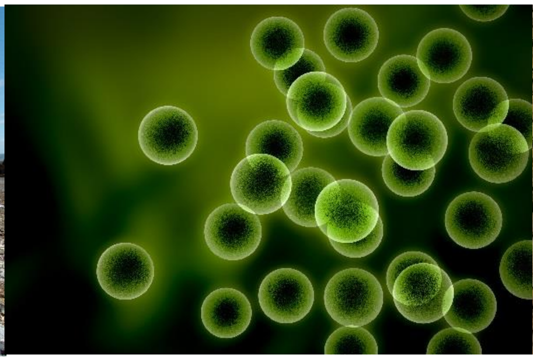
Department for Transport

Advanced fuels: call for evidence


December 2013

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Department for Transport
Great Minster House
33 Horseferry Road
London SW1P 4DR
Telephone 0300 330 3000
Website www.gov.uk/dft
General email enquiries FAX9643@dft.gsi.gov.uk

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Ministerial foreword

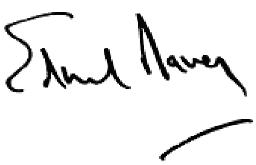
The UK has ambitious plans to move to a clean energy system. Transport must play its part in this. To make this happen we will need to develop sustainable, low-carbon transport fuels. Though first-generation biofuels are an important step in this direction, advanced fuels could offer greater carbon savings without the same concerns around food security and land use change.

Advanced fuel technologies have the potential to reduce our reliance on imported energy, by turning unwanted waste products into valuable transport fuel. This is exciting technology and, with our world class research capabilities, the UK has the potential to become a global player in this high-tech, highly-skilled industry.

In this document we seek evidence on the current state of development of advanced fuels to guide future policy-making. We are particularly interested in evidence which:

- helps to identify those feedstocks and processes which seem to be the most promising;
- shows how advanced fuels can most effectively be deployed across multiple sectors;
- will help us to understand whether the market needs additional support to develop in the way which is needed, and whether the government has a role to play.

We look forward to engaging closely with industry and other interested parties as we develop this policy area further. This document is a key part of that.



Ed Davey
Secretary of State for Energy and Climate

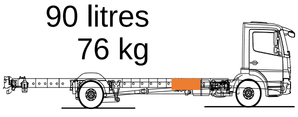
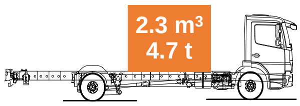
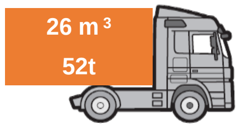
Baroness Kramer
Minister of State for Transport

Executive summary

1. The UK has challenging goals for reducing greenhouse gas emissions. Transport, which accounts for a large share of UK greenhouse gas emissions, must play its part in this transition.

2. Electric vehicles will play a key role in the shift to a low-carbon transport system. For some parts of the transport sector though, such as road freight, aviation and shipping, electrification is highly unlikely to provide a solution. In these sectors, we will need to develop low-carbon fuels that can replicate the dense energy storage currently offered by fossil fuels.

Figure 1: Battery sizes required by HGVs

Range	Diesel	100% electric with Li-Ion battery
500 km 7.5-tonne distribution operations	90 litres 76 kg 	
3000 km 44-tonne long distance operations	990 litres 836 kg 	

Calculation: consumption: 20 l/100 km /33 l/100 km, efficiency: diesel engine = 40%, electric motor = 80%, energy content: diesel = 11.8 kWh/kg,
Li-Ion battery = 0.19 kWh/kg, weight: diesel = 0.845 kg/l, Li-Ion battery = 2 kg/l
(source: Mercedes-Benz)

3. First-generation biofuels are an important step in this direction. In recent years the Renewable Transport Fuel Obligation has delivered significant carbon savings in the UK, even when taking indirect emissions into account, due to the increase in the proportion of biofuels that are now supplied from wastes. However, to date very little biofuel that could be considered 'advanced' has been supplied in the UK. In this document we define advanced fuels as those that are both low-carbon and made using an innovative process.

4. It seems clear that the future of low-carbon fuel lies with advanced fuels, such as processes that can produce transport fuel from bin bag waste. Advanced fuels could offer greater carbon savings without the same concerns around food security and land use change. While the potential of these technologies is clear, they have not yet been widely commercialised.

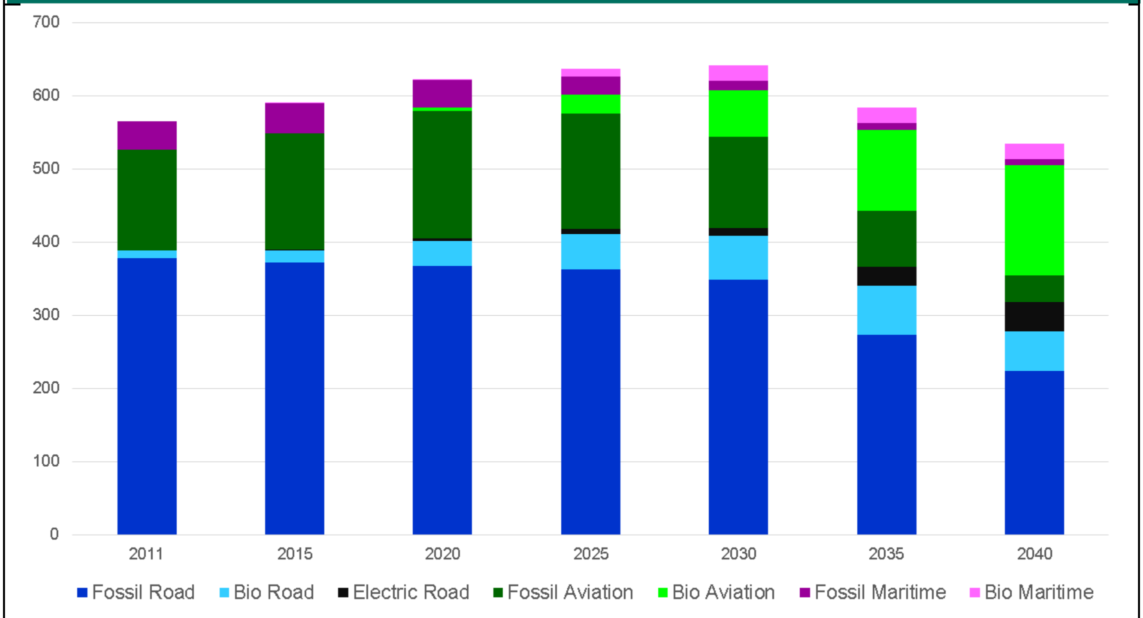
5. In this call for evidence, we are interested in whether further government support will be necessary to bring advanced fuel technologies to market.

Transport sectors

6. We are looking for views on whether support for advanced fuels should be focussed on particular transport sectors. At present, the Renewable Transport Fuel Obligation only offers support for the supply of biofuels in road transport. In future, it seems likely that advanced fuels will need to be used increasingly in sectors which are hard to decarbonise by other means, such as aviation and shipping.

7. We are interested in stakeholder views on whether there is an advantage for offering support in sectors other than road transport. We are also interested in views on what physical or legal barriers there might be to the use of advanced fuels in different transport sectors.

Figure 2: Energy in transport 2011-2040 (TWh by fuel type and mode)



(source: Redpoint modelling for UK Bioenergy Strategy, 2012)

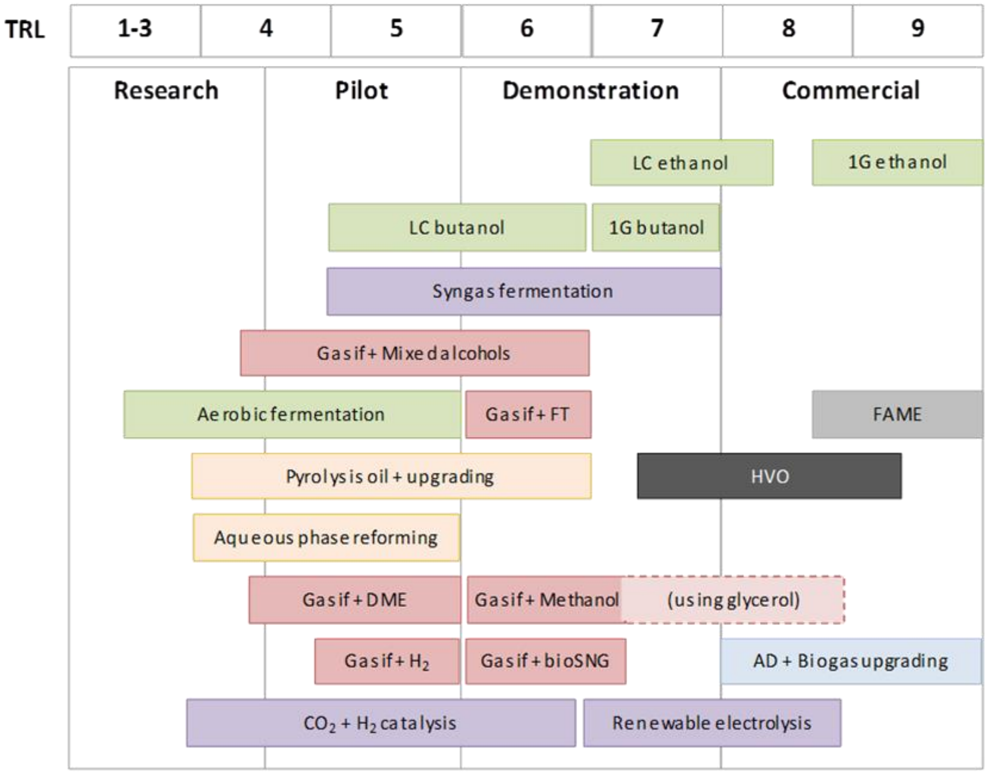
Fuels

8. There are a range of low-carbon technologies that could play a large role in decarbonising transport. In this document, we identify four key technologies:

- Advanced biofuels
- Hydrogen
- Synthetic fuels and fuels from fossil waste
- Biomethane

9. We are interested in the views of stakeholders on the technical potential of each of these fuels, and on what timescales their commercialisation and deployment can reasonably be expected.

Figure 3: Technology Readiness Levels of possible pathways for biofuels



(source: E4Tech,2013, "'Advanced' biofuel feedstocks – An Assessment of Sustainability")

Support mechanisms

10. One of the key aims of the call for evidence is to establish whether additional UK government action will be necessary to develop the advanced fuel technologies we need to decarbonise transport.

11. It seems clear that different kinds of government support could be targeted at different stages of the product development cycle. At early stages of technological development, 'technology push' interventions, such as investment in research and development, are likely to be most helpful. At later stages, 'market pull' approaches, such as supply obligations or subsidies, can be more useful.

