Summary: Intervention & Options

Department /Agency: Department for Transport	Title: Impact Assessment of proposals for a UK Renewable Energy Strategy - Transport	
Stage: Strategy	**Version: 1**	**Date:**
Related Publications:		

Available to view or download at:

Contact for enquiries: Sam Waugh **Telephone: 0207 944 5283**

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

The potential measures in the consultation document seek to address two issues: climate change and energy security. Using renewable energy can reduce greenhouse gas emissions and provide an alternative to using fossil fuels as a source of energy. The market will not solve the climate change problem itself because of the extra costs of renewable energy compared to fossil fuels. Existing intervention has also had limited impact.

The European Community has therefore agreed the Renewable Energy Directive which imposes mandatory targets on Member States in order to rapidly increase the use of clean renewable energy. The Directive requires the UK to increase its renewable energy mix from less than 2% today to 15% by 2020, with an individual binding target for the Transport sector of 10%. This Impact Assessment considers the impact of three biofuel deployment/blending levels in 2020 that will meet the RED 10% renewable energy transport target and contribute to the overall 15% target.

What are the policy objectives and the intended effects?

To meet the Directive's 10% target for the share of renewable energy in the UK transport sector by 2020, compared with around 4% from 2013/14 under existing policies, and by doing so to contribute towards the UK's overall 15% renewable energy target.

What policy options have been considered? Please justify any preferred option.

This impact assesment considers potential biofuel deployment scenario that meet the 10% renewable energy transport target and contribute to the overall 15% target. The three scenarios are:

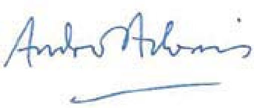
- Blending biofuels into petrol and diesel so that the fuel supplied is 10% biofuel by energy content,
- Blending biofuels into petrol and diesel so that the fuel supplied is 8% biofuel by energy content,
- Blending biofuels into petrol and diesel so that the fuel supplied is 12% biofuel by energy content.

When will the policy be reviewed to establish the actual costs and benefits and the achievement of the desired effects? The Government will consult further on the implementation of the RED in the transport sector later in the year. Detailed discussion of the costs, benefits and other features of the policy design will therefore be presented in future IAs.

Ministerial Sign-off For consultation stage Impact Assessments:

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

Signed by the responsible Minister:



....Date: 08 / 06 / 2009

Summary: Analysis & Evidence

Scenario: 1	**Description: Blending biofuels into petrol and diesel so that the fuel supplied is 10% biofuel by energy content** **(See page 5 and 6 for explanation of the summary sheet)**

COSTS

ANNUAL COSTS		Description and scale of **key monetised costs** by 'main affected groups'
One-off (Transition)	**Yrs**	Additional fuel resource costs = **-£11,405m to -£3,373m**
-£256m		Infrastructure costs = **-£256m**
Average Annual Cost (excluding one-off)		Welfare loss due to reduced driving = **-£155m to -£32m**
-£900m to -£272m		**Total Cost** (PV) **-£11,816m to -£3,661m**

Other **key non-monetised costs** by 'main affected groups' Possible indirect impacts on biodiversity, food prices and release of greenhouse gases if growing biofuels requires land use change.

BENEFITS

ANNUAL BENEFITS		Description and scale of **key monetised benefits** by 'main affected groups'
One-off	**Yrs**	Monetised reduction in GHG emissions = **£3,361m to £2,973m**
£ 0		Ancillary benefits = **£2,912m to £1,131m**
Average Annual Benefit (excluding one-off)		
£484m to £316m		**Total Benefit** (PV) **£6,272m to £4,104m**

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

Ancillary impacts arising from a reduction in congestion, air pollution, noise, road infrastructure and accidents. Market / employment opportunities in agriculture and biodiesel production; diversity and security of national fuel supply; likely positive impact on innovation.

Key Assumptions/Sensitivities/Risks

Fuel resource cost changes are dependent on both oil price and biofuel price scenarios. See Assumptions and Impacts from page 14 for more details.

Price Base Year **2008**	Time Period Years **22**	**Net Benefit Range** (NPV) **-£5,544m to £442m**	**NET BENEFIT** (NPV Best estimate) **-£2,591m**

What is the geographic coverage of the policy/option?		UK		
On what date will the policy be implemented?		2010		
Which organisation(s) will enforce the policy?		DfT		
What is the total annual cost of enforcement for these organisations?		n/a		
Does enforcement comply with Hampton principles?		Yes		
Will implementation go beyond minimum EU requirements?		Yes/No		
What is the value of the proposed offsetting measure per year?		n/a		
What is the value of changes in greenhouse gas emissions?		£2,973m to £3,361m		
Will the proposal have a significant impact on competition?		No		
Annual cost (£-£) per organisation (excluding one-off)	Micro	Small	Medium	Large
Are any of these organisations exempt?	Yes	No	N/A	N/A

Impact on Admin Burdens Baseline (2005 Prices)			(Increase - Decrease)
Increase of £ N/A	Decrease of £ N/A	**Net Impact**	£ N/A

Key: **Annual costs and benefits: Constant Prices** **(Net) Present Value**

Summary: Analysis & Evidence

Scenario: 2	**Description: Blending biofuels into petrol and diesel so that the fuel supplied is 8% biofuel by energy content**

COSTS

ANNUAL COSTS		Description and scale of **key monetised costs** by 'main affected groups'
One-off (Transition)	**Yrs**	Additional fuel resource costs = **-£6,083m to -£1,481m**
-£256m		Infrastructure costs = **-£256m**
Average Annual Cost (excluding one-off)		Welfare loss due to reduced driving = **-£73m to -£16m**
-£484m to -£126m		**Total Cost** (PV) **-£6,413m to -£1,754m**

Other **key non-monetised costs** by 'main affected groups' Possible indirect impacts on biodiversity, food prices and release of greenhouse gases if growing biofuels requires land use change.

BENEFITS

ANNUAL BENEFITS		Description and scale of **key monetised benefits** by 'main affected groups'
One-off		Monetised reduction in GHG emissions = **£2,614m to £2,367m**
£ 0		Ancillary benefits = **£1,714m to £686m**
Average Annual Benefit (excluding one-off)		
£334m to £235m	**Tot**	**Total Benefit** (PV) **£4,328m to £3,053 m**

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

Ancillary impacts arising from a reduction in congestion, air pollution, noise, road infrastructure and accidents. Market / employment opportunities in agriculture and biodiesel production; diversity and security of national fuel supply; likely positive impact on innovation.

Key Assumptions/Sensitivities/Risks

Fuel resource cost changes are dependent on both oil price and biofuel price scenarios. See Assumptions and Impacts from page 14 for more details.

Price Base Year **2008**	Time Period Years **22**	**Net Benefit Range** (NPV) **-£2,085m to £1,299m**	**NET BENEFIT** (NPV Best estimate) **-£378m**

What is the geographic coverage of the policy/option?			UK	
On what date will the policy be implemented?			2010	
Which organisation(s) will enforce the policy?			DfT	
What is the total annual cost of enforcement for these organisations?			£ N/A	
Does enforcement comply with Hampton principles?			Yes	
Will implementation go beyond minimum EU requirements?			Yes/No	
What is the value of the proposed offsetting measure per year?			£ N/A	
What is the value of changes in greenhouse gas emissions?			£2,367m to £2,614m	
Will the proposal have a significant impact on competition?			No	
Annual cost (£-£) per organisation (excluding one-off)	Micro	Small	Medium	Large
Are any of these organisations exempt?	Yes	No	N/A	N/A

Impact on Admin Burdens Baseline (2005 Prices) (Increase - Decrease)

Increase of £ N/A Decrease of £ N/A **Net Impact** £ N/A

Key: **Annual costs and benefits: Constant Prices** **(Net) Present Value**

Summary: Analysis & Evidence

Scenario: 3	**Description: Blending biofuels into petrol and diesel so that the fuel supplied is 12% biofuel by energy content**

COSTS

ANNUAL COSTS		Description and scale of **key monetised costs** by 'main affected groups'
One-off (Transition)	**Yrs**	Additional fuel resource costs = **-£17,466m to -£5,602m**
-£256m		Infrastructure costs = **-£256m**
Average Annual Cost (excluding one-off)		Welfare loss due to reduced driving = **-£274m to -£54m**
-£1,377m to -£445m		**Total Cost** (PV) **-£17,996m to -£5,912**

Other **key non-monetised costs** by 'main affected groups' Possible indirect impacts on biodiversity, food prices and release of greenhouse gases if growing biofuels requires land use change.

BENEFITS

ANNUAL BENEFITS		Description and scale of **key monetised benefits** by 'main affected groups'
One-off	**Yrs**	Monetised reduction in GHG emissions = **£4,606m to £4,053m**
£ 0		Ancillary benefits = **£4,249m to £1,620m**
Average Annual Benefit (excluding one-off)		
£684m to £437m		**Total Benefit** (PV) **£8,856m to £5,673m**

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

Ancillary impacts arising from a reduction congestion, air pollution, noise, road infrastructure and accidents. Market / employment opportunities in agriculture and biodiesel production; diversity and security of national fuel supply; likely positive impact on innovation.

Key Assumptions/Sensitivities/Risks

Fuel resource cost changes are dependent on both oil price and biofuel price scenarios. See Assumptions and Impacts from page 14 for more details.

