launches a call for evidence on the future of the RTFO and opportunities for higher targets to be implemented in the early 2020s.
50. Analysis of a scenario where E10 is introduced and RTFO targets are increased in 2022 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 £173/tCO_2 (2015 prices). More detail on these calculations can be found in annex C.
51. 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 included to compare 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 two costings provided for the E10 policy (blue lines). The higher blue line shows the cost including lifecycle accounting (which includes emissions associated with biofuel production) with the lower blue line showing the cost via carbon budget accounting (which attributes a 100% GHG saving to biofuels)[8]. 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.

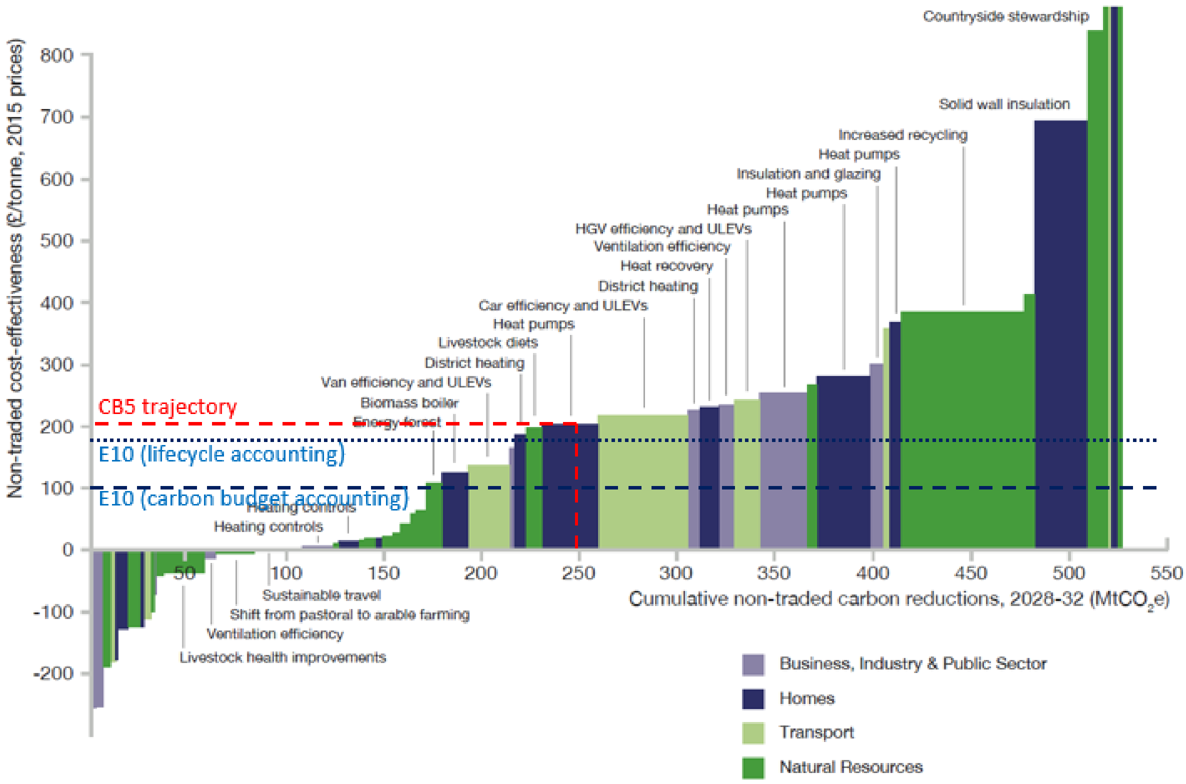

Figure 3: Marginal abatement cost curve showing the cost of carbon saving opportunities in the UK (for the heat and transport sectors). The red dotted line shows the level of carbon savings required by carbon budget 5 targets (central case). The blue dotted lines show the cost of carbon savings associated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

2.3 UK bioethanol sector

Overview

52. 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, 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.
53. Significant amounts of bioethanol supplied under the RTFO come from outside the UK. The most recent RTFO biofuel statistics (2017/18)[9] indicate that UK feedstocks accounted for 217 million litres of the UK bioethanol supply (29% of the total UK bioethanol supply).
54. This trend is largely attributed 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

[8] 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.

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

capacity has outstripped demand creating challenging trading conditions in which UK plants have struggled to compete.

Improving market conditions

55. UK producers have been clear that were domestic demand to increase as a result of E10 introduction, it could help improve market conditions. Introducing E10 would approximately double the demand for ethanol in the UK.
56. 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.
57. UK producers have cautioned that if the UK does not introduce E10 it is likely the domestic industry may not remain viable.

Wider benefits

58. 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 plant in the North East of England source their wheat locally, providing a stable market for farmers in the area.
59. 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 650,000 tonnes per year, replacing e.g. more costly soya bean-based feed from South America. This has a further net benefit in terms of GHG emissions reductions.
60. 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

61. 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.
62. 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

63. E10 is a blend of petrol with up to 10% bioethanol blended into fossil petrol.
64. 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.
65. 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.

Barriers to industry-led E10 introduction

66. The reason ethanol is blended into petrol is to reduce GHG emissions from fossil fuels used in vehicles. 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, discussed in the rationale for intervention.
67. There are two factors that act as additional barriers to the market-led introduction of E10:

- Vehicle compatibility and labelling requirements.
- Slightly lower energy density of ethanol meaning small decrease in fuel efficiency (and therefore higher per mile fuel costs).

68. These points are discussed in more detail in the sections below but have created a significant barrier to the market-led introduction of E10.
69. 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 thought to be the favoured choice for fuel suppliers to meet their RTFO targets cost effectively.
70. 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.

Need for Government-led introduction

71. 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.
72. 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. It removes competition concerns for fuel retailers and ensures consumers face the same choices at filling stations nationwide, as is currently the case.
73. 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 bioeconomies.

Commercial barrier: Vehicle compatibility and labelling

74. 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.
75. 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. 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 manufacturer trade associations have produced guides to vehicle compatibility to help owners identify the fuels their vehicles can use[10,11].
76. Estimates for 2019 show that 96.6%[12] 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.
77. 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.

---

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

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

[12] 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)

78. 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.
79. 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. A revision of this message is being considered in section 3 of the consultation.