12. In this document we consider four broad kinds of 'market pull' mechanisms that might be considered if further support is needed. These are:

- A sub-target
- Fixed-price support
- Multiple certificates within a supply obligation
- A carbon-linked supply obligation

13. We are interested in the views of interested parties as to whether government action is needed and, if so, as to which of these approaches is most likely to spur investment in advanced fuel facilities in the UK.

How to respond

The call for evidence will run from 12 December 2013 to 21 February 2014. Please ensure that your response reaches us before the closing date. Responses to the call for evidence can be submitted either through a response template or an online form. Both can be found at the following link https://www.gov.uk/government/consultations/advanced-fuels-call-for-evidence.

If you would like further copies of this document, it can be found at the web address above. Please contact Tom Barrett (tom.barrett@dft.gsi.gov.uk) if you would like alternative formats (Braille, audio CD, etc).

Please send responses to:

Advanced fuels: call for evidence
Low Carbon Fuels, Zone 31-34
Great Minster House
33 Horseferry Road
London
SW1P 4DR

Phone 020 7944 5817

Fax 020 7944 3533

Advancedfuels.callforevidence@dft.gsi.gov.uk

When responding, please state whether you are responding as an individual or representing the views of an organisation. If responding on behalf of a larger organisation, please make it clear who the organisation represents and, where applicable, how the views of members were assembled.

There will be a general stakeholder event to discuss the call for evidence and advanced fuels on 15 January 2014. If you would be interested in attending this event, please contact Tom Barrett.

Freedom of information

Information provided in response to this call for evidence, including personal information, may be subject to publication or disclosure in accordance with the Freedom of Information Act 2000 (FOIA) or the Environmental Information Regulations 2004.

If you want information that you provide to be treated as confidential, please be aware that, under the FOIA, there is a statutory Code of Practice with which public authorities must comply and which deals, amongst other things, with obligations of confidence.

In view of this it would be helpful if you could explain to us why you regard the information you have provided as confidential. If we receive a request for disclosure of the information, we will take full account of your explanation, but we cannot give an assurance that confidentiality can be maintained in all circumstances. An automatic confidentiality disclaimer generated by your IT system will not, of itself, be regarded as binding on the Department.

The Department will process your personal data in accordance with the Data Protection Act (DPA) and in the majority of circumstances this will mean that your personal data will not be disclosed to third parties.

1. Introduction

1.1 The UK has challenging goals for reducing greenhouse gas emissions. The Climate Change Act commits the UK to reduce greenhouse gas emissions by 80% in 2050 compared to 1990 levels. In the transport sector, 10% of energy demand must be met from renewable sources by 2020[1].

1.2 Doing nothing is not an option. Scientists at the UN's Intergovernmental Panel on Climate Change agree that "warming of the climate system is unequivocal, and … human influence on the climate system is clear"[2].Uncontrolled greenhouse gas emissions would lead to potentially catastrophic climate change.

1.3 One option that could make a big contribution to cutting the UK's carbon emissions is bioenergy. The UK Bioenergy Strategy concluded that energy from biomass can make an important contribution, provided that it is used in the right way and from sustainable sources[3].

1.4 Biofuels are a form of bioenergy used in transport. In the UK we started blending biofuels into petrol and diesel for road transport midway through the last decade. The UK was at the forefront of seeking to ensure the sustainability of the biofuels used. We introduced one of the first voluntary sustainability reporting systems in 2008. Since 2011, mandatory criteria have been in place which biofuels must meet to qualify for government support.

1.5 The UK government was also amongst the first to recognise the increasing concern about the effects of indirect land use change and commissioned research which reported in the 2008 Gallagher Review[4]. Partly as a result of UK pressure, the European Commission agreed to review European biofuels legislation. They have since brought forward proposed amendments to European legislation to address the impacts of indirect land use change, and reduce the competition for land between crop-based biofuels and food crops.

1.6 Now a new generation of advanced low-carbon fuel technologies is beginning to emerge. Advanced fuels from wastes have the potential to deliver significant emissions reductions with far fewer sustainability concerns than first-generation biofuels. They are therefore likely to play an important role in meeting our decarbonisation targets.

1.7 This document is intended to seek evidence on the current state of advanced fuel development. We are looking to understand the

[1] The 2020 RED transport target can be met with less than 10% of transport energy coming from renewable sources. This is because RED allows fuels derived from certain feedstocks, such as wastes, to count twice when calculating progress against the target.
[2] Intergovernmental Panel on Climate Change, 2013, IPCC Press Release
[3] HMG, 2012,'UK Bioenergy Strategy',
[4] Renewable Fuels Agency, 2008, Gallagher Review of the indirect effects of biofuels production

deployment potential of various fuel technologies, whether the market needs support or encouragement to develop and whether there is anything that the government can or should do.

1.8 The evidence we are seeking is intended to form a comprehensive knowledge base from which we can set out a clear policy.

Scope of the call for evidence

1.9 Transport makes up a large proportion of our domestic greenhouse gas emissions (21% by source in 2010[1]). The size of transport's share of emissions means that progress in decarbonising the sector is crucial.

1.10 Market forces alone may not be enough to deliver the advanced fuel technologies needed to decarbonise the transport sector. This call for evidence seeks to establish whether this assessment is correct and whether there is a need for government to intervene. If so, we are interested in what the most appropriate policy mechanisms would be. Some options are explored in this document. The policy mechanisms that we are seeking views on are intended as measures that could be put in place either alongside or as part of the existing Renewable Transport Fuel Obligation, rather than as a replacement for it.

1.11 In this document, as a working definition, we define advanced fuels as those that are both low-carbon and innovative. We propose a non-exhaustive list of broad categories of advanced fuels in section four. We are interested in views on what criteria should be used to define a fuel as ‘advanced’.

1.12 As part of its proposal to amend the Renewable Energy and Fuel Quality Directives, the European Commission proposed a set of feedstocks for advanced biofuels, known as ‘Annex IX’. We are interested in views and evidence on the suitability of these feedstocks and any that have been overlooked.

1.13 Alongside this document we are publishing a report by E4Tech – "'Advanced' biofuel feedstocks – an assessment of sustainability". This report, for the first time, provides a comprehensive assessment of the Annex IX feedstocks and considers how we should define a sustainable, advanced biofuel feedstock. The report also provides a good overview of the state of the advanced fuel sector. We refer to it as a starting point for discussion of various issues throughout the call for evidence.

Potential to develop high-tech UK industry

1.14 Decarbonising our transport infrastructure can be an engine for long-term, green growth. Investing in new technologies and developing expertise in advanced engineering will allow Britain to better compete in the global race.

1.15 With world-class research expertise in the fields of plant science, biochemistry, chemical engineering, mechanical engineering and automotive development, the UK is well placed to become a global

[1] DfT, 2012, Total greenhouse gas emissions from transport

leader in the emerging advanced biofuels industry. If the world is willing to take the necessary steps to avoid dangerous climate change in the 21st century, then in the decades to come these new fuel technologies will be bought and sold all over the world.

1.16 These technologies also have the potential to reduce the costs of cutting carbon. If biofuels were not used in transport, the cost of making the necessary greenhouse gas emission reductions by other means has been estimated at £5billion per year by 2050[1].

Bioenergy and indirect land use change

1.17 UK government policy on bioenergy is set out in the 2012 Bioenergy Strategy. This set out four principles to ensure that bioenergy is only used in the right circumstances. These are:

- Bioenergy should deliver genuine carbon reductions, including indirect emissions;
- Bioenergy should make a cost effective contribution to UK carbon emission objectives;
- Support for bioenergy should aim to maximise the overall benefits and minimise costs across the economy;
- Policy makers should assess the impact of biofuel deployment, including on food security, biodiversity and so on.

1.18 Any further policy for commercialising advanced fuels must be consistent with these principles.

1.19 Emissions caused by indirect land use change (or ILUC) occur when the cultivation of a crop for biofuel displaces the cultivation of a crop for other purposes. ILUC can lead to substantial carbon emissions if, for example, forest is cleared to make way for new crop cultivation. It is not possible to make a direct link between the cultivation of a particular field for biofuels and carbon emissions due to ILUC. The effects must be determined through modelling, calculating the difference in emissions between a projected scenario with biofuel use and a counterfactual without.

1.20 When the effect of ILUC is taken into account, many crop based first-generation biofuels deliver significantly lower emission savings. In some cases they can even be more polluting than some fossil fuels. Some advanced fuels have no ILUC impact, others have a much lower ILUC impact. Thus they will compare very favourably with many first-generation biofuels when considering the total emissions savings from a fuel.

1.21 The European Union is currently negotiating amendments to the Renewable Energy Directive to address ILUC. This could provide further impetus to the development of advanced biofuels. Some of the support mechanisms that are considered in this document could be used as a way of implementing the requirements of a revised directive.

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[1] 'ESME' modelling by the Energy Technologies Institute

The Renewable Transport Fuel Obligation

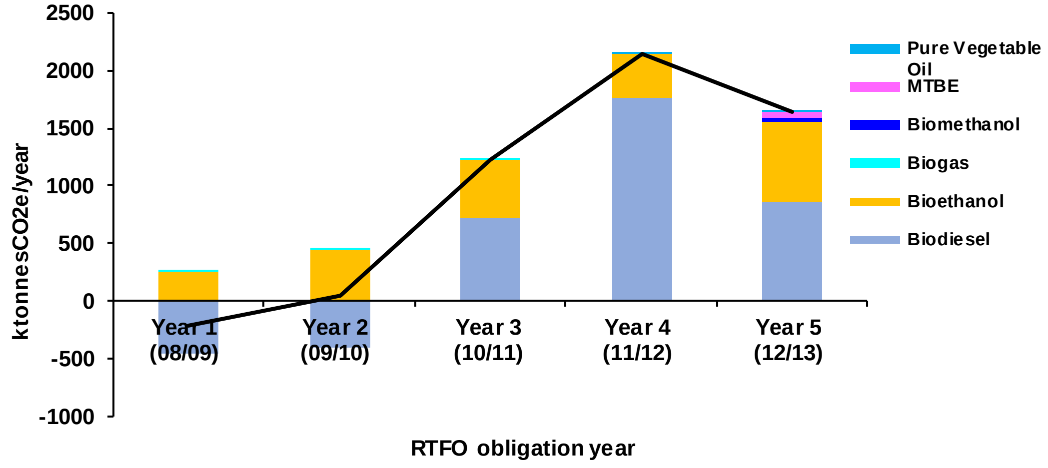
1.22 The Renewable Transport Fuel Obligation (RTFO) was introduced in 2008. It sets targets for the use of renewable fuels in UK road transport with the aim of reducing carbon emissions. It is our primary mechanism for incentivising the supply of renewable fuels in transport.

1.23 The RTFO places an obligation on fossil fuels suppliers to ensure that a certain proportion of their fuel is from sustainable biofuels. Obligated suppliers must demonstrate that they have met their obligation by redeeming Renewable Transport Fuel Certificates (RTFCs). RTFCs can be freely traded, so their price is set by the market. Renewable fuels made from certain feedstocks, such as waste and residues, receive twice as many certificates for each litre of fuel supplied.