Price Base Year **2008**	Time Period Years **22**	**Net Benefit Range** (NPV) **-£9,141m to -£239m**	**NET BENEFIT** (NPV Best estimate) **-£4,857m**

What is the geographic coverage of the policy/option?			UK	
On what date will the policy be implemented?			2010	
Which organisation(s) will enforce the policy?			DfT	
What is the total annual cost of enforcement for these organisations?			n/a	
Does enforcement comply with Hampton principles?			Yes	
Will implementation go beyond minimum EU requirements?			No	
What is the value of the proposed offsetting measure per year?			n/a	
What is the value of changes in greenhouse gas emissions?			£4,053m to £4,606m	
Will the proposal have a significant impact on competition?			No	
Annual cost (£-£) per organisation (excluding one-off)	Micro	Small	Medium	Large
Are any of these organisations exempt?	Yes	No	N/A	N/A

Impact on Admin Burdens Baseline (2005 Prices)					(Increase - Decrease)
Increase of	£ N/A	Decrease of	£ N/A	**Net Impact**	£ N/A

Key: **Annual costs and benefits: Constant Prices** **(Net) Present Value**

Evidence Base (for summary sheets)

Strategic Overview

The EU 2020 renewable energy targets set by the Renewable Energy Directive (RED) includes a binding target to source 10% of the energy used in the transport sector (excluding aviation and international shipping) from renewables by 2020. This Impact Assessment focuses on the potential contribution of biofuels to meeting 10% RED transport target. The costs, benefits and wider impacts of the overall package across all three sectors are set out in the general IA.

The social issue

A market failure occurs when the free market acts in a way which does not maximise society's welfare. One example of this is climate change resulting from greenhouse gas emissions, which is formally known as a negative externality. Where there is no incentive for the free market to rectify this it may be appropriate for public policy to do so through government intervention in the market.

Further action is therefore needed in order for the UK to meet its 2020 and 2050 climate change goals and move towards becoming a low carbon economy in the absence of incentives for the free market to do so.

The Stern Review on the Economics of Climate Change emphasised that "The scientific evidence points to increasing risks of serious irreversible impacts from climate change associated with business-as-usual (BAU) paths for emissions". In identifying possible solutions, the Review stressed the importance of taking action on three fronts: creating a common carbon price to reflect the marginal damage of greenhouse gas emissions; promoting a shift towards low carbon technologies; and removing barriers to behaviour change. This policy measure is focused on the second of these strands - incentivising innovation and encouraging the development of lower cost, low carbon technology.

It is common for new technologies to take considerable time to develop in terms of their functionality, efficiency and affordability as well as their public acceptability. An inability of some new technologies to overcome barriers to market entry in the short or medium term can result in the persistence of imperfect competition. One reason for the delay in such technologies entering the market can be unease over the level of risk in investment decisions with uncertain outcomes and payback periods. If the government can intervene in the market to reduce these uncertainties, possibly through regulations which create a minimum level of demand, then it would be reasonable to expect investment to increase.

Where we want to be: Setting a policy background to the social issue

The Renewable Energy Directive and renewable transport energy

The Renewable Energy Directive contains two targets to be met by Member States by 2020. First is that 15% of all UK energy (electricity, heat and transport) will come from a renewable source. The second is a specific 10% renewable energy target for the transport sector (excluding aviation and international shipping).

For the 10% transport target it is expected that biofuels will make up the majority of the effort, although renewable electricity used in vehicles and rail may make a small contribution. Biofuels will only count towards the targets if they meet specified sustainability criteria. To incentivise electric road vehicles the renewable electricity used in them counts 2.5 times towards the transport target, and (advanced) 2nd generation, waste/residue biofuel twice towards the transport target. This multiple counting of advanced/waste biofuel and renewable electricity in electric vehicles does not apply to the overall UK 15% target of the Renewable Energy Directive, only to the 10% transport target.

The Fuel Quality Directive and renewable transport energy

There is also another policy that may impact on the amount of renewable energy that is being used in the transport sector. The Fuel Quality Directive (FQD) requires that in 2020 transport fuel suppliers must deliver a 6% reduction in the life cycle GHG emissions. The Directive identifies an additional 4% reduction (2% from refinery Carbon Capture & Storage plus supply of electricity for electric vehicle use and 2% through the purchase of Kyoto Clean Development Mechanism credits), however this will not become mandatory unless and until confirmed by a Commission review and further amendment of the Directive.

The 6% GHG reduction obligation is expected to be met through (i) improved industrial practices in the extraction and refining of fossil fuels, such as reductions in flaring, and (ii) the use of GHG saving biofuels. Initial estimates suggest that the improvements in the production of fossil fuels may contribute between -0.6% and 1.6% towards fuel suppliers' GHG reduction obligation by 2020, with a central 1% estimate. Thus it is expected that biofuels will be used to meet the rest of obligation.

It is worth noting that the FQD does not recognise a double credit for GHG reductions from second generation or waste biofuels, so that the GHG reductions from any such advanced biofuels that are used will only count once. The implementation of the FQD GHG reduction obligation is being considered separately by the Department for Transport, but the notion of the need for biofuels in a second policy area needs to be recognised here.

Where we are now: The policy background

In April 2008, the Government introduced a Renewable Transport Fuel Obligation (RTFO), requiring transport fuel suppliers to ensure that 5% of total road fuel sales by volume (equivalent to about 4% by energy) are from renewable sources by 2010-11, with an obligation level of 2.5% and 3.75% for 2008-09 and 2009-10 respectively. The Renewable Fuels Agency (RFA) was created to administer the RTFO.

Concerns that the production of biofuels could lead to increases in emissions rather than reducing them led the Government to commission a major review of the indirect effects of biofuel production in February 2008. The review was led by Professor Gallagher, Chair of the Renewable Fuels Agency. The review concluded that biofuels could contribute greenhouse gas savings from transport, but that there was a risk that then current biofuel policies would lead to a net increase in GHG emissions and thus the rate of increase in the UK's RTFO should be slowed.

In response to the Gallagher review, the Government accepted that there was a case for a degree of caution support for biofuels until the evidence is clearer about the wider environmental and social effects of biofuels. Early in 2009 the RTFO order was amended to slowdown the biofuel obligation so that it would increase from 2.5% in 2008-09, to 3.25% in 2009-10, 3.5% in 2010-11, 4% in 2010-11, 4.5% in 2011-12 and then 5% from 2013-14 and thereafter.

How do we get where we want to be?

The main areas of opportunity for increasing the use of renewable energy in transport include:

- *Biofuels* - are a direct GHG saving renewable technology for the transport sector. The GHG that is emitted into the atmosphere when they are burned is offset by the GHG that the crop has absorbed as it grows (see Annex A for a brief introduction to biofuels). By blending biofuels with fossil fuels the amount of renewable energy that is used in transport fuels is increase.

- *Electric vehicles and electric rail* - are two other areas that can contribute renewable energy to the transport sector. These technologies increase the amount of renewable energy being used in the transport sector by displacing fossil fuels with renewable electricity from the grid, for instance, wind or tidal power.

Meeting the target: Analysis of Potential Measures

The most realistic renewable energy alternative to meet the 10% transport target is biofuels. The impact assessment therefore focuses explicitly on this technology. The aim of the impact assessment is not so much to delineate specific scenarios, but to demonstrate a range of possible deployment scenarios in which biofuel is used to satisfy both the requirements of the RED and the FQD. The scenarios presented are possible practical consequences of compliance with the RED transport target and the FQD GHG reduction obligation, the way in which those EU requirements are implemented is still to be considered and a more developed impact assessment will be produced to accompany the implementation proposals. This IA considers to a range of three biofuel deployment scenarios, which are set out in more detail below.

Scenario 1: Blending biofuels into petrol and diesel so that the fuel supplied is 10% biofuel by energy content

This scenario assumes that fuel producers are able to make some GHG savings from the production of petrol and diesel and the average GHG savings from biofuels remain close to 50%. Thus 10% biofuel will probably be needed to meet the 6% GHG FQD target. In this scenario, if advanced or waste/residue biofuel technology becomes commercially available and contribute towards the target, the counting of this technologies will mean that the UK will overshoot the 10% Transport RED target.

Scenario 2: Blending biofuels into petrol and diesel so that the fuel supplied is 8% biofuel by energy content

This scenario assumes that fuel producers are able to make significant GHG savings from the production of petrol and diesel and the average GHG savings from biofuels rise above 50%. The additional use of advanced/waste biofuels and electric vehicles/rail mean that the UK can consume less than 10% biofuel and still meet the RED and FQD targets.

Scenario 3: Blending biofuels into petrol and diesel so that the fuel supplied is 12% biofuel by energy content

This scenario assumes that fuel producers are not able to make any GHG savings from the production of petrol and diesel and the average GHG savings from biofuels remain at the minimum 50% level. Thus more than 10% biofuel is needed to meet the FQD. There is overshoot on the RED target. The impact assessment of this scenario therefore also includes the extra costs and benefits of a level of biofuel deployment over what is required to meet the 10% transport target.

Rail and Electric Vehicles

Although the most realistic renewable energy alternative to meet the 10% target in 2020 are biofuels, the 2008 RES consultation document also highlighted that the emergence of electric vehicles could potentially contribute to long term carbon reduction and renewable energy targets. However, even if technologically robust and economically viable electric vehicle options do emerge in the next decade, there is considerable uncertainty about the potential for significant large scale impacts on renewable energy or carbon targets, power demand or grid operation prior to 2020. A joint study by ARUP and Cenex into the potential for electric vehicles was recently commissioned by DfT and BERR, see link of report below. The ARUP-Cenex study considered a series of uptake scenarios for electric vehicles up to 2030. Their business as usual scenario assumed up to 3 million electric or plug in hybrids by 2030, 'mid-range' assumed 4 million, and 'High' of around 11 million. Under these scenarios, and given the average EU renewable electricity grid mix increasing to 30% by 2020 and the EV 2.5 multiplier toward the 10% RED target, electric vehicles would contribute 0.02%, 0.17% and 0.35% to the 10% respectively for each scenario.

http://www.berr.gov.uk/files/file48653.pdf

Rail is responsible for about 3% of UK surface transport energy and 1% of UK carbon emissions come from rail. Trains are currently powered either by gas oil or electricity. Proposed changes to the Fuel Quality Directive will require rail to switch to zero sulphur diesel (road quality diesel) from the beginning of 2012, it is likely that rail will be offered automotive quality diesel fuel with whatever level of biofuel is required for road use. So the industry's working assumption is that its fuel will include 5% biofuel by volume by 2013/14.