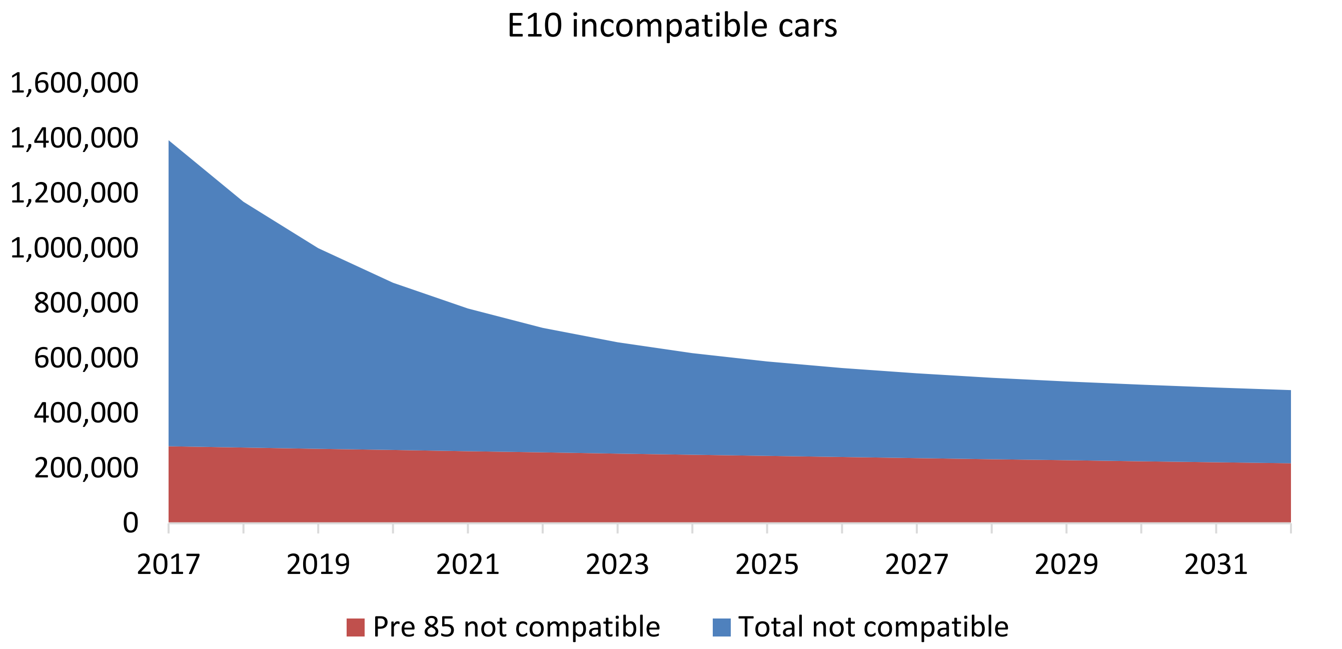

Figure 4: Number of incompatible vehicles with E10. Based on 2016 SMMT/DVLA E10 compatibility dataset

2.5 Commercial barrier: Energy density and costs

80. Bioethanol is less energy dense than petrol and contains only 65% of the energy content of fossil petrol. This means, as more ethanol is blended into fossil petrol, less energy is contained in one litre of petrol.
81. Based on a direct relationship between energy and mileage, 1.7% more litres of E10 are required to drive a given distance compared to E5 (see annex C for more detail).
82. This reduction in mileage is taken into account when calculating the GHG savings from E10. Overall CO_2 emissions when using E10 will still be 1.8% less than with E5.
83. Moving from E5 to E10 is estimated to reduce per litre petrol costs by 0.2 pence per litre. However, as the energy content of the fuel will also decrease, overall fuel costs for petrol cars are therefore estimated to increase by 1.6% as a result of moving from E5 to E10 (more details on these calculations can be found in annex C).

2.6 Keeping E5 available (Protection Grade)

84. 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.
85. Accordingly, any introduction of E10 petrol also needs to consider how access to E5 is maintained.
86. 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.
87. 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.

3 Problem under consideration and rationale intervention

3.1 Rationale for intervention

88. Petrol currently supplied in the UK contains no more than 5% ethanol (E5). Increasing this to up to 10% (E10) has the potential to reduce carbon emissions by around 0.8 megaton per year, according to DfT modelling (see Annex C).
89. Fuel retailers have made clear that, without Government intervention, they are unlikely to supply E10 as a commercial decision due to a "first-mover problem".
90. Because E10 fuel comes at a higher cost to consumers with no immediate and direct benefits to them (the benefits of reduced CO_2 are not felt as consumers drive), consumers would likely choose E5 petrol. This is despite the significant societal and environmental benefits that could be realised by a switch to E10, particularly in the medium to long term.
91. In addition, fuel suppliers claim to be unable to supply E10 in a coordinated and uniform way due to fears of breaking competition law. No single fuel retailer has been willing to unilaterally introduce E10 due to concern of putting themselves at a commercial disadvantage (due to consumers preferring E5 fuel), creating a first-mover problem.
92. Consequently, regulatory change is seen as the only effective tool to overcome the negative externality associated with the supply of E5 and to better capture the societal benefits of greater consumption of E10.
93. The RTFO scheme, which currently provides the regulatory incentive for biofuel supply in the UK is not sufficient to overcome these commercial barriers. This is in particular true for current target levels, which do not require E10 to be supplied, but is likely to remain the case even if targets were increased. This is mainly due to the RTFO scheme being imposed on fuel suppliers, with fuel retailers making the forecourt decisions on which fuel blend to stock.
94. There are also concerns that, should a single fuel retailer/supplier move to E10, the roll-out would be fractured and confusing for motorists. Experience in other countries have demonstrated that introductions that are carefully managed, with a given introduction date and nationwide communications, will deliver the best chance for a smooth roll out. Most recently, Belgium and the Netherlands have introduced E10 in such a manner. Minimal issues have been reported with high uptake of E10.

International evidence demonstrating the consumer preference for E5 and need for regulatory intervention.

95. 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 (~47%[13] and ~13% respectively[14]).
96. On the other hand, countries that have only kept E5 available as premium fuel (as is the only option taken forward in this consultation), Finland (~70%[15]), Belgium (~80%[16]) and the Netherlands[17], have seen much quicker and more comprehensive uptake.

---

[13] French market share data - https://www.bioethanolcarburant.com/categorie/bioethanol_data/

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

[15] Finland - https://www.e10bensiini.fi/en/news

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

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

3.2 Policy objective

97. For the UK to meet its future carbon budgets, additional emissions savings policies are required. In terms of biofuels, introducing E10 petrol to increase ethanol blending is a clear and well understood option for reducing GHG emissions in the long run for the road transport sector.
98. While a decision on future RTFO target changes is not expected to be made until the early 2020s (see section 2.2), E10 is likely to be needed as part of efforts to maximise emissions savings for carbon budget 4 and 5. 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.
99. 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.
100. 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

101. 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.

102. The Government response to that call for evidence has been published alongside this consultation and Impact Assessment but is 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.

103. As a result, we are not proposing to require E10 to be introduced in this manner in the new 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

104. 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.

105. 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.

106. 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

107. 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).

108. The three-grade approach has been ruled out following the 2018 Call for Evidence, as discussed in paragraphs 101 to 103.

109. Based on these factors, and the success of "two grade" introductions elsewhere in Europe (paragraph 96), 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.

110. 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.

Option 1 – Do nothing

111. 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 is the baseline against which the other options are assessed.

Q1. Ethanol blending levels are currently at around 4.6% annually. Do you expect these to change if no policy intervention is made?

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

112. 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.

113. 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 which is a 50:50 weighted average of the high and low scenarios.

Q2. Is it reasonable to assume that requiring fuel retailers to label all 95 octane petrol fuel as 'E10' would remove any commercial disadvantage associated with being the first supplier to shift to E10? Q3. What would you expect the E10 fuel blend to be under policy option 2: a) E4.6 b) E9.8 c) an average of the two d) other (please specify)?

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

114. 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.

115. The key difference between with this option and option 1 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.

116. 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 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 which is a 50:50 weighted average of the high and low scenarios.

Q4. Is it reasonable to assume that requiring all fuel retailers to supply a 95 octane petrol as a minimum E5.5 would remove any commercial disadvantage associated with being the first supplier to shift to E10?

Q5. What would you expect the E10 fuel blend to be under policy option 3: a) E5.5 b) E9.8 c) an average of the two d) other (please specify)?