1.24 The Department for Transport has committed to reviewing the performance of the RTFO. A draft of this 'Post-Implementation Review' (PIR) is due to be published shortly, and will consider amendments made to the RTFO in December 2011 to implement the Renewable Energy Directive (RED). When carrying out the review we will take into account the responses to this call for evidence. The responses received, along with evidence from other sources, will be incorporated into the PIR for final publication in April 2014.

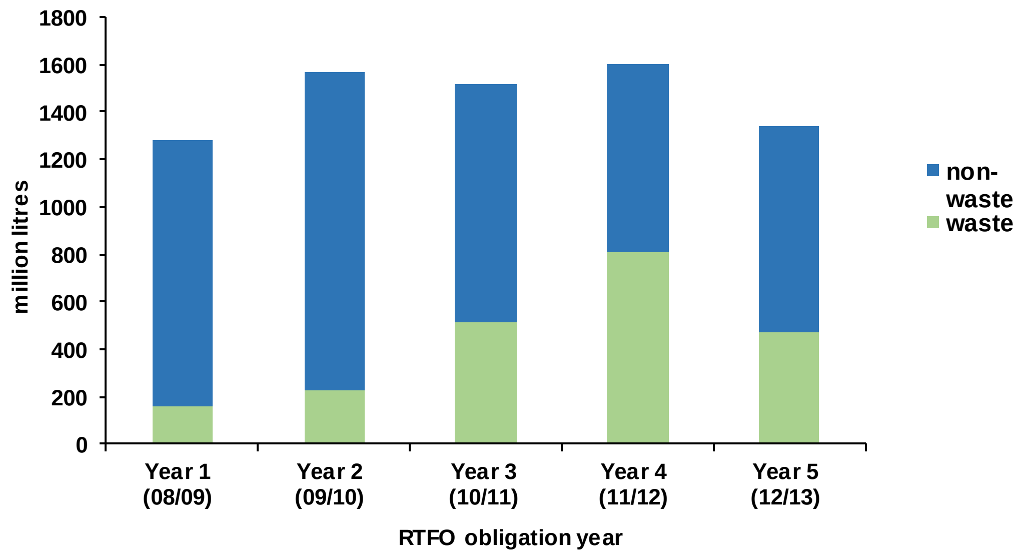
1.25 The volume of biofuel supplied in the UK has increased from 1.3 billion litres in its first year (2008/09) to 1.6 billion litres in 2011/12. Over the same period we have made progress in reducing carbon emissions, with the reported average savings, compared with fossil fuels, increasing from 46% to 61%. In the last three years, we have seen significant carbon savings under the RTFO, even when taking into account estimates of indirect effects. An increasing proportion of the biofuels supplied are now also produced from waste (see Figures 1.1 and 1.2 below).

Figure 1.1: Greenhouse Gas savings from biofuel – taking into account both direct and indirect emissions



(source: Draft Post-Implementation Review of the RTFO, 2013)
Data for Year 5 is estimated based on certificates redeemed to date.

Figure 1.2: Proportion of biofuel supplied from wastes

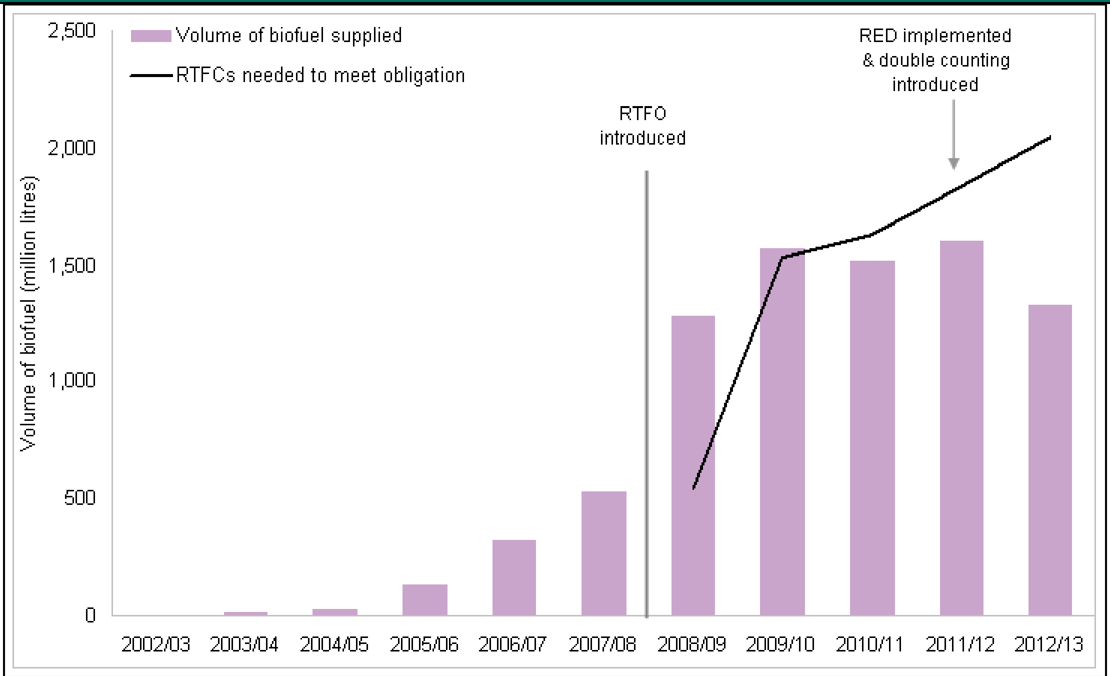


(source: Draft Post-Implementation Review of the RTFO, 2013)
Data for Year 5 is estimated based on certificates redeemed to date.

1.26 When indirect emissions are taken into account, crop-based biodiesels, which are a feedstock with a high-risk of ILUC, reduced the total greenhouse gas savings between 2008-2010. However, from 2010/11 onwards, an increase in the amount of biodiesel derived from used cooking oil and bioethanol increased total savings.

1.27 This change in the fuel mix is partly due to the changes made to the scheme in 2011 to introduce double-counting for fuels derived from wastes. This introduction of double-counting offered further support for the most sustainable biofuels. Double-counted fuels, such as used cooking oil, receive twice the number of certificates as other fuels. Double certification has also had the effect of reducing the overall volume of fuel required to meet the obligation (see Figure 1.3 below).

Figure 1.3: RTFO supply volumes versus obligation level



(source: Post-Implementation Review of the RTFO)

Sustainability and compliance

1.28 The RTFO was amended in December 2011 to include the sustainability criteria required by the RED. Suppliers must now meet greenhouse gas savings and provide evidence that the cultivation of fuel feedstocks has not damaged areas of high carbon stocks (e.g. virgin forests or peat land) or high biodiversity.

1.29 In order to be able to track the evidence back to source, suppliers throughout the supply chain must account for their product on a mass balance basis. This ensures that for every unit of sustainable biofuels sold there is verifiable evidence that the corresponding sustainable feedstock has actually been produced.

Advanced fuels and the demonstration competition

1.30 However, despite the clear progress that has been made under the RTFO, to date very little biofuel that could be considered ‘advanced’ has been supplied in the UK. The call for evidence seeks to understand the reasons for this and whether further steps could encourage a more rapid deployment of advanced biofuels.

1.31 Advanced fuels could offer several advantages over some ‘first-generation’ biofuels. They are potentially more environmentally and socially sustainable, particularly if made from waste or residue feedstocks. Waste feedstocks do not compete with food crops, and in many cases can deliver greenhouse gas savings of above 80% compared with fossil fuels. Some advanced fuels are also 'drop-in' fuels, meaning they can be mixed with fossil fuels at very high blend levels without the need to alter vehicles or infrastructure. Some advanced fuels can also be deployed in sectors such as aviation, maritime and freight – sectors that are otherwise very hard to decarbonise.

1.32 The government has already taken steps to support the growth in the supply of advanced fuels. On 1 August 2013 we announced the availability of £25m of capital funding for an advanced biofuel demonstration plant competition[1].

1.33 The funding is intended to underpin significant private sector investment in one or more demonstration-scale advanced biofuel plants and drive the development of a domestic industry.

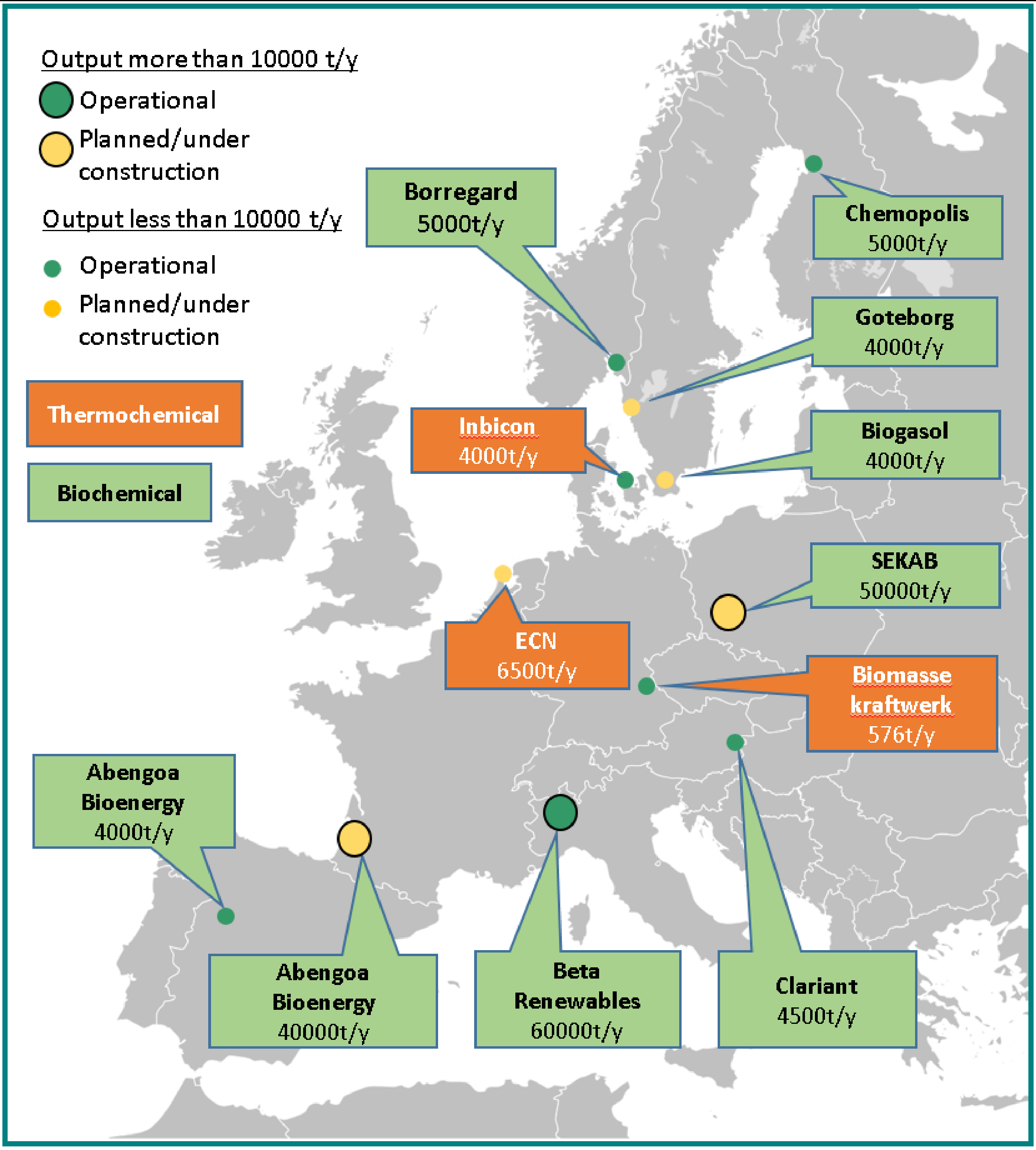
1.34 A feasibility study for the competition was commissioned in October 2013. The feasibility study will provide expert advice on the structure and design of the proposed competition. This study will include eligibility criteria and funding scheme options, and will conclude by the end of January 2014.