Currently 39% of the rail network is electrified with electric trains accounting for about 65% of total passenger kilometres. Given the average EU renewable electricity grid mix increasing to 30% by 2020 the current electrified rail network could potentially contribute up to around 0.5% towards the RED transport 10% target.

Further electrification of rail is another possibility for increasing the amount of renewable energy in the transport sector. However, the potential scope for this policy is small because diesel rail makes up only a small proportion of the total energy use of the transport sector. The Department for Transport is working closely with Network Rail to understand the costs and potential timescales for electrifying the Midland and Great Western Main Lines. A decision on the electrification of these two lines will be announced later this year. In parallel, an industry working group led by Network Rail is considering the case for electrifying a much wider range of routes including "infill" schemes that can join up existing parts of the electrified network. This group is also expected to publish a report of its findings later this year.

Summary of costs and benefits

Tables 1 to 3 below summarise the estimated costs and benefits of meeting the 10% renewable energy target using the (four) DECC fossil fuel price assumptions and three agricultural yield growth assumptions. More discussion of the assumptions used in the analysis can be found in the Assumption and Impacts section below from page 12.

10% by energy in 2020

Table 1: Impact to 2030 of blending 10% biofuel by energy content by 2020

	High Cost	Central Cost	Low Cost
Present Value Costs	-11,816	-7,821	-3,661
- Of which fuel costs	-11,405	-7,481	-3,373
- Of which are infrastructure costs	-256	-256	-256
- Of which welfare loss	-155	-83	-32
Present Value Benefits[2]	6,272	5,229	4,104
- GHG Savings	3,361	3,184	2,973
- Ancillary Benefits	2,912	2,045	1,131
Cost-Benefit Analysis			
- Net Present Value (without ancillary)[1]	-8,455	-4,636	-688
- Net Present Value (with ancillary)	-5,544	-2,591	442
- Cost effectiveness (£/tCO_2) [2]	94	65	32
Distributional Analysis			
- Net Present Value for Government	5,568	5,672	5,771
- Net Present Value for Firms	-3,790	-3,153	-2,463
- Net Present Value for Consumers	-7,322	-5,110	-2,866
GHG Impacts (MtCO_{2e})			
- UK Non-Traded GHG saved	98	93	88
- UK Non-Traded GHG saved in 2020	7.1	6.8	6.4
- Global WTW GHG saved	73	68	62
- Global WTW GHG saved in 2020	5.4	5.1	4.6
Fuel Impacts in 2020			
- Increase in renewable energy (TWh)	27.7	27.6	27.5
- Reduction in fossil fuels (m litres)	3,330	3,202	3,048
- Impact on Petrol price (ppl) in 2020	3.2	0.9	-2.7
- % change in driving costs in 2020 [3]	8.0%	5.7%	2.9%
- Impact on Diesel price (ppl) in 2020	2.4	1.82	1.0
- % change in driving costs in 2020 [3]	2.5%	1.9%	1.0%
Non-monetised Impacts	Positive impacts on innovation, security of supply and congestion. Possible negative impacts on biodiversity, food commodity prices and GHG's if biofuels require land use change.		

[1] Reflects total benefits minus total costs discounted over the lifetime of the measure. These costs and benefits exclude 'ancillary impacts'' e.g. air quality. [2] Including ancillary impacts. [3] The change driving costs, pence per kilometre, also take into account the lower energy content of biofuels and are thus a more accurate measure of the impact on the motorist.

8% by energy in 2020

Table 2: Impact to 2030 of blending 8% biofuel by energy content by 2020

	High Cost	Central Cost	Low Cost
Present Value Costs	-6,413	-4,093	-1,754
- Of which fuel costs	-6,083	-3,796	-1,481
- Of which are infrastructure costs	-256	-256	-256
- Of which welfare loss	-73	-41	-16
Present Value Benefits[2]	4,328	3,714	3,053
- GHG Savings	2,614	2,503	2,367
- Ancillary Benefits	1,714	1,211	686
Cost-Benefit Analysis			
- Net Present Value (without ancillary)[1]	-3,799	-1,590	613
- Net Present Value (with ancillary)	-2,085	-378	1,299
- Cost effectiveness (£/tCO_2) [2]	70	43	14
Distributional Analysis			
- Net Present Value for Government	4,201	4,235	4,253
- Net Present Value for Firms	-1,585	-1,319	-1,130
- Net Present Value for Consumers	-4,701	-3,294	-1,824
GHG Impacts (MtCO_{2e})			
- UK Non-Traded GHG saved	64	61	58
- UK Non-Traded GHG saved in 2020	4.6	4.5	4.2
- Global WTW GHG saved	71	67	64
- Global WTW GHG saved in 2020	5.2	5.0	4.7
Fuel Impacts			
- Increase in renewable energy (TWh)	17.8	17.7	17.6
- Reduction in fossil fuels (m litres)	2,140	2,063	1,970
- Impact on Petrol price (ppl) in 2020	1.9	0.4	-2.1
- % change in driving costs in 2020 [3]	5.5%	4.1%	2.2%
- Impact on Diesel price (ppl) in 2020	0.8	0.5	0.3
- % change in driving costs in 2020 [3]	0.8%	0.6%	0.3%
Non-monetised Impacts	Positive impacts on innovation, security of supply and congestion. Possible negative impacts on biodiversity, food commodity prices and GHG's if biofuels require land use change.		

[1] Reflects total benefits minus total costs discounted over the lifetime of the measure. These costs and benefits exclude 'ancillary impacts'' e.g. air quality. [2] Including ancillary impacts. [3] The change driving costs, pence per kilometre, also take into account the lower energy content of biofuels and are thus a more accurate measure of the impact on the motorist.

12% by energy in 2020

Table 3: Impact to 2030 of blending 12% biofuel by energy content by 2020

	High Cost	Central Cost	Low Cost
Present Value Costs	-17,996	-12,197	-5,912
- Of which fuel costs	-17,466	-11,795	-5,602
- Of which are infrastructure costs	-256	-256	-256
- Of which welfare loss	-274	-146	-54
Present Value Benefits[2]	8,856	7,340	5,673
- GHG Savings	4,606	4,356	4,053
- Ancillary Benefits	4,249	2,984	1,620
Cost-Benefit Analysis			
- Net Present Value (without ancillary)[1]	-13,390	-7,841	-1,860
- Net Present Value (with ancillary)	-9,141	-4,857	-239
- Cost effectiveness (£/tCO_2) [2]	103	74	39
Distributional Analysis			
- Net Present Value for Government	6,905	7,095	7,300
- Net Present Value for Firms	-6,380	-5,351	-4,016
- Net Present Value for Consumers	-9,666	-6,601	-3,524
GHG Impacts (MtCO_{2e})			
- UK Non-Traded GHG saved	138	132	124
- UK Non-Traded GHG saved in 2020	10.1	9.6	9.1
- Global WTW GHG saved	101	94	85
- Global WTW GHG saved in 2020	7.5	7.0	6.4
Fuel Impacts			
- Increase in renewable energy (TWh)	37.7	37.6	37.5
- Reduction in fossil fuels (m litres)	4,545	4,364	4,143
- Impact on Petrol price (ppl) in 2020	4.5	1.3	-3.3
- % change in driving costs in 2020 [3]	10.6%	7.3%	3.7%
- Impact on Diesel price (ppl) in 2020	4.3	3.4	2.0
- % change in driving costs in 2020 [3]	4.5%	3.4%	1.9%
Non-monetised Impacts	Positive impacts on innovation, security of supply and congestion. Possible negative impacts on biodiversity, food commodity prices and GHG's if biofuels require land use change.		

[1] Reflects total benefits minus total costs discounted over the lifetime of the measure. These costs and benefits exclude 'ancillary impacts'' e.g. air quality. [2] Including ancillary impacts. [3] The change driving costs, pence per kilometre, also take into account the lower energy content of biofuels and are thus a more accurate measure of the impact on the motorist.

Assumptions and Impacts

The assumptions and the results of this impact assessment are to give an illustrative estimate on the potential costs and benefits of these biofuel deployment scenarios considered. The scenarios presented are possible practical consequences of compliance with the RED transport target and the FQD GHG reduction obligation, the way in which those EU requirements are implemented is still to be considered and a more developed impact assessment will be produced to accompany the implementation proposals. Where stated, certain assumptions have had to be made given the uncertainties and should not be seen as official forecasts or policy intentions.

Counterfactual and Scenarios

Counterfactual and Scenarios

Counterfactual

All of the impacts estimated in this assessment use the amended RTFO as a counterfactual. The government has consulted on a slowdown to the original RTFO, such that fuel operators will be obligated to supply 5% biofuels by volume (around 4.3% by energy) in 2013-14. The pathway to this target has been adjusted to take account of both the slowdown in the amended order and the impact of the legal discrepancy drafted into the original order. Once the RTFO 5% obligation has been met in 2013-14, it is assumed to remain constant to 2020 and beyond.