5 Analytical approach and summary of outcomes

5.1 Analytical approach and assumptions

117. 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.

118. We have assumed that waste biodiesel is the marginal fuel in the RTFO. 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).

119. Therefore, any increase in the bioethanol supply (which is not accompanied by a corresponding change to the RTFO target level) would result in reduced biodiesel supply.

120. 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).

121. The potential impacts of introducing E10 alongside increased RTFO targets (which would increase to accommodate the additional bioethanol) have also been analysed and are presented in annex C.

	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 • Fuel pump labelling costs	• Reduced mobility resulting from higher fuel costs • Higher crop prices
benefits	• GHG savings from biofuel blending	• 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. • Introduction of E10 will create space for RTFO targets to be increased in the future which will yield additional GHG savings (see annex C for analysis of such a scenario)

Q6. What do you consider to be the major costs and benefits associated with the introduction of E10?

Q7. What do you consider to be the marginal fuel supplied under the RTFO?

5.2 Option 1 – Do nothing

122. 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

123. In a do-nothing scenario we envision that standard grade petrol would continue to be sold as 95 Octane E4.6 during the period 2021 – 2030.

124. The RTFO fuel supply of biodiesel, bioethanol, diesel and petrol for this option are shown below:

Fuel	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Biodiesel	1,979	2,000	2,012	2,023	2,029	2,041	2,053	2,063	2,074	2,086
Bioethanol	704	692	684	677	668	663	657	651	647	643
Total Biofuel	**2,683**	**2,692**	**2,696**	**2,700**	**2,697**	**2,703**	**2,710**	**2,714**	**2,720**	**2,729**
Fossil Diesel	32,905	32,696	32,540	32,352	32,096	31,919	31,773	31,565	31,371	31,193
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	**46,869**	**46,422**	**46,093**	**45,756**	**45,322**	**45,028**	**44,753**	**44,427**	**44,144**	**43,892**
Total Fuel	**49,551**	**49,115**	**48,789**	**48,455**	**48,019**	**47,731**	**47,463**	**47,141**	**46,864**	**46,620**

Figure 5: Baseline fuel supply volumes (million litres)

125. In the do-nothing scenario, the crop bioethanol supply is projected to fall over time from 704 million litres in 2021 to 643 million litres by 2029. 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[18]. More detail on fuel supply projections can be found in annex B.

126. 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**
2020	0.42	0.45	0.56	0.8
2021	0.42	0.45	0.56	0.8
2022	0.42	0.46	0.56	0.81
2023	0.43	0.46	0.57	0.81
2024	0.43	0.47	0.57	0.82
2025	0.44	0.47	0.58	0.82
2026	0.45	0.48	0.59	0.84
2027	0.45	0.49	0.59	0.84
2028	0.45	0.5	0.59	0.85
2029	0.46	0.51	0.6	0.86
2030	0.47	0.51	0.61	0.86

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

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

127. The overall cost of the fuel supply is then calculated by multiplying projected supply volumes by projected prices.

Fuel	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Biodiesel	1,595	1,635	1,661	1,684	1,704	1,735	1,757	1,776	1,804	1,822
Bioethanol	383	377	371	367	362	360	355	351	350	347
Total Biofuel	**1,978**	**2,011**	**2,032**	**2,051**	**2,066**	**2,095**	**2,113**	**2,127**	**2,154**	**2,170**
Fossil Diesel	12,541	12,588	12,659	12,713	12,733	12,927	12,994	13,030	13,206	13,251
Fossil Petrol	5,838	5,800	5,789	5,786	5,769	5,837	5,839	5,844	5,920	5,943
Total fossil fuel	**18,380**	**18,389**	**18,447**	**18,499**	**18,502**	**18,764**	**18,833**	**18,874**	**19,126**	**19,194**
Total Fuel	**20,358**	**20,400**	**20,479**	**20,550**	**20,568**	**20,859**	**20,946**	**21,001**	**21,280**	**21,364**

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

Q8. Do the baseline biofuel supply projections appear reasonable? If not, please specify what fuels you would expect to be supplied.

Q9. How do you expect the biofuel-fossil fuel price spread to evolve going forward? Do you expect it to a) increase b) decrease or c) stay constant?

128. The costs of supplying blended petrol and diesel is estimated at £20bn in 2021 increasing to £21bn in 2030.

129. 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).

130. 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 Directive19). 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.

	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)

131. Multiplying fuel supply volumes by fuel emissions factors gives total GHG emissions

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

132. 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 122 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)

Q10. Do you think that the values used for biofuel and fossil fuel GHG emission factors are appropriate? Are you aware of any alternative values we could use?

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 which is a 50:50 weighted average of the high and low scenarios.

Cost: Fuel supply impacts

Low scenario (E4.6)

133. 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)

134. 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:

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Biodiesel	-353	-348	-344	-341	-337	-334	-331	-328	-305	-264
Bioethanol	+751	+740	+733	+726	+717	+711	+704	+698	+650	+567
Fossil Diesel	+324	+319	+316	+313	+309	+306	+303	+301	+279	+242
Fossil Petrol	-493	-486	-481	-476	-470	-466	-462	-458	-426	-372
Total Fuel	+229	+226	+223	+221	+218	+217	+215	+213	+198	+173

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

135. 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, two litres of bioethanol are supplied for every litre of waste biodiesel displaced.

136. 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

216 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.

Q11. Do you consider the estimated fuel supply impacts for option 2 to be reasonable? If not, please specify the changes you would make.

137. Multiplying the change in fuel supply by projected fuel prices gives the following cost profile:

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Biodiesel	-326	-322	-320	-319	-316	-317	-316	-315	-317	-317
Bioethanol	429	424	421	419	416	417	416	414	416	416
Fossil Diesel	170	169	169	169	169	171	171	172	174	175
Fossil Petrol	-225	-223	-223	-223	-222	-225	-225	-225	-228	-229
Total Fuel	49	48	47	47	46	46	46	45	45	45

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

138. Bioethanol costs increase by £429m in 2021 falling to £416m in 2030. The decrease in waste biodiesel leads to a cost saving of £326m in 2021 falling to £317m in 2030.

139. Fossil petrol costs decrease by £225m in 2021 increasing to £230m in 2030. The increase in fossil diesel leads to a cost of £170m in 2021 to £175m in 2030.

140. Overall, the total fuel supply cost increases by £49m in 2021 falling to £45m in 2030.

Cost: Incompatible vehicles

141. 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.

142. To estimate vehicle compatibility, we have taken data from the SMMT[20] 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.

143. 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 2016

144. The current 12-month average retail price[21] 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.

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

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

145. 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[22]. 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 provided estimates for vehicle mileage with the oldest vehicles in the fleet averaging 4700 miles per year.

146. 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.

147. 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)

148. 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.

149. This cost differential would also include the increased VAT paid as the base blend 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:

	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)

150. This gives a cost of £28m in 2021 to £15m in 2030.

151. 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.

Cost: Fuel labelling

152. 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[23].

153. 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 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	-	-	-	-	-	-	-	-	-
Low estimate (£m)	*£0.40*	-	-	-	-	-	-	-	-	-
High estimate (£m)	*£2.00*	-	-	-	-	-	-	-	-	-

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

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

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

154. 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.

155. 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.

