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1. Executive Summary

1.1. The challenge

Concerns over the impacts of biofuels on land use change and food prices provide a driver for promoting biofuels produced from feedstock that do not compete with land for food production. Using a range of wastes and residues, and possibly non-food crops, would alleviate these concerns. But, biofuels produced from non-food feedstocks, lignocellulosic feedstocks in particular, are not yet commercially available.

It is widely accepted that one of the key aspects hindering the progression from pilot to demonstration plant, and from demonstration to commercial plant is the scale and risk associated with the required investment. Developers have also been unable to raise this finance because of the uncertainty around biofuels policy beyond 2020 and, therefore, the size of the future market. From a technology perspective, the component processes for making a number of advanced biofuels have now been proven, but the costs associated with developing integrated demonstration and first commercial plants, and uncertainty in market uptake and value of the output fuels, remain a significant barrier to realising commercial production. Those technologies that have reached, or will soon reach, large demonstration or early commercial scale have done so with public sector funding.

1.2. Rationale for the Competition

Whilst the UK has world leading research and engineering capabilities in advanced biofuel technologies, it does not currently have any large scale demonstration or early commercial plants in operation or construction. UK technology companies have however demonstrated an interest in developing technologies elsewhere, where a combination of market pull, financial support and existing infrastructure has made these regions more attractive. European initiatives, such as ERANET Plus and Horizon 2020, may provide investment and demonstration opportunities in the UK, but, to date, funding for demonstration activities has found its way to countries with established support for the scale up of the sector.

DfT announced in August 2013 that it would make £25m of capital funding available for an advanced biofuel demonstration competition, which would underpin significant private sector investment in the development of such facilities in the UK. The aims of the Competition are to:

- Allow the UK to make progress in meeting its 2020 RED target, whilst uncertainty remains over the extent to which conventional biofuels may contribute towards this target;
- Reduce greenhouse gas emissions from transport (to and beyond 2020);
- Increase manufacturing and economic activity in the UK; and
- Increase innovation and intellectual property development in the UK.

This feasibility study concludes that there is opportunity for a UK Competition to support projects that increase the Technology Readiness Levels (TRL) of advanced biofuels, promoting technologies at pilot and small-scale demonstration stages (TRL 5-6) to small or large scale demonstration (TRL 6-7). Such activities have the potential to deliver the Department for Transport's stated objectives for the Competition, where proposals also demonstrate exploitation of intellectual property for UK benefit and potential for future commercial deployment of the technology in the UK.

Analysis demonstrates how the wider UK economy could benefit from the development of the advanced biofuel sector. The Competition would be an important means to stimulate private investment in the UK and participate in the value generated by the growth of the industry in the UK and globally. The potential Gross Value Added to the UK economy from the sector could be up to £120M – £170M per year in 2020, rising to up to £260M – £520M per year in 2030.

As seen in other countries, continued technology development to commercial deployment is likely to require on-going support, either from existing or new schemes. The lack of a supportive policy framework (especially beyond 2020) remains a barrier to the commercialisation of advanced biofuels, and, whilst the Competition may proceed without this policy framework in place, there is a risk that further deployment will not be realised if policy uncertainty is not also addressed.

1.3. Ambition and aim of the Competition

The ambition of the Competition is to pave the way for a first-of-a-kind commercial scale plant, by reducing the associated technological risk. The advanced biofuel chain demonstrated should have the potential for significant economic and environmental impact, in terms of development or demonstration of intellectual property, job creation, economic growth and reducing greenhouse gas emissions through the supply of low carbon sustainable fuels.

The aim of the Competition will be to prove that the production of advanced biofuels is technically viable, and to test the economic viability at a commercial scale.

In order to ensure the Competition achieves its stated objectives and contributes more generally to sustainable road transport, it is necessary to clearly define the scope of the Competition and provide criteria to assess the eligibility of proposed projects. This includes defining "advanced biofuels" for the purpose of the Competition. The definition most compatible with the Competition objectives is:

Biofuels delivering high greenhouse gas emissions savings produced from sustainable, non-food feedstocks via not yet commercial conversion technologies.

1.4. Scope of the Competition and eligibility of projects

This study finds that to meet the objectives stated by the Department for Transport, proposals must apply technologies suitable for the conversion of sustainable, non-food feedstocks to transport fuels in the UK. Proposed projects should increase the TRL of the technology, promoting technologies already at TRL 5-6 to TRL 6-7, and should produce fuels suitable for use in one or more transport modes.

So that projects may be evaluated against their potential contribution towards the Competition objectives, proposals must include performance and cost targets, intellectual property and technology exploitation plans, and a business case for the deployment of the technology. They should also provide evidence regarding the sustainability of the feedstocks used by the technology, including alternative uses of the feedstocks and the indirect environmental and social impacts associated with their use for biofuel production. Important considerations in the selection of projects will be the development and exploitation of intellectual property for UK benefit, and the future commercial deployment of the technology in the UK.

The application must be made by a legal entity established in the UK. This does not exclude partnership with legal entities not established in the UK.

1.5. Feasibility and viability of the Competition

The study concludes that the State Aids block exemption for Environmental Protection is the most suitable route to support advanced biofuel demonstration projects. It is important to note that only the additional costs of an advanced biofuels demonstration plant compared to the costs of a conventional plant (for example a first generation biofuel plant) are eligible for calculating aid intensity, which should typically not exceed 45% of the eligible costs, except for SMEs.