Scenarios

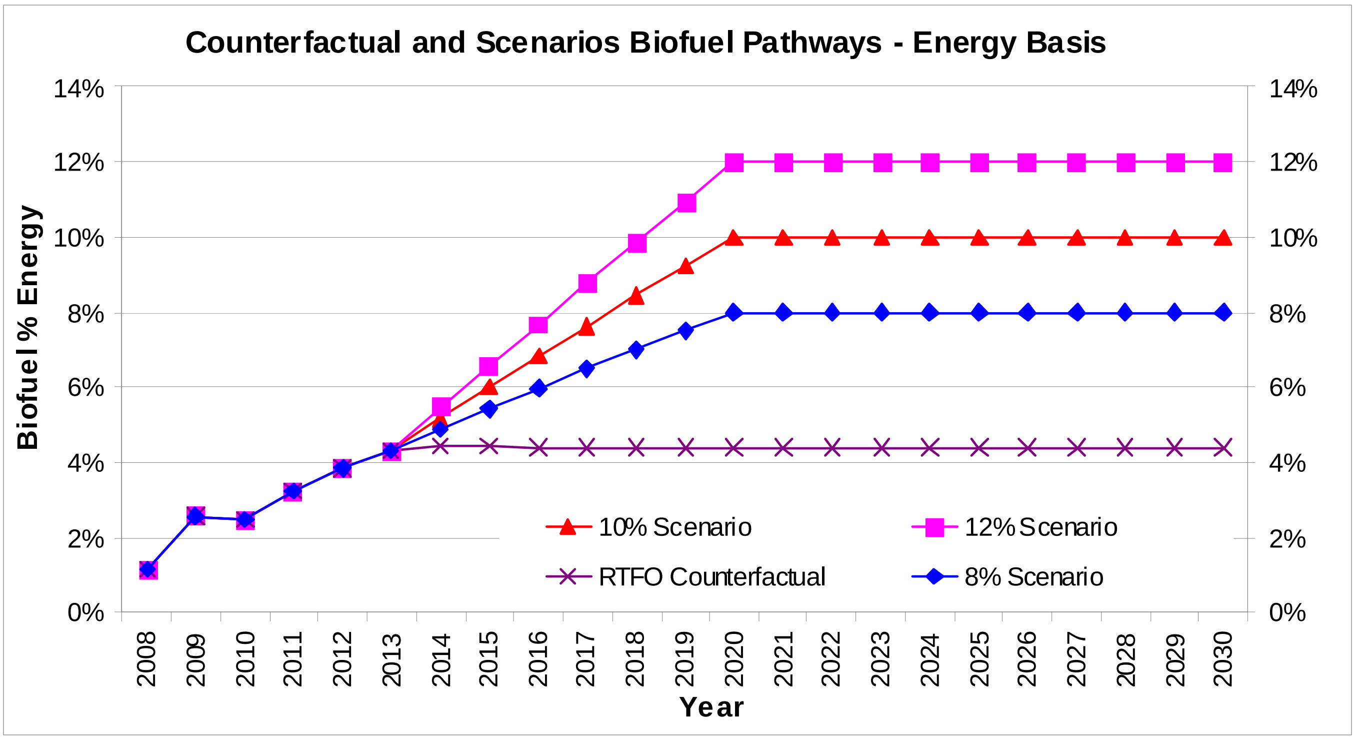
The scenarios were established by considering about how much biofuel might be deployed as a consequence of the RED target and FQD obligation. Up until 2013 the biofuel blend is assumed to be the same as in the counterfactual, and then a linear path to the scenarios 2020 assumed blend is used. The 2020 blend level is then held constant to 2030. As described above, three potential biofuel deployment scenarios, 8%, 10% and 12% have been considered.

On the aforementioned methodology, these narrative scenarios for the counterfactual and scenarios translate into the following uptake rates, measured in terms of market penetration by energy.

Table 4: Overall Biofuel % market penetration by energy

	Counterfactual RTFO	**Scenario 1 8% biofuel in 2020**	**Scenario 2 10% biofuel in 2020**	**Scenario 3 12% biofuel in 2020**
2008	1.1%	1.1%	1.1%	1.1%
2009	2.5%	2.5%	2.5%	2.5%
2010	2.4%	2.4%	2.4%	2.4%
2011	3.1%	3.1%	3.1%	3.1%
2012	3.7%	3.7%	3.7%	3.7%
2013	4.2%	4.2%	4.2%	4.2%
2014	4.3%	4.8%	5.0%	5.3%
2015	4.3%	5.3%	5.9%	6.5%
2016	4.3%	5.9%	6.7%	7.6%
2017	4.3%	6.4%	7.6%	8.7%
2018	4.3%	7.0%	8.4%	9.8%
2019	4.3%	7.5%	9.2%	10.9%
2020	4.3%	**8.0%**	**10.0%**	**12.0%**
2021-30	4.3%	8.0%	10.0%	12.0%

Chart 1: Biofuel deployment counterfactual and assessed scenarios



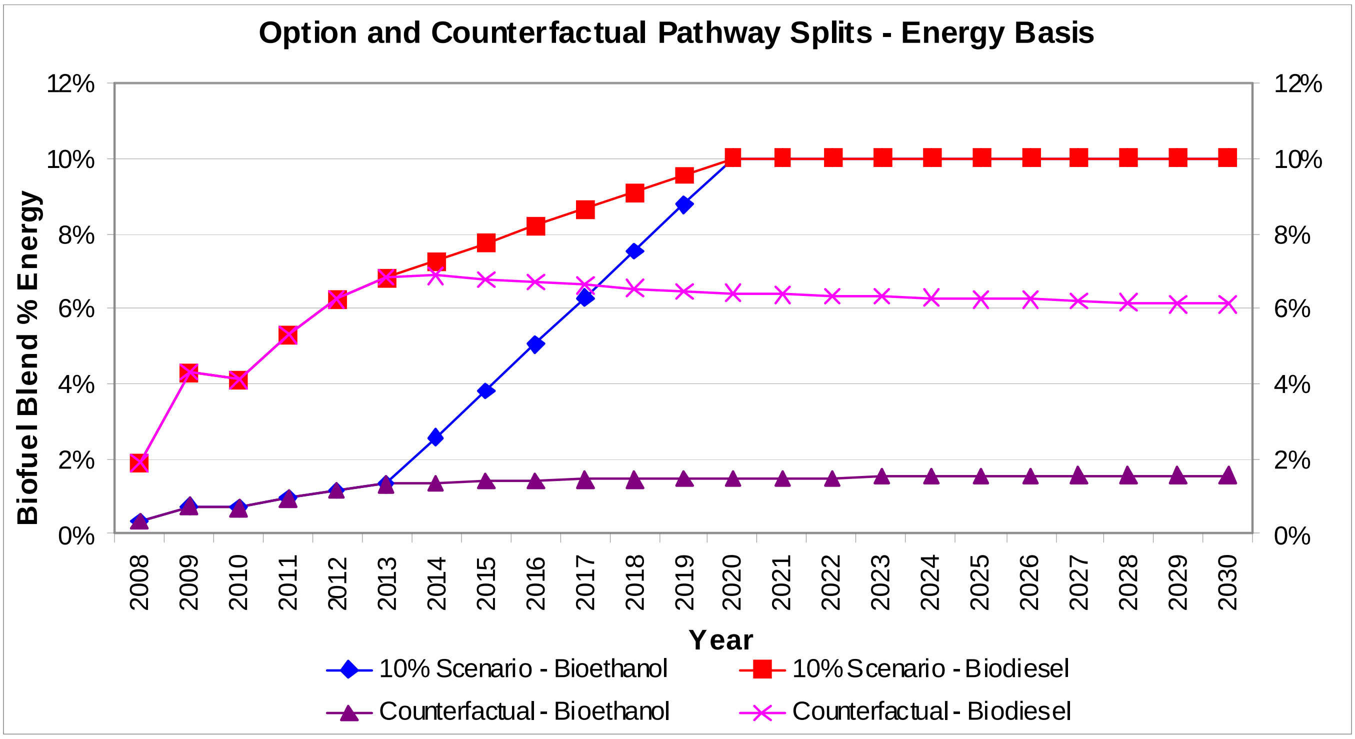
Deployment of bioethanol and biodiesel

So far in the only completed RTFO obligation year (2008-09) consumption of biodiesel has contributed to meeting 84% of the obligation with bioethanol meeting the other 16%. One of the main reasons for biodiesel meeting the majority of the obligation is that it is cheaper and easier to handle and distribute in a blend with fossil fuel compared with bioethanol. In the future we expect this to continue, even when the obligation reaches 5%, as the new blending limits within the Fuel Quality Directive will allow a 7% biodiesel blend. This will allow the use of biodiesel to continue to be consumed more and this analysis has assumed that biodiesel will contribute towards 80% of the biofuel obligation. The counterfactual assumes that the biodiesel blend contributes towards 80% the obligation through to 2030.

There is uncertainty around the consumption split between bioethanol and biodiesel come 2020. Biodiesel has higher energy content than bioethanol on a per litre basis, but is also forecasted to be more expensive than bioethanol and FAME (Fatty Acid Methyl Esters – the most common biodiesel) will currently only be able to be blended up to 7% by volume. Bioethanol will need extra infrastructure investment to be deployed on a wider scale and has a lower energy content. However, bioethanol is expected to be cheaper than biodiesel and most ethanol sources attain higher GHG savings which will be helpful to suppliers having to meet the GHG reduction obligation in the FQD. There are also great uncertainties on the technical constraints of both fuels to be blended to a high enough degree to meet the 10% RED target and 6% FQD obligation. Thus given this uncertainty, each of the deployment scenarios assumes that by 2020 the obligation will be met evenly with bioethanol and biodiesel on an energy basis. For example, under the central biofuel scenario that stipulates an overall consumption of 10% biofuel by energy in 2020, both the bioethanol and the biodiesel blend will be 10% by energy.