Benefit: GHG savings

Low scenario (E4.6)

156. There are no additional GHG savings in the low scenario as the fuel supply is the same 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)

157. 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	-24	-24	-25

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

158. 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

159. 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 (which would be labelled as E10) under this option, there is a higher risk a smooth transition from E5 to E10 will fail to take place.

Cost-benefit summary for Option 2

160. The table below shows a summary of monetised costs and benefits for the central scenario (E7.2), the low scenario (E4.6) and the high scenario (E9.8) for the appraisal period of 2021 to 2030.

161. In the central scenario, total costs of £370m are made up of (1) £200m of additional biofuel blending costs; (2) £169m of costs to incompatible vehicles; and (3) £1m fuel pump labelling costs. GHG savings are estimated to fall by 1.6 MTCO2e which is valued at -£103m (a negative benefit). Overall this gives a policy net present value of -£473m. £/tCO2e is not given as there are no GHG savings under this scenario.

162. 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 £1m labelling costs. Overall this gives a policy net present value of -£170m. £/tCO2e is not given as there are no GHG savings under this scenario.

163. In the high scenario, total costs of £570m are made up of (1) £400m of additional biofuel blending costs; (2) £169m of costs to incompatible vehicles; and (3) £1m fuel pump labelling costs. GHG savings are estimated to fall by 3.2 MTCO2e which is valued at -£205m (a negative benefit). Overall this gives a policy net present value of -£775m. £/tCO2e is not given as there are no GHG savings under this scenario.

	central (E7.2)	low deployment (E4.6)	high deployment (E9.8)
Cost of fuel labelling	1	1	1
Cost to incompatible vehicles	169	169	169
Biofuel blending costs	200	0	400
Total Costs	**370**	**170**	**570**
Carbon benefits	-103	0	-205
Total Benefits	**-103**	**0**	**-205**
NPV	**-473**	**-170**	**-775**

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

	central (E7.2)	low deployment (E4.6)	high deployment (E9.8)
GHG savings (MTCO2e)	-1.6	0.0	-3.2
£/tCO2e	n/a	n/a	n/a

Figure 19: Option 3 GHG savings impact covering appraisal period 2021 to 2030 (MTCO2e)

RTFO target increase sensitivity

164. 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 the early 2020s is shown in the tables below.

165. In the central scenario, the target increase is assumed to be met through a mixture of bioethanol and waste biodiesel. Total costs of £1,644m are made up of (1) £1,360m of additional biofuel blending costs; (2) £169m of costs to incompatible vehicles; and (3) £1m fuel pump labelling costs. GHG savings are estimated to increase by 8.9 MTCO2e which is valued at £577m. Overall this gives a policy net present value of -£1,067m. Carbon cost effectiveness[24] under the central scenario is £120/tCO2e.

166. 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 £1,444m are made up of (1) £1,047m of additional biofuel blending costs; (2) £169m of costs to incompatible vehicles; and (3) £1m fuel pump labelling costs. GHG savings are estimated to increase by 10.5 MTCO2e which is valued at £680m. Overall this gives a policy net present value of -£765m. Carbon cost effectiveness under the low scenario is £73/tCO2e.

167. In the high scenario, the target increase is assumed to be met entirely through increased bioethanol blending. Total costs of £1,844m are made up of (1) £1,674m of additional biofuel blending costs; (2) £169m of costs to incompatible vehicles; and (3) £1m fuel pump labelling costs. GHG savings are estimated to increase by 7.3 MTCO2e which is valued at £474m. Overall this gives a policy net present value of -£1,370m. Carbon cost effectiveness under the high scenario is £187/tCO2e.

[24] £/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

	central (E7.2)	low deployment (E4.6)	high deployment (E9.8)
Cost of fuel labelling	1	1	1
Cost to incompatible vehicles	169	169	169
Biofuel blending costs	1,360	1,047	1,674
Total Costs	**1,644**	**1,444**	**1,844**
Carbon benefits	577	680	474
Total Benefits	**577**	**680**	**474**
NPV	**-1,067**	**-765**	**-1,370**

Figure 20: Option 2 summary cost-benefit data covering appraisal period 2021 to 2030 – with increased RTFO targets (£m, 2019 prices, discounted)

	central (E7.2)	low deployment (E4.6)	high deployment (E9.8)
GHG savings (MTCO2e)	8.9	10.5	7.3
£/tCO2e	120	73	187

Figure 21: Option 2 GHG savings impact covering appraisal period 2021 to 2030 – with increased RTFO targets (MTCO2e)

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

168. 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.

169. 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.

170. 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 which is a 50:50 weighted average of the high and low scenarios.

Cost: Fuel supply

Low scenario (E5.5)

171. Under this scenario the ethanol blend increases to E5.5 in 2021. This gives rise to the fuel supply changes:

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Biodiesel	-73	-72	-71	-71	-70	-69	-69	-68	-68	-67
Bioethanol	+156	+154	+152	+151	+149	+147	+146	+145	+144	+143
Fossil Diesel	+67	+66	+65	+65	+64	+64	+63	+62	+62	+62
Fossil Petrol	-102	-101	-100	-99	-98	-97	-96	-95	-94	-94
Total Fuel	+48	+47	+46	+46	+45	+45	+44	+44	+44	+44

Figure 22: Change in fuel supply moving between the baseline and E5.5 (million litres)

172. 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, two litres of bioethanol are supplied for every litre of waste biodiesel displaced.

173. 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 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.

> Q12. Do you consider the estimated fuel supply impacts for option 3 to be reasonable? If not, please specify the changes you would make.

174. Multiplying the change in fuel supply by projected fuel prices gives the following cost profile:

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Biodiesel	-53	-53	-52	-52	-52	-52	-52	-52	-52	-52
Bioethanol	70	70	69	69	68	68	68	68	68	68
Fossil Diesel	28	28	28	28	28	28	28	28	28	29
Fossil Petrol	-37	-37	-37	-37	-36	-37	-37	-37	-37	-37
Total Fuel	8	8	8	8	8	8	7	7	7	7

Figure 23: Change in cost of fuel supply moving between the baseline and E9.5 (£m, 2019 prices, undiscounted)

175. The increase in crop bioethanol costs £70m in 2021 falling to £68m in 2030. The decrease in waste biodiesel leads to a cost saving of £53m in 2021 falling to £52m in 2030.

176. 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 £28m over the appraisal period.

177. Overall, the total fuel supply cost is estimated to increase by £7m to £8m per year over the appraisal period.

High scenario (E9.8)

178. 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:

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Biodiesel	-353	-348	-344	-341	-337	-334	-331	-328	-305	-264
Bioethanol	+751	+740	+733	+726	+717	+711	+704	+698	+650	+567
Fossil Diesel	+324	+319	+316	+313	+309	+306	+303	+301	+279	+242
Fossil Petrol	-493	-486	-481	-476	-470	-466	-462	-458	-426	-372
Total Fuel	+229	+226	+223	+221	+218	+217	+215	+213	+198	+173

Figure 24: Change in fuel supply moving between the baseline and E9.8 (million litres)

179. 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, two litres of bioethanol are supplied for every litre of waste biodiesel displaced.

180. 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 216 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.