1.35 Responses to the call for evidence will feed into our thinking as we determine the best way to structure and run the advanced demonstration plant competition.

1.36 Figures 1.4 and 1.5 below show the extent of the commercialisation of advanced biofuels in the US and EU[2].

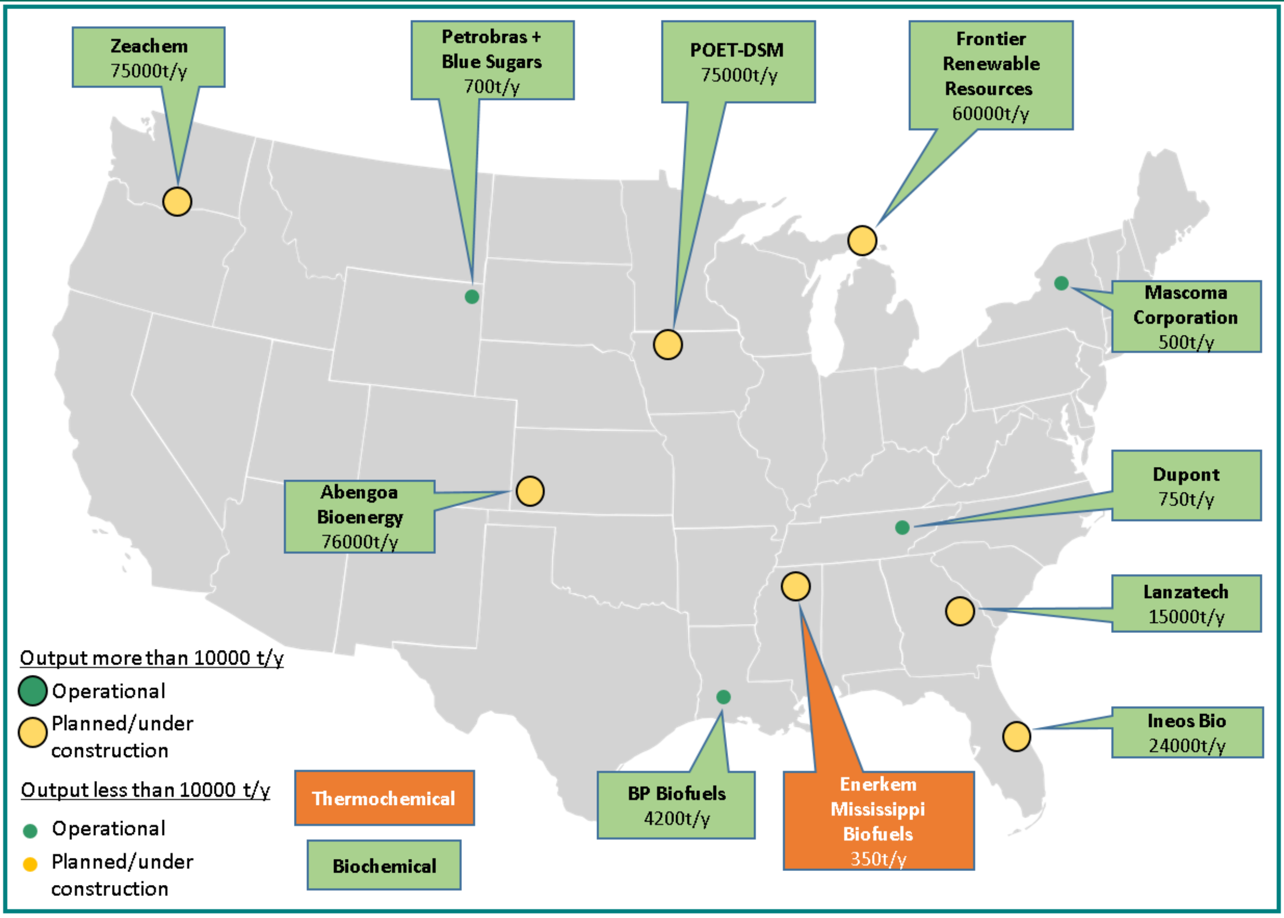
[1]https://www.gov.uk/government/news/25-million-for-advanced-biofuel-demonstration-projects
[2]The data for these maps is taken from an International Energy Agency project that is tracking the development of advanced biofuel plants across the globe (IEA Bioenergy Task 39, http://demoplants.bioenergy2020.eu/)

Figure 1.4: Map of advanced biofuel plants in the EU



(Data source: Bioenergy2020+ GmbH, Plants shown are biochemical and thermochemical of demo stage or commercial scale, with stated output above 100t/y)

Figure 1.5: Map of advanced biofuel plants in the USA



(Data source: Bioenergy2020+ GmbH, Plants shown are biochemical and thermochemical of demo stage or commercial scale only, with stated output above 100t/y)

1.37 The picture shows an industry at an early stage of development. Europe has a greater number of plants that are operational, but these are generally of a smaller scale than those in the US. There are a number of large plants that are either planned or in construction in the US. The EU also has a larger number of thermochemical plants than the US, although the leading technology on both sides of the Atlantic seems to be biochemical.

1.38 The UK currently has no advanced biofuel plants, at either commercial or demonstration scale. The government's recently announced competition, and this call for evidence, provide an opportunity to change this.

Aims of this call for evidence

1.39 Through this document we are looking to understand more about the role that advanced fuels can play in decarbonising transport and how best we can move towards this goal.

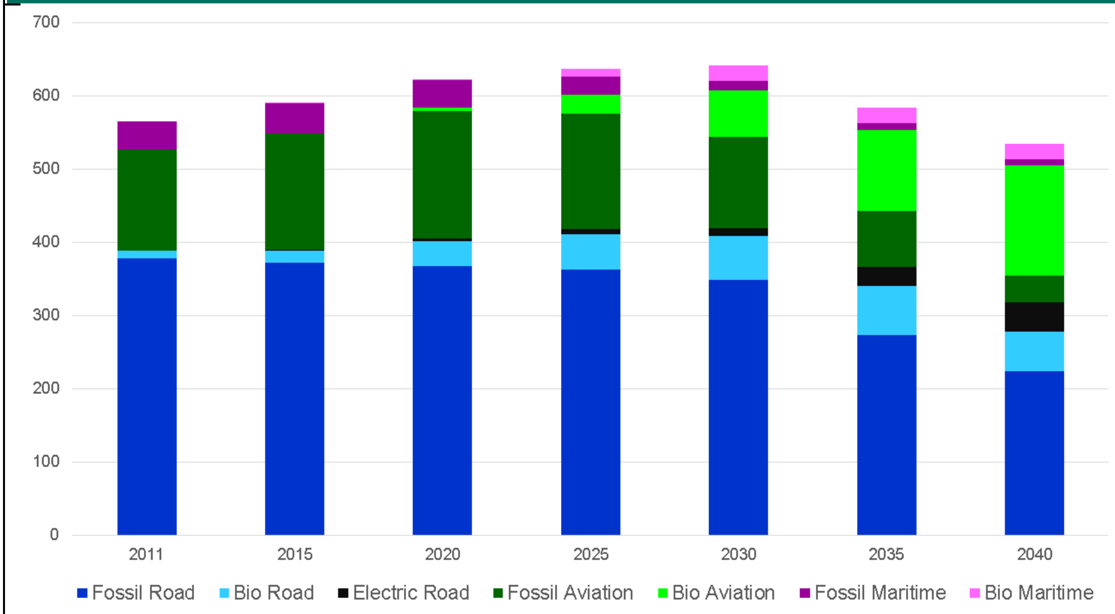
1.40 Throughout the document questions can be found in green boxes. Key questions are in bold and may be followed by related supplementary questions. Respondents are invited to answer as many, or as few, as they wish.

2. Transport sectors

2.1 The government's strategy for ultra-low emissions vehicles (ULEVs)[1] aims to support the development of a market for ULEVs such as plug-in and hydrogen fuel cell electric vehicles. While electric vehicles will play a substantial role in decarbonising road transport, other parts of the transport sector, such as shipping and aviation, will be harder to decarbonise. These sectors are likely to require the development and deployment of advanced, low-carbon liquid or gaseous fuels. At present, the RTFO only provides support for the use of biofuels in road transport.

2.2 The analysis in the government's Bioenergy Strategy shows what the contribution of advanced fuels could be towards our 2020 targets and beyond.

Figure 2.1: Energy in transport 2011-2040 (TWh by fuel type and mode)



(source: Redpoint modelling for UK Bioenergy Strategy, 2012)

2.3 As well as the use of advanced fuels in transport, we must also consider the role that these fuels could play in other energy sectors (such as heat or energy storage). We are therefore interested in views on the potential interaction of these others sectors with transport as the UK becomes increasingly decarbonised.

2.4 We are also interested in views on whether compatibility with current fuels can or should be maintained, or whether a transition towards new

[1] Driving the Future Today: A strategy for low-emission vehicles, DfT, 2013

vehicles and refuelling infrastructure is required. If the latter, we are interested in views on what steps government might need to take to encourage this change.

Aviation

2.5 Across the EU, aviation fuel consumption is expected to grow by 2% annually, leading to a more than doubling of carbon emissions by 2050[1]. However, many renewable power sources are not suitable for aviation as fuel sources with high power-to-weight ratios and the ability to withstand low temperatures are required. Advanced fuels are therefore a promising way to reduce carbon emissions in the aviation sector.