For each of the scenarios we assume that there is a linear increase in the use of bioethanol and biodiesel. The picture that appears when considering the splits, then, is one in which the deployment scenario proportion of ethanol in the petrol blend rises at a faster rate, catching up to the scenario proportion of biodiesel in the diesel blend by 2020. The baseline amounts of ethanol and biodiesel change slightly from the RTFO obligation year of 2013-14 due trends in fossil fuel consumption driven by the dieselisation of the fleet.

Chart 2: Bioethanol and Biodiesel blend by energy in counterfactual and 10% Biofuel



Uptake of advanced and waste/residue biofuels

Advanced and waste/residue biofuels may contribute to the total obligated biofuel target, and uptake encouraged by the double credit included in the RED. There exists a considerable amount of uncertainty surrounding the uptake. The RED (article 21) defines the biofuels which qualify to be counted twice as 'biofuels produced from wastes, residues, non-food cellulosic material, and lingo-cellulosic material'. This is interpreted as including] biomass-to-liquid technologies such as cellulosic ethanol and biodiesel from Fischer-Tropsch gasification. There are large unknowns relating to the speed at which such advanced biofuels will develop from prototype technologies to be commercially viable in terms of production on an industrial scale at a price that is competitive with 'first generation' biofuels and/or fossil fuels. Despite this uncertainty, projections including those by the EU commission suggest that advanced and waste/residue biofuel deployment will be at least the 2% needed so that 8% biofuel by energy will meet the 10% RED transport target in 2020 .

Monetised Costs

<u>Additional fuel resource cost of biofuels</u>

To analyse the potential additional fuel resource costs of biofuels, the analysis considered: the additional pre-tax cost of biofuels compared to fossil fuels, the extra fuel consumed due to the energy penalty of biofuels and the reduced mileage driven due to the higher fuel costs. Sensitivities were carried out on two key inputs inputs into fossil and biofuels:

- *Price of Oil* – Oil is an input into the production of both petrol/diesel and biofuel. Each oil price scenario was used to separately analyse the impact on the resource cost impact of fossil fuel (using the DfT forecasting model) and biofuel (using the FAO-OECD Aglink model – see below). The latest DECC Fossil Fuel Price assumptions were used to analyse this.

- *Agricultural yield growth* – for some feedstocks and production techniques, biofuel is still an infant technology. There is uncertainty in both future agricultural feedstock prices and how the costs of producing biofuel may change over time. To try and capture some of this uncertainty, a sensitivity on the agricultural yield growth of biofuel feedstocks was included in the analysis. For most scenarios the trend yield growth was used, but a trend

+/- 50% was also analysed to produce an upper and lower range on the additional biofuel resource cost.

The scenarios analysed are set out in table 5 below:

Table 5: Guide to Interpretation of the oil price and agricultural yield scenarios used to analyse the additional resource cost of biofuel

Additional Resource cost scenario	Oil Price (£2008)	Agricultural yield growth	Cost Scenario of Biofuel
Maximum	Scenario 1 - \$60 in 2020	Trend - 50%	High Cost
Intermediate	Scenario 1 - \$60 in 2020	Trend	-
	Scenario 2 - \$80 in 2020	Trend	Central Cost
	Scenario 3 - \$120 in 2020	Trend	-
	Scenario 4 - \$150 in 2020	Trend	-
Minimum	Scenario 4 - \$150 in 2020	Trend + 50%	Low Cost

The cost of the scenario is the highest where the difference between the resource cost of fossil fuel and of biofuel is greatest. The maximum resource cost difference occurs under the lowest oil price (Scenario 1 - \$60) where fossil fuels resource cost is at its lowest and with a reduced agricultural yield (Trend – 50%) and thus where biofuel resource costs are their highest. By setting a pessimistic assumption on agricultural yield growth with the lowest oil price, the gap between fossil fuel and biofuel was maximised. This is labelled as the High Cost end of the range of resource costs and is used in the cost-benefit summary sheets at the front and in tables 1-3.

A central resource cost difference was required to produce a central set of costs and benefits for the Impact Assessment. For the central estimate we used oil price Scenario 2 - \$80 and trend agricultural yield growth. This is labelled as the Central Cost of resource costs and is used in the cost-benefit summary sheets at the front and in tables 1-3.

At the other end of the spectrum, combining an optimistic assumption on agricultural yield (Trend + 50%) with the highest oil price (Scenario 4 - \$150) minimised the additional resource cost of biofuel. This is labelled as the High Cost end of the range of resource costs and is used in the cost-benefit summary sheets at the front and in tables 1-3. While this is not an exhaustive analysis of possible sensitivities or the maximum possible range in the additional resource of biofuels, this gives a clear example of the potential.

<u>Fossil fuel resource costs</u>

DECC have published the latest government Fossil Fuel Price assumptions in May 2009, see link below. The oil price assumptions to 2030 have been converted into petrol and diesel prices using DfT's fuel price forecasting model. The pre-tax petrol and diesel price forecasts under each oil price scenario are given in table 7 and 8 on pages 20 below.

http://www.berr.gov.uk/files/file51365.pdf

<u>Biofuel resource costs</u>

The biofuel prices that are assumed in the analysis are derived from outputs produced by the OECD-FAO Aglink-Cosimo model.

The OECD-FAO Aglink-Cosimo model is a partial equilibrium agricultural commodities model that has a biofuels module attached to it. The biofuels component of the model is focused on four major economic centres: the EU27 group, the USA, Canada, and Brazil. Other important economic areas also enter the modelling, however, including Indonesia, Thailand, Argentina, and China. This gives good coverage of biofuel production: these areas accounted for 95% of world ethanol production and 82% of world biodiesel production in 2007. The model operates by taking a bottom up approach to estimating ethanol and biodiesel prices. Net cost production functions take into account feedstock prices, production costs, revenues from by-products and capital costs. These net cost functions interact with demand functions that are defined by mandates and the price of fossil fuel substitutes. This market clearing price mechanism operates in terms of a global market, taking into account prevailing restrictions on international trade.

The OECD-FAO Aglink-Cosimo model was used to generate ethanol and biodiesel price outputs under different EU27 biofuel mandates against a baseline level of demand from other key economic regions. Each run of the model generated one mandate/price output scenario that was interpreted as an individual point on a EU27 consumption supply curve. This process was repeated over a variety of oil price and agricultural yield scenarios in order to give a range of possible biofuel costs and prices. These supply curves were then be used to estimate the price of ethanol and biodiesel assuming that the UK is a price taker in the EU27 market. The steps involved in this methodology are set out more fully below.

OECD-FAO Aglink-Cosimo baseline.

The OECD-FAO Aglink-Cosimo baseline that was used for the preparation of the 2008 OECD outlook paper was taken as the starting point, but it was necessary to make a few adjustments to the assumptions to create a suitable baseline for this analysis. The most important update was issued to include up to date assumptions on mandates in the major economic centres. The US demand side included the Energy Independence and Security Act (EISA). The Brazilian mandate on biodiesel was included, and the Brazilian tax incentives that stimulate the production of ethanol were kept in line with OECD estimates. The much smaller Canadian targets of a 5% ethanol blend and a 2% biodiesel blend by 2010 are also built into the baseline. Exchange rates used are in accordance with those assumed for DECC fossil fuel price projections.

Using the supply curves.

Having established a functional relationship between EU demand and price for ethanol and biodiesel, an assumption was made as to the uptake pathways for EU biofuel demand. The assumed rate of uptake for ethanol and biodiesel was taken from an 2007 EU Commission report on “The impact of a minimum 10% obligation for biofuel use in the EU27 in 2020 on agricultural markets.” This gives a projection of the use of ethanol and biodiesel in million tonnes of oil equivalent. The expected use was used as a basis on which to split the consumption of ethanol and biodiesel when using the supply curves. This split is then applied to trajectories for three scenarios of 8%, 10%, and 12%. The trajectories used are given in the table 6 below.

Table 6: EU27 Biofuel uptake given three 2020 scenarios

Year	Projected uptake 8% in 2020	Projected uptake 10% in 2020	Projected uptake 12% in 2020
2008	2.40%	3.00%	3.60%
2009	2.88%	3.60%	4.32%
2010	2.96%	3.70%	4.44%
2011	3.04%	3.80%	4.56%
2012	3.60%	4.50%	5.40%
2013	4.08%	5.10%	6.12%
2014	4.56%	5.70%	6.84%
2015	5.04%	6.30%	7.56%
2016	5.52%	6.90%	8.28%
2017	6.00%	7.50%	9.00%
2018	6.56%	8.20%	9.84%
2019	7.04%	8.80%	10.56%
2020	8.00%	10.00%	12.00%

This produces three sets of prices for both ethanol and biodiesel on a pence per litre basis that were fed into the cost benefit analysis under the UK uptake assumptions that were outlined previously in the section on counterfactuals. This assumes that the UK is a price taker, where the obligation level in the UK has no influence on the price of ethanol or biodiesel that is found in the EU.

The output prices of ethanol and biodiesel from the OECD-FAO Aglink-Cosimo model under different assumptions about oil price and agricultural yield are shown in the tables 7 and 8 below. These are prices on a litre volume basis, to assess the actual cost of the fuel one will also need to factor in the relative energy contents of the fuels.