181. Multiplying the change in fuel supply by projected fuel prices gives the following cost profile:

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Biodiesel	-326	-322	-320	-319	-316	-317	-316	-315	-317	-317
Bioethanol	429	424	421	419	416	417	416	414	416	416
Fossil Diesel	170	169	169	169	169	171	171	172	174	175
Fossil Petrol	-225	-223	-223	-223	-222	-225	-225	-225	-228	-229
Total Fuel	49	48	47	47	46	46	46	45	45	45

Figure 25: Change in fuel supply costs between the baseline and E9.8 with increased target

182. Bioethanol costs increase by £429m in 2021 falling to £416m in 2030. The decrease in waste biodiesel leads to a cost saving of £326m in 2021 falling to £317m in 2030.

183. Fossil petrol costs decrease by £225m in 2021 rising to £229m in 2030. The increase in fossil diesel leads to a cost of £170m in 2021 rising to £175m in 2030.

Overall, the total fuel supply cost increases by £49m in 2021 falling to £45m in 2030.

Cost: E10 incompatible vehicles

184. Costs to owners of incompatible vehicles are the same as described in option 1.

Cost: Fuel labelling

185. Costs of fuel labelling is the same as described in option 1.

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

186. 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 27: Monetised GHG savings benefit of moving from the baseline to E5.5 (£m, 2019 prices, undiscounted)

187. 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 28: GHG savings impact of moving from the baseline to E9.8 (MTCO2e/year)

188. 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.

189. 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	-24	-24	-25

Figure 29: Monetised GHG savings benefit of moving from the baseline to E9.8 (£m, 2019 prices, undiscounted)

190. 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).

Cost-benefit summary for option 3

191. The table below shows a summary of monetised costs and benefits for the central scenario (E7.7), the low scenario (E5.5) and the high scenario (E9.8) for the appraisal period of 2021 to 2030.

192. In the central scenario, total costs of £403m are made up of (1) £233m of additional biofuel blending costs; (2) £169m of costs to incompatible vehicles; and (3) £1m fuel pump labelling costs. GHG savings are estimated to fall by 1.8 MTCO2e which is valued at -£120m (a negative benefit). Overall this gives a policy net present value of -£522m. £/tCO2e is not given as there are no GHG savings under this scenario.

193. In the low scenario, total costs of £235m are made up of (1) £65m of additional biofuel blending costs; (2) £169m of costs to incompatible vehicles; and (3) £1m fuel pump labelling costs. GHG savings are estimated to fall by 0.5 MTCO2e which is valued at -£34m (a negative benefit). Overall this gives a policy net present value of -£269m. £/tCO2e is not given as there are no GHG savings under this scenario.

194. In the high scenario, total costs of £570m are made up of (1) £400m of additional biofuel blending costs; (2) £169m of costs to incompatible vehicles; and (3) £1m fuel pump labelling costs. GHG savings are estimated to fall by 3.2 MTCO2e which is valued at -£205m (a negative benefit). Overall this gives a policy net present value of -£775m. £/tCO2e is not given as there are no GHG savings under this scenario.

	central (E7.7)	low deployment (E5.5)	high deployment (E9.8)
Cost of fuel labelling	1	1	1
Cost to incompatible vehicles	169	169	169
Biofuel blending costs	233	65	400
Total Costs	**403**	**235**	**570**
Carbon benefits	-120	-34	-205
Total Benefits	**-120**	**-34**	**-205**
NPV	**-522**	**-269**	**-775**

Figure 30: Option 3 summary cost-benefit data covering appraisal period 2021 to 2030 (£m, 2019 prices, discounted)

	central (E7.7)	low deployment (E5.5)	high deployment (E9.8)
GHG savings (MTCO2e)	-1.8	-0.5	-3.2
£/tCO2e	n/a	n/a	n/a

Figure 31: Option 3 GHG savings impact covering appraisal period 2021 to 2030 (MTCO2e)

RTFO target increase sensitivity

195. 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 the early 2020s is shown in the tables below.

196. In the central scenario, the target increase is assumed to be met through a mixture of bioethanol and waste biodiesel. Total costs of £1,677m are made up of (1) £1,507m of additional biofuel blending costs; (2) £169m of costs to incompatible vehicles; and (3) £1m fuel pump labelling costs. GHG savings are estimated to increase by 8.6 MTCO2e which is valued at £560m. Overall this gives a policy net present value of -£1,117m. Carbon cost effectiveness[25] under the central scenario is £129/tCO2e.

197. 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 £1,510m are made up of (1) £1,340m of additional biofuel blending costs; (2) £169m of costs to incompatible vehicles; and (3) £1m fuel pump labelling costs. GHG savings are estimated to increase by 10.0 MTCO2e which is valued at £646m. Overall this gives a policy net present value of -£864m. Carbon cost effectiveness under the low scenario is £87/tCO2e.

198. In the high scenario, the target increase is assumed to be met entirely through increased bioethanol blending. Total costs of £1,844m are made up of (1) £1,674m of additional biofuel blending costs; (2) £169m of costs to incompatible vehicles; and (3) £1m fuel pump labelling costs. GHG savings are estimated to increase by 7.3 MTCO2e which is valued at £474m. Overall this gives a policy net present value of -£1,370m. Carbon cost effectiveness under the high scenario is £187/tCO2e.

	central (E7.7)	low deployment (E5.5)	high deployment (E9.8)
Cost of fuel labelling	1	1	1
Cost to incompatible vehicles	169	169	169
Biofuel blending costs	1,507	1,340	1,674
Total Costs	**1,677**	**1,510**	**1,844**
Carbon benefits	560	646	474
Total Benefits	**560**	**646**	**474**
NPV	**-1,117**	**-864**	**-1,370**

Figure 32: Option 3 summary cost-benefit data covering appraisal period 2021 to 2030 – with increased RTFO targets (£m, 2019 prices, discounted)

	central (E7.7)	low deployment (E5.5)	high deployment (E9.8)
GHG savings (MTCO2e)	8.6	10.0	7.3
£/tCO2e	129	87	187

Figure 33: Option 3 GHG savings impact covering appraisal period 2021 to 2030 – with increased RTFO targets (MTCO2e)

[25] £/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

6 Annex

Annex A: Glossary of Terms

Fuel terminology

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

E10 - a blended fuel consisting of 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 32x 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[26] (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

[26] 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[27] (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[28] (sheet RTFO_05) and ILUC factors are taken from DIRECTIVE (EU) 2015/1513[29] (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

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

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

[29] 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[30] (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

Biofuels

Biofuel price projections are based upon analysis of price trends in biofuel and fossil fuel markets and projected fossil fuel prices (table A8).