2.6 Following extensive testing and in-depth technical review, a selection of biofuels were approved for commercial use in aviation in 2011 in the United States[2]. In the wake of this several initiatives were established to speed up the commercialisation of advanced biofuels and set objectives for future deployment.

2.7 They included the European Advanced Biofuels Flight Path Initiative[3], launched by the European Commission in coordination with members of the aviation and biofuels industry. It sets out a roadmap and milestones to achieve two million tonnes of sustainable aviation biofuel by 2020. In addition, the European Commission's Flight Path 2050 sets an objective of a 75% reduction in CO2 emissions by 2050[4]. Alternative fuels are expected to contribute heavily to the meeting of this target.

Shipping

2.8 Compared with other parts of the transport sector, shipping has been shown to be an energy-efficient means of transportation.

2.9 The Committee on Climate Change conducted a review of abatement opportunities in shipping in 2011[5]. They concluded that the efficiency of shipping had improved significantly in recent decades and that there were a range of technical and operational measures that could improve it still further. However, the review also made clear that, in the longer term, full decarbonisation of the sector is likely to require the use of new fuels.

2.10 In recent years, there has been increasing interest in the use of natural gas as a shipping fuel[6] and other fuels, such as methanol, are also being trialled. These changes are largely being driven by new legislation to control pollutant emissions from shipping, but could ultimately open the door for the use of biomethane or synthetic gaseous fuels in the sector.

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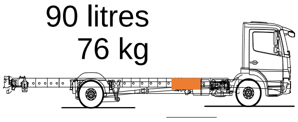
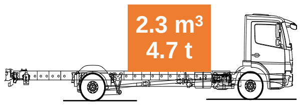
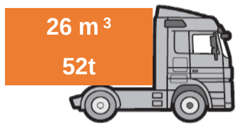
[1] p7, '2 Million Tons per Year: A performing biofuels supply chain for EU aviation', August 2013, (http://ec.europa.eu/energy/renewables/biofuels/doc/20130911_a_performing_biofuels_supply_chain.pdf)
[2] p20, 'Biofuels Issues and Trends', U.S. Energy Information Administration, October 2012, (http://www.eia.gov/biofuels/issuestrends/pdf/bit.pdf)
[3] http://ec.europa.eu/energy/renewables/biofuels/flight_path_en.htm
[4] 'Flight Path 2050: European's Vision for Aviation – Report of the High Level Group on Aviation Research', European Commission, 2011, (http://ec.europa.eu/transport/air/doc/flightpath2050.pdf)
[5] Committee on Climate Change, Review of UK Shipping Emissions, 2011
[6] Lloyds Register, LNG-fuelled deep sea shipping, 2012

Road transport

2.11 Heavy goods vehicles (HGVs) present a similar problem to aviation by requiring very dense energy sources. Without a step-change in technology, battery power is unlikely to provide a solution for the heavier end of the freight sector.

Figure 2.2: Battery sizes required by HGVs

Range	Diesel	100% electric with Li-Ion battery
500 km 7.5-tonne distribution operations	90 litres 76 kg 	
3000 km 44-tonne long distance operations	990 litres 836 kg 	

Calculation: consumption: 20 l/100 km /33 l/100 km, efficiency: diesel engine = 40%, electric motor = 80%, energy content: diesel = 11.8 kWh/kg,
Li-Ion battery = 0.19 kWh/kg, weight: diesel = 0.845 kg/l, Li-Ion battery = 2 kg/l

(source: Mercedes-Benz)

2.12 The Low Carbon Truck Demonstration Trial was launched in November 2011 as a means of introducing low-carbon vehicles, running on alternative and dual fuels, to UK fleets as well as the creation of a gas refuelling network. A total of £11.3m of funding was awarded to 13 projects. The trial is currently underway and is due to report in 2015.

2.13 In the UK, natural gas is currently taxed at a lower rate than petrol and diesel. In the December 2013, the government announced that the current lower rate of fuel duty for natural gas in transport would be guaranteed for ten years, until 2024. This will provide certainty for fleet owners looking to invest in natural gas fuelled vehicles and infrastructure. An increase in the number of natural gas fuelled vehicles would greatly expand the range of potential low-carbon fuels that can be used by the UK fleet.

2.14 We should also consider whether advanced biofuels will continue to have a role in the decarbonisation of passenger cars. Light road transport, such as vans and cars, has more decarbonisation options than heavier vehicles. Electric vehicles offer zero emissions at the tailpipe and are highly effective for many uses. Therefore, scarce bioenergy resources are most likely to be needed in the HGV and non-road sectors, However, recent reports[12] have argued that sustainable biofuels could offer cost

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[1] 'An affordable transition to sustainable and secure energy for light vehicles in the UK', Energy Technologies Institute, 2013

[2] 'The Role of Biofuels Beyond 2020', Element Energy, 2013

effective carbon savings in passenger vehicles, when compared to other low-carbon vehicle technologies.

2.15 As the analysis in Figure 2.1 above shows, the internal combustion engine will continue to be used in road transport even out to 2040. This suggests that access to advanced fuels is likely to remain an important component of any decarbonisation strategy for the road sector.

Rail

2.16 The government is currently undertaking a major rail electrification programme. However, large parts of the network, and nearly all freight trains, still rely heavily on diesel. Rail is also now included as part of the RTFO following recent changes to include fuel used in non-road mobile machinery.

Q1. Should Government focus support for advanced fuels in certain transport sectors? If so, why?

1A. What are your views on the government's analysis of the use of advanced biofuels in different transport sectors, as set out in the UK Bioenergy Strategy? Do you have alternative estimates of the future uptake of advanced fuels in each transport sector?

1B. What physical or legal barriers are thereto the uptake of advanced fuels in different transport sectors?

3. Fuels

3.1 Since its inception the RTFO has successfully encouraged the supply of biofuels from crops and wastes. We would like to understand what other fuels might need to be supported as part of the transition to a low-carbon transport system.

3.2 We are interested in what criteria should be used to determine whether a fuel is 'advanced'. As a working definition, we define 'advanced' fuels as both low-carbon and made using an innovative process (ie a process that has not yet been widely commercialised).

3.3 In this section we are asking for specific evidence on four fuel technologies that could be considered advanced. These technologies are:

- Advanced biofuels
- Hydrogen
- Synthetic fuels from electricity
- Biomethane

3.4 In this chapter we look in detail at each fuel technology, and ask specific questions about the potential of each one. We also have some more general questions below that apply to all four of these technologies.

Q2. Is UK Government support necessary to commercialise advanced fuel technologies? If so, why?

2a. What should 'advanced' mean? What role should process, feedstock and sustainability have in this definition?

2b. What economic opportunities are there for the UK in developing this industry?

Advanced biofuels

3.5 The government's Bioenergy Strategy suggests that biofuels will need to play a crucial role in the UK transport sector to 2050.Advanced biofuels offer a range of advantages over conventional biofuels, including improved sustainability.

3.6 In their report on advanced biofuel feedstocks, E4tech have proposed an analytical framework for whether support should be considered for advanced biofuel feedstocks. They propose the following criteria:

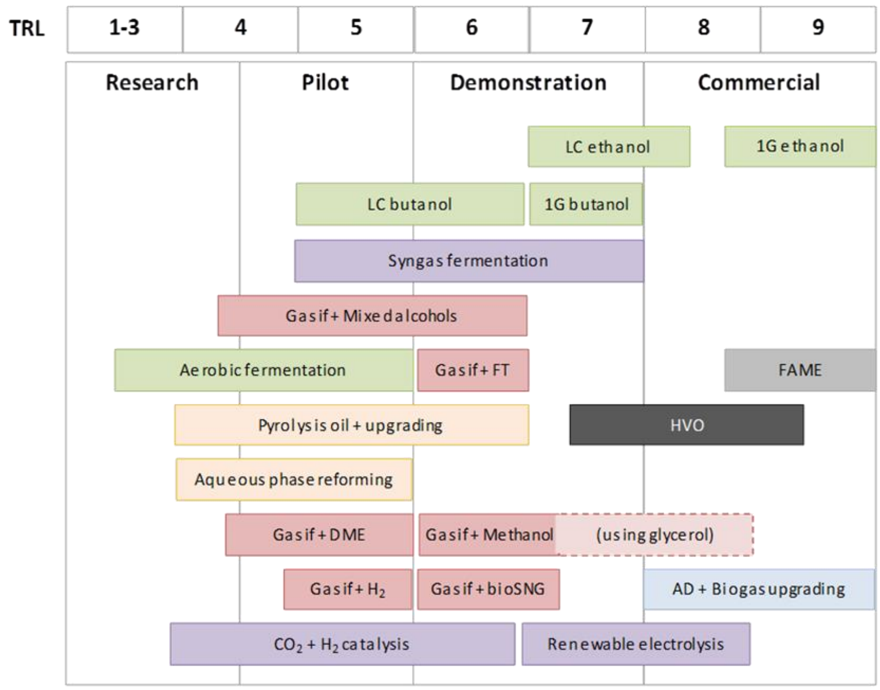
- The advanced biofuel route should offer direct greenhouse gas emissions savings above a desired threshold versus a fossil fuel baseline;

- If the feedstock is currently not collected or is disposed of, support should only be offered if the collection/extraction can be sustainable;
- If significant competing uses already exist for the feedstock, then diversion to biofuels should only be supported if the likely substitution of alternative resources in these competing uses does not pose a high risk. If substitution by more fossil fuels or land-based crops is likely, only the supply fractions without competing uses should be supported;
- If the feedstock is an agricultural or forestry residue, it does not come from land with high biodiversity value, or conversion of high carbon stock or peat land;
- If the feedstock is grown specifically for biofuels, then the land used should not compete directly with food production, unless mitigating measures are successfully implemented to minimise the risk of ILUC (e.g. global protection of high carbon stock land, above baseline yield increases, optimal use of co-products, supply chain efficiencies and farming system integration).

3.7 In terms of a working definition for those feedstocks that are lowest risk, many of the indirect risks can be avoided if under-utilised resources are sustainably sourced, land is not converted, and competing use sectors are decarbonised. 'Under-utilised' encompasses additional collectable supplies, few competing uses, and/or inefficient consumption that can be improved upon to release material.

3.8 The chart below shows an estimate of the Technology Readiness Level (TRL) of a selection of technological pathways for biofuels.

Figure 3.1: Technology Readiness Levels of possible pathways for biofuels



(source: E4Tech,2013, "'Advanced' biofuel feedstocks – An Assessment of Sustainability")

Q3. What could advanced biofuels deliver, and by when?

3a. Do you agree with E4Tech's assessment of the technology readiness of different advanced fuel technologies?

3b. Do you agree with E4Tech's assessment on the availability of waste and residue feedstocks, and their estimated costs of advanced fuels?[1]

3c. Do you agree with E4Tech's proposed criteria for when an advanced biofuel should be supported?