Table 7: Petrol and Bioethanol prices, pence per litre basis in 2008 prices, assuming the EU reaches 10% biofuel by energy in 2020

Oil Price	Scenario 1			Scenario 2		Scenario 3		Scenario 4		
Fuel	BioEthanol		Petrol	BioEthanol	Petrol	BioEthanol	Petrol	BioEthanol		Petrol
Agricultural Yield growth	Trend - 50%	Trend		Trend		Trend		Trend	Trend +50%	
2010	42.25	41.35	25.72	46.47	33.64	50.07	39.19	54.83	53.38	46.71
2011	42.13	40.59	25.73	43.10	34.05	46.02	40.39	50.87	48.79	49.89
2012	42.45	40.86	26.54	45.55	34.46	49.91	41.98	56.23	53.49	53.07
2013	44.60	42.62	27.34	47.46	34.87	52.73	43.58	59.58	56.00	55.86
2014	46.76	44.27	28.14	48.24	35.27	53.73	44.78	61.48	57.08	59.04
2015	48.19	44.70	28.95	48.07	35.68	53.94	46.38	62.12	56.85	62.22
2016	47.87	43.29	29.75	46.30	36.09	51.84	47.58	59.31	54.18	65.40
2017	47.30	42.15	29.76	44.94	36.50	50.08	49.17	56.15	51.45	65.41
2018	47.62	41.41	29.77	43.84	36.90	49.03	50.77	55.06	50.08	65.42
2019	47.60	40.46	29.78	42.68	37.31	47.75	51.97	53.27	48.27	65.44
2020	48.39	40.36	29.80	41.94	37.72	46.91	53.56	51.81	46.57	65.45

Table 8: Diesel and BioDiesel prices, pence per litre basis in 2008 prices, assuming the EU reaches 10% biofuel by energy in 2020

Oil Price	Scenario 1			Scenario 2		Scenario 3		Scenario 4		
Fuel	BioDiesel		Diesel	BioDiesel	Diesel	BioDiesel	Diesel	BioDiesel		Diesel
Agricultural Yield growth	Trend - 50%	Trend		Trend		Trend		Trend	Trend +50%	
2010	64.96	63.23	27.76	67.06	36.75	69.40	43.04	73.31	71.66	51.58
2011	63.07	60.88	27.76	65.50	37.20	68.72	44.39	74.07	72.06	55.18
2012	65.29	62.62	28.66	66.60	37.65	70.24	46.19	76.32	74.04	58.77
2013	67.21	64.15	29.56	67.67	38.10	71.75	47.99	78.47	75.80	61.92
2014	66.84	63.44	30.46	67.06	38.55	71.83	49.34	80.00	77.05	65.51
2015	67.09	63.30	31.36	67.03	39.00	72.67	51.13	82.65	79.44	69.11
2016	67.43	63.22	32.26	66.91	39.45	73.24	52.48	84.71	81.24	72.70
2017	67.16	62.56	32.26	66.26	39.90	73.24	54.28	84.01	80.05	72.70
2018	68.07	63.03	32.26	66.84	40.35	74.62	56.08	86.95	82.62	72.70
2019	68.13	62.72	32.26	66.58	40.80	75.09	57.42	88.32	83.72	72.70
2020	70.07	64.10	32.26	68.11	41.25	77.39	59.22	91.33	85.97	72.70

Energy Penalty of biofuels

A lower energy content has been factored in for all biofuel blends. This increases the total amount of fuel needed to travel the same amount of miles, and reduces the overall GHG emission savings achieved. Bioethanol has around 2/3 of the energy of petrol and biodiesel 9/10 of the energy of diesel. Table 9 below illustrates the energy content of the different fuels:

Table 9: Energy content of fossil and biofuels (MJ/l)

	Energy content (mega-joules/ litre)	**% of fossil fuel**
Petrol	33	
Bioethanol	21	64.8%
Diesel	37	
Biodiesel	33	90.5%

Welfare loss due to reduced driving

In those scenarios where fuel costs increase due to blending biofuels into petrol and diesel, overall driving costs increase. An increase in the cost of driving will cause motorists to reduce the amount of mileage travelled. This has been estimated using a price elasticity of the demand for petrol and diesel. A price elasticity of -0.25, falling to -0.15 by 2025, has been used in the analysis to take account of motorists responding to a fuel price increase. This is a cost to society as motorists are losing the benefit they received from the reduced mileage travelled.

Infrastructure Costs

Information from industry has implied that there will have to be some further infrastructure investment to be able to blend and distribute bioethanol biofuels when their deployment becomes necessary. This is expected to be around £250m.

Other Assumptions

- Obligated fuel suppliers are likely to pass costs on to their customers in the UK and thus 100% cost pass-through has been assumed.
- As the UK will be legally obligated to meet a certain renewable energy target it has been assumed in this analysis that the present RTFO buy-out option will not apply post 2010.
- A discount rate of 3.5% is assumed for every year to present estimates in net present terms. This is consistent with all government analysis.

Non-monetised Costs

Fuel Poverty

As illustrated in tables 1 to 3 above, fuel costs are likely to increase in most scenarios as a result of deploying biofuel. To the extent that this affects non-transport fuels then it is possible that this could increase fuel poverty to some sectors of society. This potential social cost has not been assessed.

Biodiversity and Land use change

There could potentially be biodiversity loss and GHG emissions from land use change with the expansion of biofuel crop growth. There are great uncertainties in this area of analysis of biofuels. This potential social cost has not been assessed.

Food Prices

There could potentially be impacts on food prices with the expansion of biofuel crop growth. There are great uncertainties in this market and the magnitude that biofuels could have on food prices. This has not been assessed.

Monetised Benefits

Reduced Greenhouse Gas emissions

The benefits of renewable fuels are primarily their carbon savings compared with the use of conventional fossil fuel (petrol and diesel) – see Annex A.

The GHG emission savings from the use of renewable fuels are usually quantified as net life cycle emissions. This is an estimate of the GHG emissions from the production and combustion of the renewable fuel versus the production and combustion emissions of conventional fossil fuels. The EU sustainability criteria require that biofuels offer at least a 35% life cycle GHG saving compared to fossil fuel in order to be counted towards the RED renewable energy targets and national obligation or support schemes. This will rise to 50% in 2017.

Currently according to information from the RTFO reporting as published by the Renewable Fuels Agency, UK consumed biofuel achieves an average 47% GHG saving compared to fossil fuel. Many biofuels achieve greater savings than this, including Brazilian Sugarcane which generally achieves over 70% GHG savings. Thus it is more than likely that given the current GHG saving methodology, many of the biofuels consumed in the UK will achieve GHG savings above the minimum EU threshold. However, as presented in the Gallagher Review last year there is currently a concern that biofuels may cause indirect land use change. Given the potential for greater than minimum GHG savings, but also the uncertainty around the potential future impact of indirect land use change - this analysis for simplicity has assumed that the average GHG saving will be the minimum EU threshold of 35% and then 50%. These have been used for the biofuel scenarios 10% and 12%. For the 8% scenario a 35% and then 65% GHG saving assumption has been used as this is the minimum GHG saving needed to meet the FQD 6% GHG obligation in 2020.

Both biofuels and fossil fuels are traded internationally, however, meaning that it is important to specify exactly where these emissions savings are occurring in order to attribute benefits and costs associated with changes in GHG emissions correctly.

In the case of the UK, it is also important to distinguish between emissions impacts that occur in traded and non-traded sectors of the economy. The traded sector includes industry, while the non-traded sector includes both transport and agriculture.

Calculating disaggregated GHG emissions impacts along these lines requires a complex methodology which is set out below.

<u>How are the emissions from fossil fuels and biofuels estimated?</u>

Fossil fuels have two points of emissions. The first point of emissions is from the extraction and refining of the fuel (Well-to-Tank), while the second is from the actual combustion of the fuel in the end vehicle (Tank-to-Wheel). The extraction and refining are estimated to constitute 15% of the fuels total lifecycle emissions (Well-to-Wheel).

Biofuels similarly have two points of emissions. Under IPCC inventory guidance, however, biofuels are not counted as emitting GHGs at the point of combustion (Tank-to-Wheel). This is because any GHG's emitted during combustion would have been sequestered from the atmosphere when the biofuel crop feedstock was cultivated. However, the agricultural and industrial processes that are involved in producing and refining the biofuel feedstock are likely to lead to increases in GHG emissions (Field-to-Tank). This means that the net saving attributed to biofuels over the life cycle (Field-to-Wheel) are dependant solely on the Field-to-Tank agricultural and industrial processes.

Since fossil fuel and biofuel emissions occur at different points, and since both fossil fuel and biofuel is internationally traded, it is important to assess how we attribute emissions savings from UK biofuel consumption.

Estimating the emission savings of biofuels on the UK non-traded sector.

It is assumed that all biofuel supplied in the UK is combusted in the UK. Thus since biofuels are assumed to emit zero emissions upon combustion, there is a GHG emission saving from displacing fossil fuel with biofuel. These emission savings accrue to the UK in the non-traded sector.

In addition to this the GHG impacts of biofuel consumption that use biofuel originated in the UK needs to be taken into account. Emissions increases that occur in the agricultural sector relating to biofuel feedstock production for UK consumption also need to be included. These emissions also accrue in the UK non-traded sector.

<u>UK Non-Traded GHG emission savings from Biofuel</u> =

+ Emissions saved from non-combustion of displaced fossil fuel
– Emissions from the UK agricultural production of domestically consumed biofuel

Estimating the emission savings of biofuels on the UK traded sector.

There will also be an impact on emissions in the UK traded sector. While emissions in the traded sector are already subject to “cap and trade” restrictions of the EU ETS it is important to consider how biofuels impact on meeting the cap.

Emissions savings from UK industrial processes relating to displaced fossil fuel are offset by emissions from UK industrial processes relating to the production of biofuel to give a net impact emissions impact attributable to the UK traded sector.

Estimating the impacts of biofuels on Global GHG emissions:

Since fossil fuels and biofuels are internationally traded commodities, UK biofuels policy will inevitably generate emissions impacts on the EU and the Rest of the World.