	£/litre, 2019 prices				
	crop ethanol	crop biodiesel	UCO biodiesel	tallow biodiesel	HVO biodiesel
2020	0.56	0.68	0.8	0.78	1
2021	0.56	0.68	0.8	0.78	1
2022	0.56	0.68	0.81	0.78	1.01
2023	0.57	0.68	0.81	0.79	1.01
2024	0.57	0.68	0.82	0.79	1.02
2025	0.58	0.68	0.82	0.8	1.02
2026	0.59	0.68	0.84	0.81	1.04
2027	0.59	0.68	0.84	0.81	1.04
2028	0.59	0.68	0.85	0.82	1.05
2029	0.6	0.68	0.86	0.83	1.06
2030	0.61	0.68	0.86	0.83	1.06

Figure A9: Central biofuel price projections, £/litre

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

	£/mj, 2019 prices				
	crop ethanol	crop biodiesel	UCO biodiesel	tallow biodiesel	HVO biodiesel
2020	0.02	0.02	0.024	0.336	0.029
2021	0.02	0.02	0.024	0.336	0.029
2022	0.03	0.02	0.024	0.336	0.029
2023	0.03	0.02	0.024	0.336	0.03
2024	0.03	0.02	0.025	0.337	0.03
2025	0.03	0.02	0.025	0.337	0.03
2026	0.03	0.02	0.025	0.337	0.03
2027	0.03	0.02	0.025	0.337	0.03
2028	0.03	0.02	0.025	0.337	0.03
2029	0.03	0.02	0.026	0.338	0.031
2030	0.03	0.02	0.026	0.338	0.031

Figure A10: Central biofuel price projections, £/mj

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	266
crop biodiesel	2,175
used cooking oil biodiesel	141
tallow biodiesel	132
HVO biodiesel	196

Figure A11: projected biofuel abatement costs

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:

biofuel price (£/mj) – displaced fossil fuel 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[31] (data table 3)

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

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Low	35	35	36	36	37	38	38	39	39	40	40
Central	69	70	72	73	74	75	76	77	79	80	81
High	104	106	107	109	111	113	114	116	118	120	121

Figure A12: carbon price projections

Fuel supply volumes

Road transport fuel demand values have been taken from the Government's 2018 Energy & Emission projections[32] (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[33].

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

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.

E4.6

	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 biodiesel	0	0	0	0	0	0	0	0	0	0
HVO (waste)	0	0	0	0	0	0	0	0	0	0
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
fossil diesel	27,708	27,536	27,402	27,238	27,004	26,850	26,726	26,541	26,369	26,212
fossil petrol	13,964	13,726	13,553	13,403	13,226	13,109	12,980	12,861	12,773	12,699
NRMM diesel	5,258	5,258	5,258	5,258	5,258	5,258	5,258	5,258	5,258	5,258

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

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

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

E5.5

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
UCO biodiesel	1,779	1,765	1,755	1,743	1,728	1,718	1,709	1,697	1,686	1,677
tallow biodiesel	61	61	61	61	61	61	61	61	61	61
crop biodiesel	0	0	0	0	0	0	0	0	0	0
HVO (waste)	0	0	0	0	0	0	0	0	0	0
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
fossil diesel	27,769	27,596	27,462	27,297	27,063	26,908	26,784	26,597	26,425	26,268
fossil petrol	13,876	13,640	13,467	13,319	13,143	13,026	12,898	12,780	12,692	12,619
NRMM diesel	5,258	5,258	5,258	5,258	5,258	5,258	5,258	5,258	5,258	5,258

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

E9.8

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
UCO biodiesel	1,437	1,429	1,423	1,415	1,403	1,396	1,390	1,380	1,372	1,364
tallow biodiesel	61	61	61	61	61	61	61	61	61	61
crop biodiesel	0	0	0	0	0	0	0	0	0	0
HVO (waste)	0	0	0	0	0	0	0	0	0	0
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
fossil diesel	28,083	27,904	27,767	27,599	27,360	27,203	27,076	26,887	26,713	26,554
fossil petrol	13,427	13,198	13,031	12,887	12,716	12,603	12,480	12,365	12,280	12,209
NRMM diesel	5,258	5,258	5,258	5,258	5,258	5,258	5,258	5,258	5,258	5,258

Figure A16: biofuel and fossil fuel demand projections with E5.5 petrol/ethanol blend (million litres)

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)[34]

	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 A17: GDP deflator series

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

Annex C: Cost & Energy Calculations

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 A18: 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 A19: 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 A20: E10 energy content breakdown

E5 to E10 energy difference	1.7%

Figure A21: 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 A22: GHG emissions factors for petrol & ethanol

E5	% energy	gCO2e/mj
petrol	97%	84.9
ethanol	3%	1.4
total		86.3

Figure A23: GHG emissions factor for E5

E10	% energy	gCO2e/mj
petrol	93%	81.8
ethanol	7%	2.9
total		84.8

Figure A24: GHG emissions factor for E10

% GHG saving (E0 to E5)	1.7%

Figure A25: GHG saving moving from E0 to E5

% GHG saving (E5 to E10)	1.8%

Figure A26: GHG saving moving from E5 to E10

% GHG saving (E0 to E10)	3.5%

Figure A27: 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	0.8
2021 diesel price	£/litre	0.45
2021 certificate price	£/certificate	0.18

Figure A28: 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 * 0.18 = 0.008. Supply + margin costs (unevidenced assumption) fuel duty (£0.058/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 1.6% is calculated by dividing the energy adjusted E10 price by the E5 price (£1.30 / £1.28).

	£/litre
2021 petrol price	£0.42
2021 ethanol price	£0.56
2021 certificate price	£0.18

Figure A29: 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 A30: E5 pump price calculation

E10	% volume	£/litre	£/litre (energy adjusted)
petrol	90%	£0.38	£0.38
ethanol	10%	£0.06	£0.06
certificates	-0.25%	£0.00	£0.00
supply + margin		£0.05	£0.05
duty		£0.58	£0.59
vat		£0.21	£0.22
total		£1.27	£1.30

Figure A31: 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[35]

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

Figure A32: petrol prices (average of prices between 03/18 and 04/19)

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

'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[36] (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 A33: 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 (250MTCO2e from 2028 to 2032). 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.

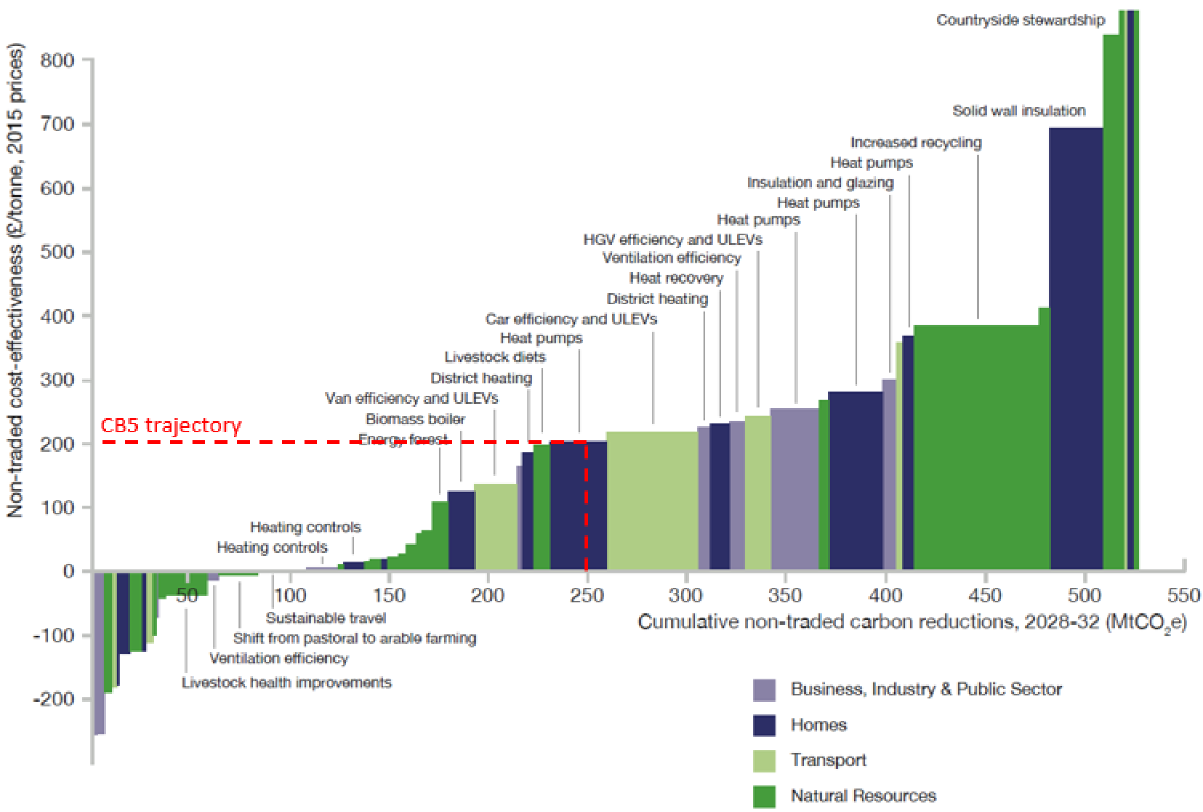

Figure A34: Carbon budget 5 marginal abatement cost curve with carbon budget 5 GHG savings target shown by red line