Hydrogen

3.9 Not all advanced fuels require the use of biomass, some can be produced without any biological inputs. These fuels can offer significant carbon savings without any of the environmental impacts of biomass cultivation. The most widely known application of these fuels is the use of hydrogen in fuel cell electric vehicles (FCEVs)[2].

3.10 The government is committed to the development of hydrogen as a transport fuel. UKH2Mobility, launched in 2012, brings together industrial participants from the utility, gas, infrastructure, fuel retail, and global car manufacturing sectors together with the UK government. This is a ground-breaking project to evaluate the potential for hydrogen FCEVs in the UK. The consortium is working collaboratively to develop a joined-up approach to the commercialisation of hydrogen.

3.11 The potential carbon benefits from the deployment of FCEVs will only be obtained by using hydrogen derived from low-carbon processes such as water electrolysis using renewable electricity. This is known as 'green' hydrogen. Currently most hydrogen is produced from steam methane reformation resulting in significant emissions of carbon dioxide and other pollutants. This is known as 'brown' hydrogen.

3.12 A key area of work being undertaken in the UKH2Mobility project is looking at the means to ensure a pathway to green hydrogen production. The price of green hydrogen is currently higher than brown hydrogen and is forecast to remain so through to 2030.

Q4. What could hydrogen deliver as a transport fuel, and by when?

[1] This data from is not included in the call for evidence. It can be found by consulting the accompanying E4Tech report directly.
[2] Although hydrogen can also be derived from biomass.

Synthetic fuels and fuels from fossil waste

3.13 Renewable electricity can also be used to generate fuels which are compatible with current vehicles and refuelling infrastructure. These ‘synthetic fuels’ use electricity as an energy source, and water and carbon dioxide as feedstocks[1]. Using this process, a range of hydrocarbon fuels can be generated, including petrol and diesel substitutes.

[1] The term synthetic fuels can also be used to describe fuels derived from fossil or biomass feedstocks, such as 'coal to liquid' or 'biomass to liquid' techniques. In this document we use the term to refer purely to synthetic fuels derived from electricity.

Carbon Recycling International – electricity to fuel

Carbon Recycling International (CRI) is an Icelandic company which has developed a process for producing renewable transport fuel by recycling CO2 emissions. In 2012 CRI opened the world's first industrial-scale plant based on their technology at Grindavik in Iceland.

The energy source for CRI's demonstration plant is electricity taken from Iceland's electricity grid, which is 100% renewable and based on hydro and geothermal power. The feedstock is CO2 from the flue gas of turbines in a nearby geothermal power plant. In future production plants based on CRI's technology, energy from diverse renewable power sources, such as wind, solar, hydro and geothermal can be used as well as CO2 from industrial emitters, such as cement or petrochemical plants.

The fuel produced is methanol, which can be blended with petrol or used for the production of biodiesel or other fuel components. Relative to gasoline or diesel, CRI's methanol offers nearly 100% greenhouse gas emission savings depending on the power mix. With power from the Icelandic grid the life cycle emission savings from production and use per unit energy are above 91% compared to fossil fuel. At maximum capacity, the demonstration plant can produce five million litres a year of renewable methanol.

(source: Carbon Recycling International)

3.14 Some of these fuels are close to being commercialised and represent an exciting opportunity for transport decarbonisation. However, it is not straightforward to consider how such fuels would be included in renewable energy obligations such as the RTFO.

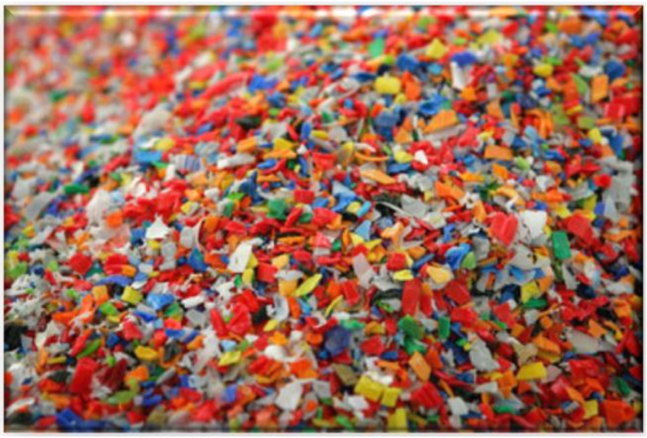
3.15 Under the Renewable Energy Directive, with fuels derived from biomass, the biomass is considered the principal energy source. The source of all biomass energy is ultimately solar energy captured through photosynthesis. Any non-renewable energy involved in the production of the fuel, such as grid electricity used in the processing plant, is limited by the minimum greenhouse gas savings that are required under the RED.

SITA – waste plastics to fuel

SITA UK is constructing the first waste plastic to fuels pyrolysis plant in the UK at Avonmouth, Bristol. This plant will generate approximately 5.5 million litres of transport fuels a year from 6,000 tonnes of waste plastics. Production is due to start in early 2014.

In the UK several hundred kilotonnes of residual waste plastics go to landfill every year. The majority of this plastic is waste packaging films and containers that are uneconomic to separate into a viable single polymer recyclate that can be sold on the market. This material is often sent to landfill or used for electricity generation. However, it can also be converted into transport fuel using a form of thermal treatment called pyrolysis.

Pyrolysis uses heat to break down the long chain polymers into a mix of shorter chain hydrocarbons. These hydrocarbons can then be refined to make naphtha for use in petrol as well as kerosene and diesel. A synthetic gas (syngas) is also created that can be burnt to generate the heat to drive the pyrolysis reaction, thereby reducing the energy requirement for the process.



One tonne of waste plastic can create around 950 litres of liquid fuels representing a 75% yield, the balance being syngas and a finely divided carbon powder that is also saleable. SITA UK plans to build more of these plants in the UK and the rest of the EU once the process at Avonmouth has been optimised.

(source: SITA)

3.16 However, with synthetic fuels, there is no biomass element. Under the current system there is therefore no clear distinction between the fossil and renewable energies incorporated into the final product. This raises the question as to how to limit the input of fossil energy into the final product, while at the same time treating such products fairly in comparison to renewable fuels from biomass. Many synthetic fuels use renewable electricity to electrolyse hydrogen. One approach may therefore be to determine the level of 'renewability' of the fuel by considering the renewable energy content of the electricity that was used to create the hydrogen. This would essentially treat renewable hydrogen (also known as green hydrogen) as equivalent to biomass when considering support for synthetic fuels.

3.17 In this approach, a hydrogen production site that takes its electricity directly from a renewable energy source (such as a wind turbine) would be considered wholly renewable. Any synthetic fuels that were then produced from this hydrogen, for example, petrol substitutes, would also be completely renewable, provided that the additional energy involved in further processing did not lead to greenhouse gas emissions beyond the minimum savings required under the RED. This would limit the input of non-renewable energies into the final product. However, it would not require the feedstocks to be from renewable sources, only the energy sources.

3.18 We are also interested in gathering more information about fuels derived from waste fossil material. In particular, those that use waste plastic or waste industrial gases as an energy source.

LanzaTech – waste gases to fuel

LanzaTech have developed a fermentation technology to produce transport fuel from industrial waste gases. Unlike traditional fermentation which relies on sugars, LanzaTech's proprietary biological microbes grow on gases.

Although the technology can be adapted to use many sources of gas, including those derived from organic matter, Lanzatech have so far developed the process for use with carbon rich waste gases produced through the chemical reactions involved in the steel manufacturing process, where carbon is used primarily to reduce iron oxide to metallic iron.

When gas fermentation is deployed in the steel mill, instead of sending a residual gas stream to a flare or power generation unit, it is cooled, cleaned and injected into a fermentation vessel. The microbes grow and increase their biomass by consuming a mix of carbon dioxide, carbon monoxide and hydrogen. As a by-product of this growth, they make ethanol. LanzaTech have also proved that further conversion of their ethanol into aviation fuel is possible.

LanzaTech's first commercial unit, producing up to 100m litres per year, is planned for deployment in China in 2014.

(source: Lanzatech)

3.19 We would be interested in views on whether there is a case for offering government support for these products, through the RTFO or some other additional mechanism.

3.20 These fuels are not renewable and are derived from fossil fuels. However, there may still be an argument for supporting them through government policy. Some waste plastics are currently transported to landfill. Some waste fossil gases, such as carbon monoxide emissions from steel production, are flared as carbon dioxide. Therefore, using these wastes for transport fuel could have broader environmental benefits.

3.21 While fuels like these are unlikely to represent a long term low-carbon solution, they could be a useful transition technology on the way towards our long-term carbon reduction goals.

Q5. What could synthetic fuels and fuels from fossil waste deliver, and by when?

5a. How should we determine the extent to which synthetic fuels from electricity are renewable?

5b. What information can you provide on technologies to produce fuel from waste fossil gas and waste plastic, and their potential benefits and drawbacks?

Biomethane

3.22 Biomethane is a fuel produced from the decomposition of biomass, which can be used as a substitute for natural gas in heat, power or transport. The biogas produced can be burned to produce electricity and heat or it can be upgraded to biomethane for use in transport or for injection into the gas grid. When used as a transport fuel, it offers greenhouse gas emission savings relative to diesel of around 80%[1].

3.23 The most common processes for producing biomethane are well established and relatively mature. There is therefore a question of whether biomethane can be considered advanced

3.24 Government, industry and delivery bodies have range of activities to reduce the barrier to biomethane deployment, which are set out in the Anaerobic Digestion Strategy and subsequent progress reports[2]. However, there are still significant barriers to the expansion in the supply of biomethane in the UK transport system. A 2010 report for the Department for Transport identified the following as the main barriers:

- The lack of refueling infrastructure, and the capital costs of refueling stations.
- The limited number of suppliers of biomethane.
- The lack of certainty with regard to government incentives and fuel duties.
- The (assumed) low residual value of gas powered vehicles.