The vast majority (over 90%) of current UK domestic biofuel consumption comes from imports. Specifically the largest imports come from Brazil, USA and Germany. In the scenarios analysed in this impact assessment, imports are assumed to still constitute around 2/3 of UK biofuel consumption emissions. Thus the UK consumption of biofuel will cause emissions to increase in other countries in the EU and the rest of the world from increased emissions from agricultural and industrial processes that are involved in the production of biofuels.

Fossil fuel imports from the EU and the Rest of the World that are displaced by the UK consumption of biofuels also need to be accounted for. Any Well-to-Tank emissions that relate to the production of fossil fuels that would have been consumed in the UK, but have been displaced by biofuel consumption are attributed to the EU and Rest of the World.

The net emissions impact of the UK consumption of biofuels upon World can therefore be calculated according to the following formula

Net Global GHG emission savings from UK consumed Biofuel =

+ Emissions saved from combustion displaced fossil fuel
+ Global industrial emissions saved from production of displaced Fossil Fuel
- Global agricultural emissions from production of UK consumed biofuels
- Global industrial emissions from production of UK consumed biofuels

Monetising disaggregated emissions estimates

UK emissions impacts that occur in the non-traded sector (‘Tank-to-Wheel emissions saved from displaced fossil fuel’ and ‘Field to Tank emissions from UK agriculture’) are valued using the new Shadow Price of Carbon (SPC).

UK emissions impacts that occur in the traded sector (‘Well to Tank emissions saved from displaced fossil fuel that originated from UK industry’) are valued using the new EU ETS traded price of Carbon.

Changes in GHG emissions that occurred outside of the UK and EU are valued using the marginal damage cost based SPC.

(For monetised GHG emissions and associated Net Present Value of the scenarios as set out in the RES Overarching Impact Assessment see Annex B)

Calculating the cost effectiveness of biofuel deployment

It is necessary to measure the efficiency with which biofuel deployment is effective in abating GHG emissions. Our understanding of efficiency is based around the metric of cost effectiveness. This is calculated by subtracting the value of UK emissions savings that occur in the non-traded sector from the NPV inclusive of ancillary benefits, and then dividing this sum by the cumulative GHG saving that is attributable to the UK non-traded sector.

Cost-effectiveness of biofuel deployment in the non-traded sector = [NPV including ancillary benefits – (UK non-traded sector emissions impact X SPC)] / 2008-2030 UK non-traded sector emission savings

Ancillary impacts – Congestion, Air Quality, Accidents, Noise and Infrastructure

There are likely to be benefits in improved congestion, air quality, reduced accidents, reduced noise and reduced transport infrastructure costs from the increase in biofuel use. These benefits are expected due to the increase fuel costs from the use of biofuels, which reduce demand for fuel and thus travel. This reduced travel generates the benefits. To monetise these benefits the reduced kilometres travelled have been multiplied by the damage costs of these externalities as published in DfT’s transport analysis guidance (www.webtag.org.uk) or National Transport Model outputs.

There is additional complexity in the impact on air quality with the use of biodiesel. Current research suggests that biodiesel increases the amount of nitrogen oxides (NO_x) emissions compared to diesel, but results in a decrease in particulate matter (PM) emissions. Each of these impacts have also been estimated for each of the scenarios using empirical relationships developed by the US Environmental Protection Agency. Using Defra’s air quality damage costs it was found that the benefit in the reduction of PM emissions more than offset the cost of the increase in NO_x emissions.

Non-monetised Benefits

Improved fuel security

Wider use of biofuels will result in a rise in the number of countries from which the UK sources energy for transport. Increasing the proportion of biofuels in retail fuels also decreases the amount of petroleum product or crude oil imports needed to satisfy domestic demand, though biofuels will still only constitute one tenth of total road fuel consumption. Overall we assess that biofuels could to a certain extent positively impact the UK's security of supply.

Potential opportunities for UK agriculture and Biofuel Refining

Based on the scenarios described above, the UK may require between 5bn-7.5bn litres of biofuel in 2020. This may be supplied domestically, imported or, most likely, a combination of the two. It has been estimated that during this period over £3bn will be invested in biofuel production within the UK. This is estimated to create or secure 2600 agricultural jobs and over 800 industrial jobs.

Innovation

The policy is likely to have a positive impact on innovation as new and cheaper ways of producing biofuels and improving carbon savings are developed.

Distributional Analysis

The distributional analysis presented in the tables above attempt to estimate the impacts that the scenarios will have on consumers, firms and the government.

Consumers

This includes the impact of:

- Change in the cost of road fuel (including fuel duty and VAT),
- Change in consumer surplus from changes in fuel costs,
- Change in GHG emissions,
- Change in air quality, noise and accident levels.

Firms

This includes the impact of:

- Change in the cost of road fuel (including fuel duty but not VAT),
- Change in firms' consumer surplus from changes in fuel costs,
- Change in accident levels.

Government

This includes the impact of:

- Change in tax revenues,
- Change in fuel costs for the rail sector. It is assumed that in the immediate future that any extra rail fuels costs are paid for through greater subsidies to the rail sector,
- Change to road infrastructure costs and accident levels.

Specific Impact Tests: Checklist

Use the table below to demonstrate how broadly you have considered the potential impacts of your deployment scenarios.

Ensure that the results of any tests that impact on the cost-benefit analysis are contained within the main evidence base; other results may be annexed.

Type of testing undertaken	***Results in Evidence Base?***	***Results annexed?***
Competition Assessment	Yes/No	Yes/No
Small Firms Impact Test	Yes/No	Yes/No
Legal Aid	Yes/No	Yes/No
Sustainable Development	Yes/No	Yes/No
Carbon Assessment	Yes/No	Yes/No
Other Environment	Yes/No	Yes/No
Health Impact Assessment	Yes/No	Yes/No
Race Equality	Yes/No	Yes/No
Disability Equality	Yes/No	Yes/No
Gender Equality	Yes/No	Yes/No
Human Rights	Yes/No	Yes/No
Rural Proofing	Yes/No	Yes/No

Annexes

Annex A – Introduction to Biofuels
Annex B – Cost-Benefit Analysis previous carbon prices
Annex C – Competition Assessment
Annex D – Small Firms Impact Test
Annex E – Sustainable Development
Annex F – Race Equality
Annex G – Disability Equality
Annex H – Gender Equality
Annex I – Rural Proofing

Annex A – Introduction to Biofuels

Technology background

Biodiesel, bioethanol and biogas (referred to in the draft Order as "natural road fuel gas…,produced wholly from biomass") are the only biofuels currently available to the UK road transport fuel market.

Biodiesel can be made from any vegetable oil, with rape seed, palm and used cooking oil being the most common. Although chemically different, it has similar properties to mineral diesel when burnt in a compression diesel engine. However, it can damage parts of an engine and consequently engine manufacturers only warrant their vehicles for use with 5% blends.

Bioethanol can be made from wheat, corn or sugar cane / beet. As with potable alcohol, it can be made from virtually any organic substance (grass, wood, green bits of municipal solid waste), but the technologies for doing so are not proven at a commercial scale. In Europe it is used in a 5% blend in petrol (E5), allowing its use without any engine modification. At low blending levels of 5% or less, it is not anticipated that mechanical considerations are a significant obstacle to ethanol up-take. There are significant distribution issues for bioethanol which mean that it is usually blended with petrol as they are loaded into road tankers for distribution to forecourts.

Biogas is just like compressed natural gas (CNG), except that it is generally produced by collecting the methane which is naturally emitted from landfill sites or other forms of rotting vegetation. It is only suitable for use in CNG-powered vehicles (of which there are only 800 or so in the UK).

Virtually all biofuels offer some emission savings, because the GHG that is emitted into the atmosphere when they are burned is offset by the GHG that the crop has absorbed as it grows. In this sense they are different from fossil fuels, which emit into the atmosphere GHG which has been safely locked away under the earth's surface for millions of years. The GHG savings from biofuels are, however, offset by the energy that is needed for cultivation, harvesting, processing and transportation. The best biofuels are those which are produced using the least energy (eg low inputs of fertiliser, processed in an energy-efficient way and transported short distances). The worst biofuels can theoretically result in greater lifecycle GHG emissions than fossil fuels (ie more energy is needed to produce them than is saved by using them).

Biofuel price driving factors:

<u>Biofuel Market</u> – this can be separated between the supply and demand of biofuels.

Demand and the willingness-to-pay for biofuels will be dependant on (i) government mandates for biofuels due to energy security and GHG savings and (ii) demand from private fuel suppliers which will be dependant on the price differential between fossil fuels and biofuels. The lower the price differential between fossil fuels and biofuels the greater the potential long term demand will be.

Supply and cost of biofuels will be dependant on (i) the amount of investment and realised improvements in the technology and production of biofuels which will be partially dependant on the long term demand for biofuels, (ii) the price of oil which will be an input cost to biofuels and (iii) the cost and supply of the agricultural feedstocks used for biofuels.

<u>Oil market</u> – the long term oil price will impact on (i) the price of fossil fuels and (ii) the cost of biofuels through direct refining and transportation costs and the cost of feedstock production in the agricultural market. The oil market will directly impact on the costs of fossil fuels and

biofuels and thus the price differential. The price of oil itself will in the long term be dependant on the demand for and supply of crude oil and processed fuels.

Agricultural Market – long term agricultural prices for biofuel feedstocks will impact on the cost of biofuels and the price differential. Agricultural prices will in the long term be dependant on the potential demand, supply and costs of producing agricultural feedstocks. Demand will be dependant on population growth, food tastes and demand for feedstocks from non-food industries. Supply will be dependant on available land, yields and the sustainability criteria set for biofuel feedstocks by governments. The costs of production will partially be dependant on the oil price as oil based fuel is an input cost to the production of feedstocks.

Annex B - Cost-Benefit Analysis previous carbon prices

This annex sets out the cost benefit analysis of the three scenarios given previously assumed price/cost of carbon. This is also presented in the RES Overarching Impact Assessment.