[36] 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]

For consistency, the £187.5/tCO2e average abatement cost (2019 prices) from the main cost benefit 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 could be compared consistently with other GHG abatement measures which are shown in the MACC. The 2015 value is £173.3 which we then superimpose on the chart above. In making this comparison, we can see that the policy cost of a successful introduction of E10 (accompanied by an increase in RTFO targets) falls below the estimated marginal abatement cost for the carbon budget 5 period.

E9.8 £/tCO2e (2019 prices)	187.5
E9.8 £/tCO2e (2015 prices)	173.3

Figure A35: estimated abatement cost for E9.8 and increased RTFO targets (£/tCO2e, discounted and net of monetised GHG benefits)

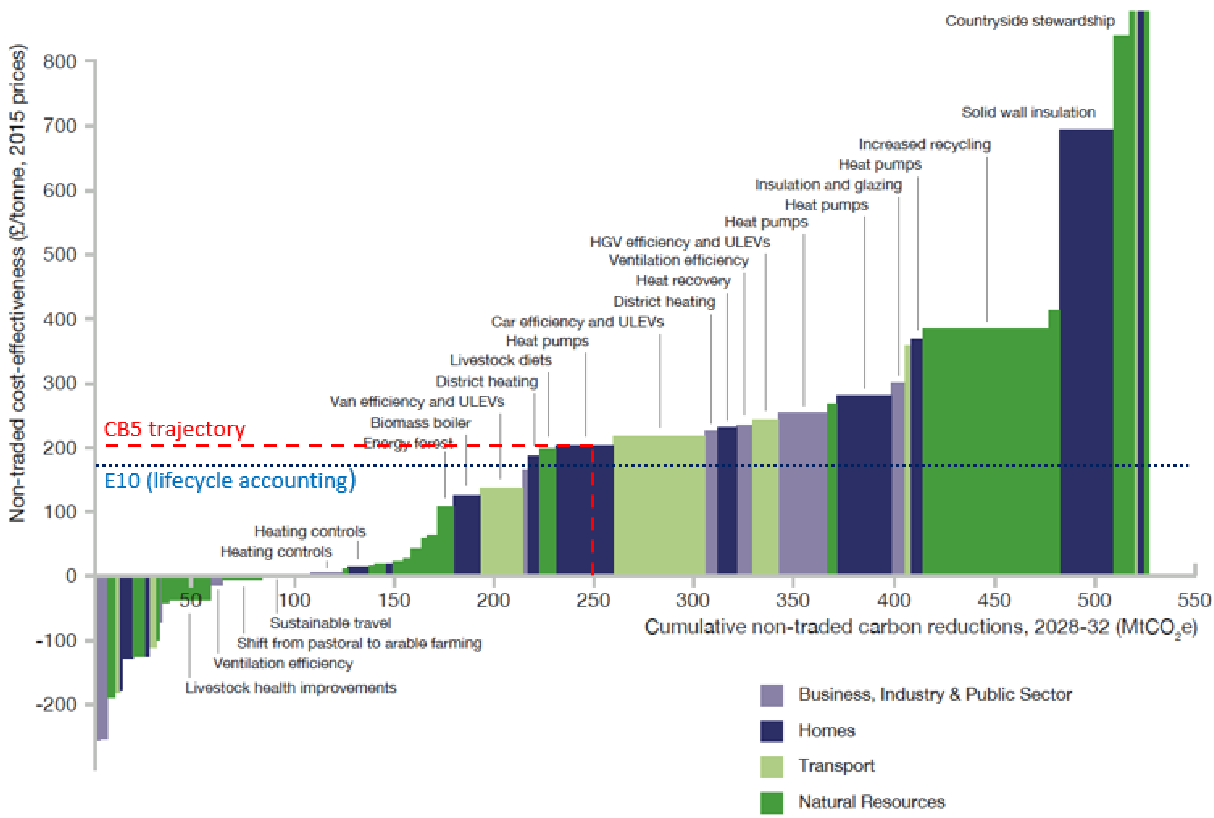

Figure A36: Carbon budget 5 marginal abatement cost curve with carbon budget 5 GHG savings target (red dotted line) and E9.8 abatement cost (blue dotted line)

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:

1G low blend waste biodiesel (UCO)	gCO2/mj	0
1G low blend waste biodiesel (tallow)	gCO2/mj	0
1G low blend crop biodiesel	gCO2/mj	0
HVO	gCO2/mj	0
Annex 9A Biodiesel	gCO2/mj	0
1G Crop Bioethanol	gCO2/mj	0
2G Advanced Ethanol (land using)	gCO2/mj	0
2G Advanced Ethanol (non land using)	gCO2/mj	0
Biomethane	gCO2/mj	0
Biomethanol	gCO2/mj	0
Development road fuel	gCO2/mj	0
Development aviation fuel	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 again use the deflator series from annex B 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)	187.5	95.9
E9.8 £/tCO2e (2015 prices)	173.4	88.7

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)