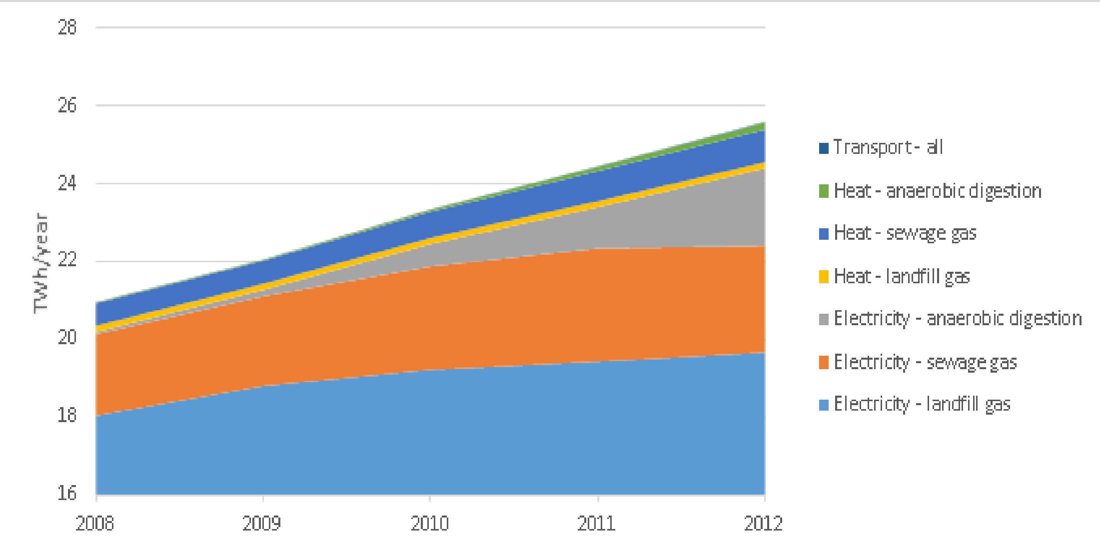
[1] Annex V, Renewable Energy Directive
[2] AD Strategy and Action Plan Annual Report 2012-13 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/229432/pb14019-anaerobic-digestion-annual-report-2012-13.pdf

3.25 The government is working with the freight industry on addressing some of these barriers through the Low Carbon HGV task force. This is an industry-led task force to promote the use of fuel efficient, low emission road freight technologies.

3.26 Biomethane already forms a fairly significant part of the UK energy mix, with 25.5 TWh supplied in 2012. Figure 3.2 shows the amount of biomethane used in the UK over the past few years. This shows that transport accounted for less than 0.005% of the total in 2011.

3.27 As Figure 3.2 shows, biomethane in the UK currently has three principal sources: landfill sites, the anaerobic digestion of sewage and anaerobic digestion of other biomass. At present most biomethane is used for the generation of electricity

Figure 3.2: Use of biomethane in UK heat, power and transport 2008-2012



(source: DECC Digest of UK Energy Statistics)

3.28 There are a number of government support schemes that offer some form of financial incentive to use biomethane in different sectors.

- The Renewables Obligation (RO) -for large-scale electricity production(over 5KW)
- The Feed-in Tariffs scheme (FITs)-for small-scale electricity production (under 5KW)
- The Renewable Heat Incentive (RHI)- for renewable heat generation
- The Renewable Transport Fuel Obligation (RTFO)- for renewable transport fuels

3.29 These support mechanisms have been designed in different ways. In the case of the RHI and FITs, tariffs are set at different levels for different technologies. These tariff levels are based on the capital and operating costs of a given technology, with the intention of allowing that technology to compete in the wider electricity and heat market.

3.30 The RO is more similar to the RTFO. Suppliers receive certificates for supplying renewable energy. These certificates are traded commodities that have no fixed price. In 2009, different bands of support were introduced into the RO to offer varied support levels by technology, reflecting different levelised costs, potential and other factors.

Table 3.1: Government support for biomethane in different sectors

	Heat	Transport	Electricity	
	Renewable Heat Incentive	**Renewable Transport Fuel Obligation**	**Feed-in Tariffs**	**Renewables Obligation**
£/MWh (biomethane)	£73	£7.37-£26.47	£32.37-£53.06 (anaerobic digestion)	£0-£3.23 (landfill) £32.35 (anaerobic digestion)

Notes: The RHI support for biomethane is based on the energy content of the renewable biomethane injected into the gas grid. In addition to this, the RHI provides support for installations generating heat from biogas, which includes gas from anaerobic digestion and syngas from gasification or pyrolysis. Installations with a thermal capacity of 200kW or less receive a tariff of 7.3p/kWh (£73/MWh) and in September 2012 DECC consulted on introducing support for heat from biogas with thermal capacities above 200kW.

The RO and FIT schemes for electricity is based on electricity generated, not biomethane energy input. So an assumed efficiency of conversion is required to convert the support available to input (biomethane) energy to allow comparisons with the other data in the table. In this calculation we have assumed 35% biomethane energy to electricity efficiency.

The RO support depends on the source of the biomethane. Renewable Obligation support for landfill (LF) gas in 2013/14 is 0 ROCs for open sites, and 0.2 ROCs for closed sites. RO data for landfill gas does not take account of Waste Heat to Power generation support. RO support for Anaerobic Digestion (AD)) is 2 ROCs in 2013/14. See 'Government Response to the consultation on the proposals for the levels of banded support under the Renewables Obligation for the period 2013-17 and the Renewables Obligation Order 2012' for further detail.

RTFO support estimates are based upon biomethane receiving double certificates, and have been assessed across a range of observed RTFC prices which have been published over the period December 2011 to July 2013 (http://www.nfpas-auctions.co.uk/etoc/trackrecord.html). Level of support is shown in 2013/14 prices.

3.31 In transport, the RTFO is designed to deliver sustainable renewable energy supply at the lowest cost. RTFO certificates are traded commodities that have no fixed price. The level of subsidy is determined by the market and effectively reflects the difference between the cost of the cheapest renewable fuel and its fossil alternative. The level of support offered by the RTFO is therefore not designed to reflect the cost of deploying a given technology.

3.32 For technologies with higher costs, such as biomethane, we will need to consider whether it is necessary to offer additional support to make their deployment commercially viable. This is particularly relevant where higher levels of government support are already offered for the use of a fuel in other sectors.

Q6. What could biomethane deliver as a transport fuel, and by when?

Nearly wholly renewable fuels

3.33 The sections above look generally at different advanced fuel technologies. In this section we are interested in understanding the percentage of renewable inputs of some specific biofuel technologies.

3.34 Under the Renewable Energy Directive, renewable fuel produced using a mixture of renewable and fossil products is described as 'partially renewable'. Examples include MTBE (methyl-tertio-butyl-ether).Most biodiesel in the UK is fatty-acid methyl-ester (FAME), which is produced from approximately 90% biomass products and 10% fossil products.

3.35 Under the RTFO, FAME is treated as wholly renewable, and receives one certificate per litre. We consulted on our treatment of FAME in 2011[1] as part of the consultation on the transposition of the Renewable Energy Directive. Following this consultation the government determined that it should continue to be treated as wholly renewable.

3.36 A number of fuels that are close to being brought to market have a similar percentage of renewable inputs as FAME, notably hydro-treated vegetable oil (HVO) and fatty-acid ethyl-ester (FAEE). First-generation biofuels can only be blended with petrol and diesel at relatively low levels (generally less than 10%) and still be compatible with current vehicles. HVO can potentially be blended at much higher levels, therefore offering a way past so called 'blend walls' the mechanical limits to how much biofuel can be used in vehicles without adaptation.

3.37 We are currently considering whether the RTFO needs amending in order to treat these 'nearly' wholly renewable fuels in the same way as FAME. However, we are keen to learn of the full range of fuels that find themselves in this position, so that any changes can be comprehensive.

Q7. Which 'nearly' wholly renewable fuels are close to commercialisation? What evidence do you have of the percentage of their inputs that are renewable?

[1] 'Consultation on the implementation of the transport elements of the Renewable Energy Directive', Department for Transport, 2013, https://www.gov.uk/government/consultations/implementation-of-the-transport-elements-of-the-renewable-energy-directive

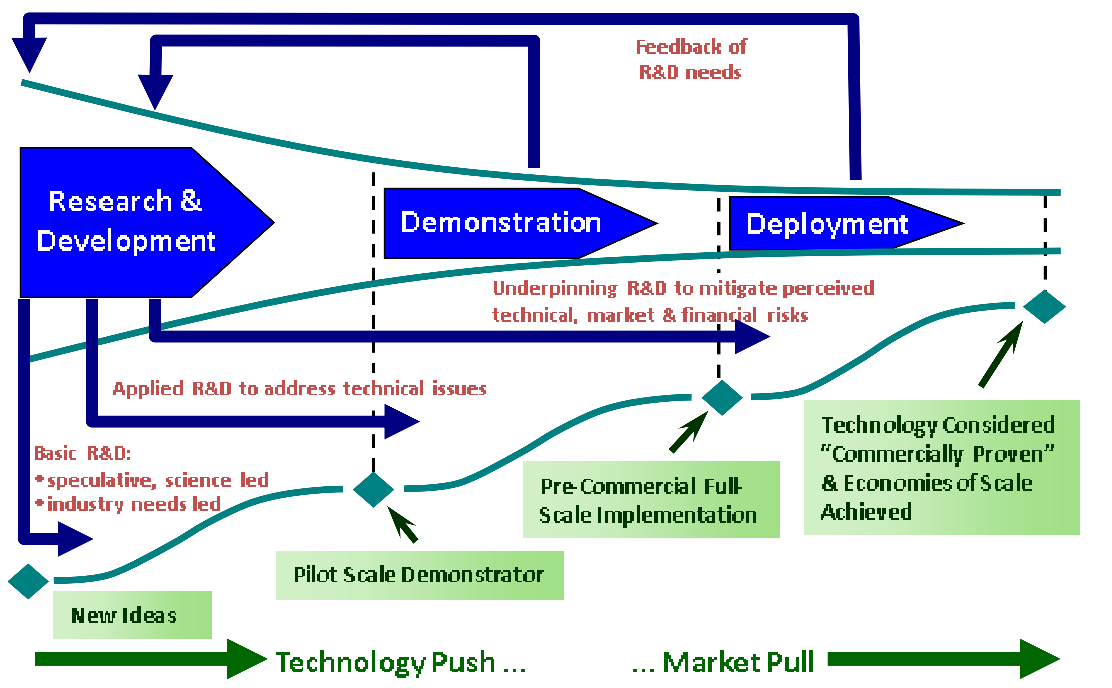
4. Support mechanisms

4.1 We are interested in views and evidence on whether government support is needed for advanced fuels to be developed and commercialised. In this section we look at the effectiveness of different forms of support.

4.2 Different fuels and conversion technologies are at different stages of development and commercialisation, so no one mechanism is likely to be effective in supporting all fuels. The following list of mechanisms is not intended to be exhaustive and is therefore set out to provoke ideas and discussion. We are keen to see any new ideas that respondents to the call for evidence might wish to suggest.

4.3 Figure 4.1 below is one model of how new technologies are developed and commercialised.

Figure 4.1: Development and commercialisation of new technologies



(source: Energy Research Partnership)

4.4 The Low Carbon Innovation Co-ordination Group, a group of UK public-sector funders of low-carbon innovation, published a Technology Impacts Needs Assessment for the bioenergy sector in 2012. This considered what support is currently offered for the development of bioenergy technologies in the UK.