10% Scenario

	High Cost	Central Cost	Low Cost
Present Value Costs	-11,816	-7,821	-3,661
- Of which fuel costs	-11,405	-7,481	-3,373
- Of which are infrastructure costs	-256	-256	-256
- Of which welfare loss	-155	-83	-32
Present Value Benefits[2]	6,228	5,198	4,087
- GHG Savings	3,361	3,184	2,973
- Ancillary Benefits	2,867	2,013	1,114
Cost-Benefit Analysis			
- Net Present Value (without ancillary)[1]	-8,455	-4,636	-688
- Net Present Value (with ancillary)	-5,588	-2,623	426
- Cost effectiveness (£/tCO_2) [2]	94	65	32
8% Scenario			
	High Cost	**Central Cost**	**Low Cost**
Present Value Costs	-6,413	-4,093	-1,754
- Of which fuel costs	-6,083	-3,796	-1,481
- Of which are infrastructure costs	-256	-256	-256
- Of which welfare loss	-73	-41	-16
Present Value Benefits[2]	4,129	3,525	2,876
- GHG Savings	2,441	2,332	2,200
- Ancillary Benefits	1,688	1,193	676
Cost-Benefit Analysis			
- Net Present Value (without ancillary)[1]	-3,971	-1,760	446
- Net Present Value (with ancillary)	-2,283	-568	1,122
- Cost effectiveness (£/tCO_2) [2]	73	46	17
12% Scenario			
	High Cost	**Central Cost**	**Low Cost**
Present Value Costs	-17,996	-12,197	-5,912
- Of which fuel costs	-17,466	-11,795	-5,602
- Of which are infrastructure costs	-256	-256	-256
- Of which welfare loss	-274	-146	-54
Present Value Benefits[2]	8,790	7,294	5,649
- GHG Savings	4,606	4,356	4,053
- Ancillary Benefits	4,184	2,938	1,597
Cost-Benefit Analysis			
- Net Present Value (without ancillary)[1]	-13,390	-7,841	-1,860
- Net Present Value (with ancillary)	-9,206	-4,903	-263
- Cost effectiveness (£/tCO_2) [2]	104	74	39

Annex C – Competition Assessment

Promotion of biofuels through regulation would result in fossil fuels for road transport being substituted by renewable fuels. It should therefore have a significant impact on the current markets. However, it is not anticipated that the effects would negatively affect the competitiveness of the fossil fuel or emerging biofuel markets.

The UK oil market is highly competitive. Traditionally it has been dominated by the UK's major oil companies, but in recent years the 'independents', have gained market share, particularly in the retail sector. In particular the sector has been affected by the entry into the market of the major supermarkets which has intensified competition. The independents have led on the introduction of biofuels into the UK market, with the supermarkets in particular increasing the availability of biofuels at the retail end of the market.

The biofuel market in the UK is very new and makes up a small proportion of overall fuel sales. The majority of biofuel sales are currently from imports, brought in by the independents, but there is also growing UK capacity, particularly for bioethanol.

Measures to promote biofuels further are likely to further develop and mainstream the biofuel market in the UK, and lead to both increased imported biofuels and domestic capacity. As with any new and emerging market, the cottage industry is likely to be replaced in time with large scale industry. This should return benefits from economies of scale and investment capacity for technological developments.

Annex D – Small Firms Impact Test

There are three types of small firms impacted by the RED

- Small firms that retail petrol through one or more forecourts;
- Small renewable fuel producers; and
- Farmers producing crops for fuel (feedstock).

The retailers are impacted by the need for a one-off clean of their tanks and other measures, as described in the costs section.

The renewable fuel producers and the producers of feedstock crops should see an expanded market for their products. Biofuel sales could increase from the current level of approximately 5bn-7.5bn litres a year by 2020. Most of this fuel will be sold to be blended into petrol and diesel by the major oil companies, who will be able to choose how they source their fuels, which may include importing. Nevertheless, this represents a significant opportunity for both farmers and biofuel producers.

Annex E – Sustainable Development

The government is committed to five principles of sustainable development.

- Living within environmental limits
- Achieving a sustainable economy
- Using sound science responsibly
- Promoting good governance
- Ensuring a strong, healthy and just society

Biofuels policy impacts on the first two of these principles and is influenced by the third.

The UK acknowledges that GHG reduction is essential if the UK is to live within environmental limits imposed by the problem of climate change. As a policy targeted at GHG reduction, biofuels contribute to this goal. This impact is quantified in the Evidence base of the impact assessment. Biofuels may also have impacts on other environmental indicators, such as biodiversity. These additional possible environmental impacts are assessed qualitatively in the Evidence base in the impact assessment.

Obligating fuel suppliers to blend biofuels with fossil fuels encourages the growth of a sustainable green economy in the UK. Likely impacts on the green economy have been examined qualitatively in the Evidence base of the impact assessment.

Biofuels policy has been influenced by the responsible use of sound science. The environmental impacts of biofuels have been widely debated in the public sphere, with issues pertaining to, for instance, life cycle emissions, direct / indirect land use change, and biodiversity. The UK government has actively engaged with these issues in an attempt to understand them from a sound scientific basis. The Gallagher Review of the indirect effects of biofuel production is a good example of this. Nevertheless biofuels remain a new and highly uncertain area. More research into developing a sound evidence base in needed to ensure that biofuels policy is developed in a sensible evidence led manner.

Annex F – Race Equality

Availability of evidence

The Department for Transport has not seen any evidence that quantitatively or qualitatively disaggregates fuel consumption patterns by racial group.

Relevance of the policy to the race equality duty

Will the target involve, or have consequences for UK consumers?

Yes. Blending biofuels with fossil fuels will have a price impact at the pump. The cost differential between biofuel and fossil fuel is expected to be passed on to the consumer at the pump.

Could these consequences differ according to people's racial group, for example, because they have particular needs, experiences or priorities?

For these consequences to have a heterogeneous impact on consumers of different racial groups, the amount of fuel consumed and the type of fuel consumed would need to vary between racial groups. If one racial group consumed more fuel than another there would be a disproportionate impact on that particular racial group. As stated above, The Department for Transport is not aware of any evidence that disaggregates fuel consumption between racial groups on a quantitative or qualitative basis.

Is there any reason to believe that people could be affected differently by the target, according to their racial group, for example in terms of access to a service, or the ability to take advantage of proposed opportunities?

See above.

Is there any evidence that any part of the proposed policy could discriminate unlawfully, directly or indirectly, against people from some racial groups?

No

Is there any evidence that people from some racial groups may have different expectations from the policy in question?

No

Annex G – Disability Equality

Availability of evidence

The Department for Transport is unaware of any quantitative or qualitative evidence that gives an assessment of the fuel consumption of disabled people relative to the population as a whole.

Relevance of the policy to the disability equality duty

Will the target involve, or have consequences for UK consumers?

Yes. Blending biofuels with fossil fuels will have a price impact at the pump. The cost differential between biofuel and fossil fuel is expected to be passed on to the consumer at the pump.

Could these consequences differ for disabled people?

For these consequences to have a negative heterogeneous impact on disabled consumers, the amount of fuel consumed and the type of fuel consumed would need to be greater for disabled people relative to the whole population. As stated above, The Department for Transport is not aware of any evidence that disaggregates fuel consumption between groups on a quantitative or qualitative basis.

Is there any reason to believe that people could be affected differently by the proposed policy, according to their racial group, for example in terms of access to a service, or the ability to take advantage of proposed opportunities?

See above.

Is there any evidence that any part of the proposed policy could discriminate unlawfully, directly or indirectly, against people from some racial groups?

No

Is there any evidence that people from some racial groups may have different expectations from the policy in question?

No

Annex H – Gender Equality

Availability of evidence

For these consequences to have a negative heterogeneous impact on consumers from different gender groups, the amount of fuel consumed and the type of fuel consumed would need to be greater for disabled people relative to the whole population. As stated above, The Department for Transport is not aware of any evidence that disaggregates fuel consumption between gender groups on a quantitative or qualitative basis.

Relevance of the policy to the gender equality duty

Will the target involve, or have consequences for UK consumers?

Yes. Blending biofuels with fossil fuels will have a price impact at the pump. The cost differential between biofuel and fossil fuel is expected to be passed on to the consumer at the pump.

Could these consequences differ between genders?

For these consequences to have a negative heterogeneous impact between genders, the amount of fuel consumed and the type of fuel consumed would need to be greater for people of a specific gender relative to the whole population. As stated above, The Department for Transport is not aware of any evidence that disaggregates fuel consumption between gender groups on a quantitative or qualitative basis.

Is there any reason to believe that people could be affected differently by the proposed policy, according to their racial group, for example in terms of access to a service, or the ability to take advantage of proposed opportunities?

See above.

Is there any evidence that any part of the proposed policy could discriminate unlawfully, directly or indirectly, against people from some gender groups?

No

Is there any evidence that people from some gender groups may have different expectations from the policy in question?

No

Annex I – Rural Proofing

Is the target expected to have a different impact on rural areas?

Distributional problems have the potential to be an issue for particularly remote rural areas that are serviced by marine tankers. The chemical properties of hydrocarbon petrol and ethanol are such that they do not bond particularly well at the molecular level, and can easily be encouraged to separate with the addition of water. This is known as Phase separation. It is problematic because standard marine tankers do not keep moisture from coming into contact with the fuel adequately. Thus in remote areas of the country that are supplied primarily by these means, such as the "Highlands and Islands" in Scotland, may not be able to take the same biofuel blend as the rest of the country.

This distributional issue is currently being investigated by the Department for Transport, where the evidence base needed to assess the implications of biofuel blending is currently being gathered.