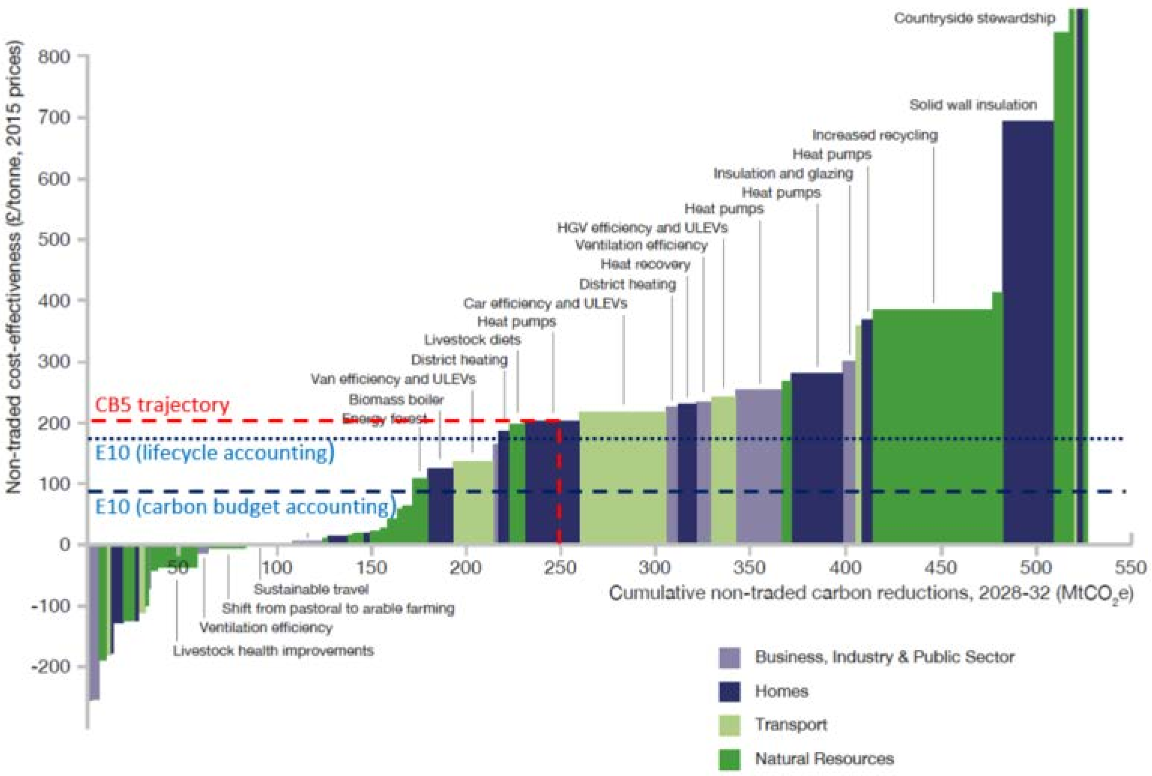

Figure A40: Carbon budget 5 marginal abatement cost curve with carbon budget 5 GHG savings target (red dotted line) and E9.8 abatement cost (lifecycle accounting & carbon budget accounting)

Sensitivity - crop biodiesel as marginal fuel

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 scenarios for policy options 2 and 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 fuel labelling	£1	£1
Cost to incompatible vehicles	£169	£169
Biofuel blending costs	-£7	£200
Total Costs	£163	£370
Carbon benefits	£194.60	-£104
Total Benefits	£194.60	-£104
Net Cost	-£32.00	£473

Figure A41: cost & monetised benefits for option 2 central scenario (E7.2) [showing both crop biodiesel and UCO biodiesel as marginal biofuel]

	Units	crop biodiesel marginal fuel	UCO biodiesel marginal fuel
NPV	£m, 2019	£32	-£473
BCR	01:00	1.2	0.3
EANDCB	£m, 2019	-£1	£23
CO2e savings impact	MTCO2e	3	-1.6
Average abatement cost	£/TCO2e	n/a	n/a

Figure A42: cost benefit summary for option 2 central scenario (E7.2) [showing both crop biodiesel and UCO biodiesel as marginal biofuel]

	total monetised values (2021 to 2030)	
	crop biodiesel marginal fuel	UCO biodiesel marginal fuel
Cost of fuel labelling	£1	£1
Cost to incompatible vehicles	£169	£169
Biofuel blending costs	-£10	£232
Total Costs	£160	£403
Carbon benefits	£229	-£120
Total Benefits	£229	-£120
Net Cost	-£69	£522

Figure A43: cost & monetised benefits for option 3 central scenario (E7.7) [showing both crop biodiesel and UCO biodiesel as marginal biofuel]

	Units	crop biodiesel marginal fuel	UCO biodiesel marginal fuel
NPV	£m, 2019	£69	-£522
BCR	01:00	1.4	-0.3
EANDCB	£m, 2019	-£1	£27
CO2e savings impact	MTCO2e	3.5	-1.8
Average abatement cost	£/TCO2e	n/a	n/a

Figure A44: cost benefit summary for option 3 central scenario (E7.7) [showing both crop biodiesel and UCO biodiesel as marginal biofuel]

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[37].

> Q13: Do you have any data on the number of fuel retailers or fuel suppliers who would be classified as either a small business (10 to 49 employees) or micro business (1 to 9 employees)?

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

> Q14: How do you think micro and small businesses could be affected by the regulations covered by this impact assessment?

Increased fuel costs

Our central estimate is that fuel costs for E10 compatible petrol cars will increase by around 1.6% for E10 incompatible cars and by around 8% for owners of incompatible cars who are assumed to purchase E5 'super grade' petrol as an alternative to E10 (see annex C for more information on these numbers).

Small and micro businesses which operate modern petrol vehicles are therefore expected to experience a 1.6% 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. 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. 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

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

37 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/827960/RPC_Small_and_Micro_Business_Assessment__SaMBA__August_2019.pdf

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)

Q15: Do you have any data on the number of fuel retail sites which have less than 3 fuel tanks (i.e. are only able to serve diesel and one grade of petrol)?
Q16: What is the minimum and typical number of petrol pumps you would expect to find at a petrol station with 3 fuel tanks (i.e. able to serve both E5 and E10 alongside diesel)?

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[38]) 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[39], 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 A49, 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[40] 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.

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

39 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]

40 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

Q17: Do you have any data on fuel retailer profit margins?

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.

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[41]. In this assessment, labelling for a smaller fuel station is estimated to cost £100 per station.

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.

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, both of 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 two options are similar in

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

nature, however the more restrictive measure, 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.

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.

Annex E: Consultation Questions

Q1. What future level of ethanol blending would you expect in the absence of any policy changes?

Q2. Is it reasonable to assume that requiring fuel retailers to label all 95 octane petrol fuel as ‘E10’ would remove any commercial disadvantage associated with being the first supplier to shift to E10?

Q3. What would you expect the E10 fuel blend to be under policy option 2: a) E5.5 b) E9.8 c) an average of the two d) other (please specify)?

Q4. Is it reasonable to assume that requiring all fuel retailers to supply a 95 octane petrol as a minimum E5.5 would remove any commercial disadvantage associated with being the first supplier to shift to E10?

Q5. What would you expect the E10 fuel blend to be under policy option 3: a) E4.6 b) E9.8 c) an average of the two d) other (please specify)?

Q6. What do you consider to be the major costs and benefits associated with the introduction of E10?

Q7. What do you consider to be the marginal fuel supplied under the RTFO?

Q8. Do the baseline biofuel supply projections appear reasonable? If not, please specify what fuels you would expect to be supplied.

Q9. How do you expect the biofuel-fossil fuel price spread to evolve going forward? Do you expect it to a) increase b) decrease or c) stay constant?

Q10. Do you think that the values used for biofuel and fossil fuel GHG emission factors are appropriate? Are you aware of any alternative values we could use?

Q11. Do you consider the estimated fuel supply impacts for option 2 to be reasonable? If not, please specify the changes you would make.

Q12. Do you consider the estimated fuel supply impacts for option 3 to be reasonable? If not, please specify the changes you would make.

Q13: Do you have any data on the number of fuel retailers or fuel suppliers who would be classified as either a small business (10 to 49 employees) or micro business (1 to 9 employees)?

Q14: How do you think micro and small businesses could be affected by the regulations covered by this impact assessment?

Q15: Do you have any data on the number of fuel retail sites which have less than 3 fuel tanks (i.e. are only able to serve diesel and one grade of petrol)?

Q16: What is the minimum and typical number of petrol pumps you would expect to find at a petrol station with 3 fuel tanks (i.e. able to serve both E5 and E10 alongside diesel)?

Q17: Do you have any data on fuel retailer profit margins?