Table 4.1: UK support for development of bioenergy technologies

Market pull (demand side)	**Technology push** (supply side)	**Enablers**
Cross Cutting: EU Renewable Energy Directive ***New Energy Crops:*** RO ***Biomethane:*** RH I, FiT ***Bioheat:*** Renewable Heat Incentive (RHI), Bioenergy Capital Grants Scheme, FiT ***Biopower:*** Renewables Obligation (RO), Carbon price, via the EU Energy Trading Scheme (ETS) ***Advanced Biofuels:*** Renewable Transport Fuel Obligation (RTFO), Preferential tax regime, Fuel Quality Directive	***Cross Cutting:*** University research – primarily funded through the re search councils (especially BBSRC and EPSRC, whose funding predominantly goes to BSBEC and SUPERGEN respectively), ETI, TSB, TSEC, EU FP7, EIBI, Regional Growth Fund ***New Energy Crops:*** BBSRC/ DEFRA Miscanthus improvement programme, Rothamsted national Willow collection, ENERGYPOPLAR funded by the FP7, SAMs algae research programmes, Energy Crops Scheme ***Biomethane:*** Waste & Resources Action Programme (WRAP) ***Bioheat:*** Carbon Trust Biomass Heat Accelerator ***Biopower:*** ETI waste from energy programme and CCS biopower engineering research ***Advancd Biofuels:*** Carbon Trust Pyrolysis Accelerator, CoEBIO3, Select project development support (e.g. Ineos Bio)	- Centre for Process Innovation (CPI) - Energy Technologies Institute (ETI) **Representative Bodies:** - National Farmers Union (NFU) - National Non-Food Crops Centre (NNFCC) - Forestry Commission - Renewable Energy Association (REA) - National Industrial Symbiosis Programme (NISP)

(source: Low Carbon Innovation Co-ordination Group, 2012, Bioenergy Technology Innovation Needs Assessment)

4.5 Below we have outlined several possible support mechanisms for advanced fuels, focussed on the 'market pull' or supply side. We are interested in views and evidence on the effectiveness of these measures or any other feasible options. Further development of any of these options would need full consultation. Any spending commitments would be subject to future spending review decisions. We envisage that these polices would be either additional to or part of the current RTFO, rather than a replacement for it. Therefore, we also welcome views on how these policies would effectively interface with the existing support that biofuels receive through the RTFO.

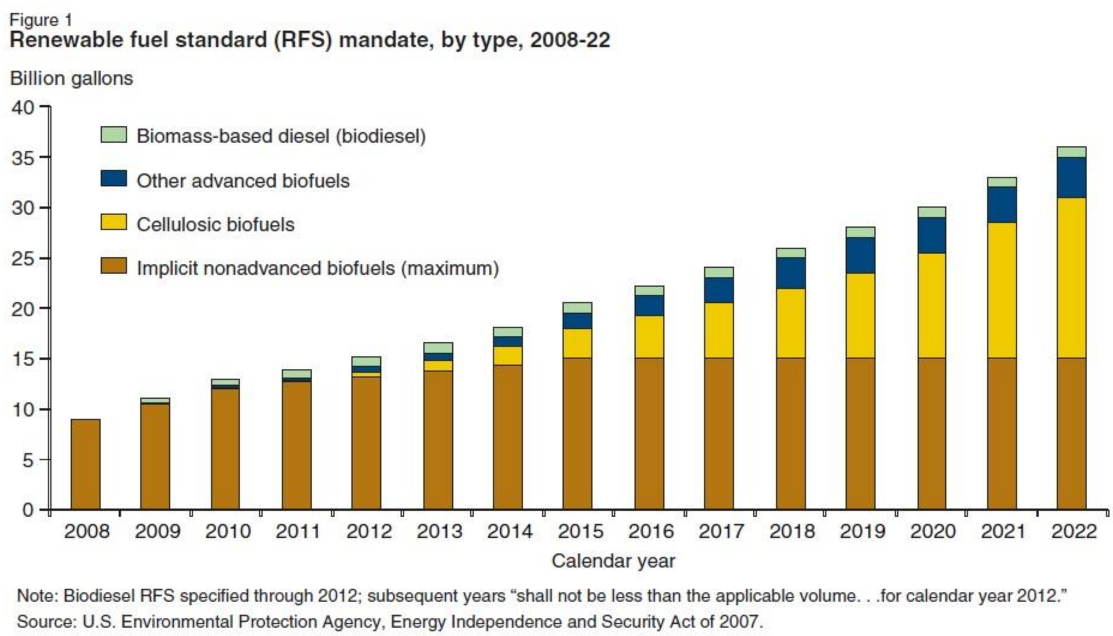
Sub-targets within a supply obligation

4.6 A sub-target for advanced fuels could operate in much the same way as the RTFO, and could potentially be operated as part of the current obligation. Suppliers could be obligated to supply a given volume of advanced fuels with the option to pay a buy-out price if they are unable to supply the fuel.

4.7 A possible model for this option could be the US Renewable Fuel Standard (or RFS). Under this system, fuel suppliers are required to blend a specified proportion of biofuel into their fuel or meet this obligation through trading credits.

4.8 The RFS creates four different obligations for each fuel supplier that they must meet each year. The most significant of these in terms of the development of advanced fuels is the ambitious mandate for cellulosic biofuels.

Figure 4.1: U.S. Renewable Fuel Standard mandate



(source: U.S. Department of Agriculture Economic Research Service)

4.9 A risk with setting firm targets is that a sub-target might simply not be met, as insufficient production capacity is available to meet it.

4.10 If suppliers cannot meet a target, they might be required to pay some sort of penalty, similar to the buy-out price in the current RTFO. This buy-out price would then effectively become a ceiling on the cost of advanced biofuels. Any supplier who could produce a product for less than this price would be reasonably confident of having a market, provided that their production costs were not any higher than those of other advanced fuel producers.

4.11 Alternatively, if there is insufficient supply government could waive the target. From 2010-12 the US Environmental Protection Agency who administer the RFS, were forced to reduce the requirement for cellulosic biofuels due to a lack of supply in the market. This approach would give less market certainty for suppliers.

Fixed-price support

4.12 Under this option a guaranteed price would be offered for advanced fuels. Such a guarantee could potentially be delivered through a number of mechanisms including a price floor (as seen in the UK carbon price floor), contracts for difference (as proposed in the UK government's electricity market reform programme) or an obligation to purchase at a fixed price (like Feed-in Tariffs in the electricity market).

4.13 Given the uncertainty around advanced fuel production costs, determining a price level that encourages investment and development would pose a challenge under this arrangement. This could potentially be determined through administrative price setting (e.g. set by government officials as in the Feed in Tariffs) or through a market based process (e.g. as in auctions used under the non-fossil fuel obligation which operated in the electricity market).

4.14 An interesting aspect of these kinds of system is that support could be offered directly to the producer of the fuel, rather than to fuel suppliers. This would create a more direct link between government support and the technology being used. This approach would therefore be a more direct way of supporting the commercialisation of specific technologies. This presents a clear contrast with some other, more technology neutral, approaches.

Multiple certificates within a supply obligation

4.15 Under this option the production of advanced fuels would be incentivised within the current RTFO structure. At present the most sustainable biofuels, those derived from wastes, residues and some advanced feedstocks, are double-counted. This means that their supply attracts twice as many certificates as biofuels that are not double-counted. This has the effect of increasing suppliers' willingness to pay for these fuels and increasing supply.

4.16 A similar system could be set up for other advanced fuels by counting them multiple times within the RTFO. Further work would be needed to determine how many multiples each advanced fuel is assigned, and on what basis.

A carbon-linked supply obligation

4.17 A similar approach to multiple certificates would be to reward fuels supplied on the basis of the carbon saving that they made. These carbon calculations are already carried out to ensure that biofuels meet the minimum carbon saving criteria required under the RED.

4.18 This would offer greater support to advanced fuels than to first generation fuels, as advanced fuels tend to produce higher carbon savings. This would be a more technology neutral approach than some of the others considered above, which by design would make no distinction between mature and emerging technologies. This kind of system has already been introduced in the US through the California Low-Carbon Fuel Standard.

4.19 This system would not only affect the support offered for low-carbon fuels, it could also affect the way the obligation is incurred. As different kinds of fossil fuel have different carbon intensities (for example, natural gas has lower GHG emissions per unit of energy than diesel), the obligation would also be incurred on a different basis.

Q8. What support mechanisms could most effectively support the development and deployment of advanced fuels in the UK?

8a. If government intervention is necessary, should the focus be on ‘technology push’ or ‘market pull’?

8b. Which of the listed supply side mechanisms would be most effective? What alternatives have we missed?

8c. What factors would be key in your decision to invest in a UK advanced fuel production capacity? How would the listed mechanisms affect them?

8d. Are you aware of any risks, problems or unintended consequences which could arise from introducing these market mechanisms?

8e. Some of the listed mechanisms could run alongside existing support for biofuels under the RTFO. What would be the likely consequences of this interaction? Would it be advantageous to offer both forms of support to advanced fuels, with a new support mechanism acting in addition to the RTFO?

Summary of call for evidence questions

1. Should the government focus support for advanced fuels in certain transport sectors? If so, why?

- 1a. What are your views on the government's analysis of the use of advanced biofuels in different transport sectors, as set out in the UK Bioenergy Strategy? Are you aware of alternative estimates of the future uptake of advanced fuels in each transport sector?
- 1b. What physical and policy barriers are there to the uptake of advanced fuels in each transport sector?

2. Is UK government support necessary to commercialise advanced fuel technologies? If so, why?

- 2a. What should 'advanced' mean? What role should process, feedstock and sustainability have in this definition?
- 2b. What economic opportunities are there for the UK in developing this industry?

3. What could advanced biofuels deliver, and by when?

- 3a. Do you agree with E4Tech's assessment of the technology readiness of different advanced fuel technologies?
- 3b. Do you agree with E4Tech's assessment on the availability of waste and residue feedstocks, and their estimated costs of advanced fuels?
- 3c. Do you agree with E4Tech's proposed criteria for when an advanced biofuel should be supported?

4. What could hydrogen deliver as a transport fuel, and by when?

5. What could synthetic fuels and fuels from fossil waste deliver, and by when?

- 5a. How do we determine the extent to which synthetic fuels from electricity are renewable?
- 5b. What information can you provide on waste fossil gas processes and their potential benefits and drawbacks?

6. What could biomethane deliver as a transport fuel, and by when?

7. Which 'nearly' wholly renewable fuels are close to commercialisation? What evidence do you have of the percentage of their inputs that are renewable?

8. What support mechanisms could effectively support the deployment of advanced fuels?

- 8a. If government intervention is necessary, should the focus be on 'market pull' or 'technology push'?
- 8b.Which of the listed mechanisms would be most effective? What alternatives have we missed?
- 8c. What factors would be key in your decision to invest in a UK advanced fuel production capacity? How would the listed mechanisms affect them?
- 8d. Are you aware of any risks, problems or unintended consequences which could arise from introducing these market mechanisms?
- 8e. How might each of these mechanisms interact with the current support offered for biofuels under the RTFO? What would be the likely consequences of this interaction? Would it be advantageous to offer both forms of support to advanced fuels, with a new support mechanism acting in addition to the RTFO?