In light of this, the proposed £25M budget for the Competition may support one or more TRL 6 demonstration project; however there is a risk that it may be insufficient to support TRL 7 demonstration, as the total investment costs for this scale of demonstration are estimated at £80M – £200M. The Competition should invite applications for activities at both TRL 6 and 7, and proposals should be evaluated and compared based on their ability to meet all of the Competition objectives. Based on the currently proposed funding, it is anticipated that proposals will request a contribution of between £5M and £25M.

To ensure Competition objectives are achieved and risks mitigated, the study recommends that the Competition should consist of a two stage application process with a call for Expressions of Interest as a first step followed by full proposals. Also, a high standard of external or internal programme management, supported by appropriate expertise, particularly in the evaluation process, will be critical to the success of the Competition.

The skills and expertise required to evaluate applications include knowledge of advanced biofuel conversion technologies, and the ability to evaluate degree of innovation, technical risk, engineering design, and scalability; knowledge of advanced biofuel feedstocks, including resource availability, prices, composition (feedstock and technology interface), and any related regulatory issues; knowledge of supply chains and of biofuel markets; and the ability to critically appraise business cases.

1.6. Proposal evaluation criteria

Proposals should be evaluated against three equally weighted sets of criteria: appropriateness, impact, and implementation. The appropriateness and impact relate to the ability of the project to meet the Competition objectives, and implementation relates to the robustness of the proposal and likelihood of successful delivery. The value for money of the project, defined as the private investment leveraged by the project and by its impact on continued development, commercialisation and the UK economy, is considered as part of the impact category.

1.7. Conclusion

A UK Competition on advanced biofuels would place the UK on the global map of nations supporting their commercialisation. Current status of development of the sector means that there is potential for additionality from UK public funding to the sector, which could support the development of UK industry related to the sector and the deployment of technology in the UK, and attract international players to the UK. This feasibility study concludes that there is opportunity for a UK Competition to support one or more advanced biofuel demonstration project, within the proposed £25M budget. However, the funding available may not be able to support some of the more cost intensive technologies and may be restricted in terms of the large scale demonstration activities it could fund (TRL 7). As a result, the Competition should invite applications for activities at both TRL 6 and 7, and this may be most effectively done through a two stage application process. All scales of demonstration may deliver against the

Competition objectives, where proposals demonstrate exploitation of intellectual property for UK benefit and potential for future commercial deployment of the technology in the UK and elsewhere, but their contribution towards the 2020 RED targets would be limited.

The Competition would be an important means to promote the UK's participation in the global advanced biofuels market, which could contribute up to £260M - £520M per year to the UK economy in 2030, and initiate the deployment of the technology in the UK.

2. Introduction

2.1. Background

In order for the UK to meet its obligations under the EU's Renewable Energy Directive (RED) and Fuel Quality Directive (FQD), significant additional renewable transport fuels and emissions reductions are required from the transport sector by 2020. Biofuels remain the single most significant option for the UK and other Member States (MS) to achieve these targets. However, there is an increasing desire at both EU and MS level to promote a shift from conventional biofuels made from food crops to biofuels made from feedstocks that do not compete with food and feed production. This is largely because of concerns around the use of conventional biofuels having significant impacts, either on food prices or on land use (and consequently biodiversity and greenhouse gas emissions). Biofuels based on wastes and residues are an increasingly attractive option, although they are not yet being produced in commercially significant volumes (with the exception of hydro-treated waste oils and fats, and methanol from crude glycerine). There are also technical issues with biodiesel (FAME) and ethanol biofuels, such as vehicle blend walls, which make new "drop-in" biofuels attractive, since they can be blended with conventional fuels at much higher levels. Recent proposals for amending the RED have included a list-based approach to defining 'advanced' feedstocks that would count double or quadruple towards national renewable transport targets, or towards a 2020 sub-target within the overall 10% target, although with considerable debate over the level proposed (no sub-target, 1%, 2.5% or at each MS's discretion), and which feedstocks will be defined as 'advanced'.

Despite the continuing policy uncertainty, there is increasing impetus for the use of "advanced biofuels" by 2020. Since these fuels are not being produced in commercial volumes, there is pressure on governments to speed up and facilitate their progression to commercialisation. It is widely accepted that one of the key aspects limiting the progression from pilot to demonstration plant, and from demonstration to commercial plant is the scale and risk associated with the required investment. Developers have been unable to raise this finance also because of the uncertainty around biofuel policy and the size of the future market. From a technology perspective, the component processes for making a number of advanced biofuels have now been proven, but the costs associated with developing integrated demonstration and first commercial plants, and uncertainty in market uptake and value of the output fuels, remain a significant barrier to realising commercial production.

There are a number of advanced biofuel pilot and demonstration plants in the EU, the US, Brazil and China. The development of first-of-a-kind commercial plants is also under way in some of these regions. The UK, however, does not have any such projects under construction, which may be a cause for concern in terms of missed economic opportunities as well as limiting its options for meeting GHG targets. In light of the UK's position in relation to meeting the RED and FQD targets and the potential attractiveness of advanced biofuels, DfT announced in August 2013 that it would make £25m of capital funding available for an advanced biofuel demonstration competition, which would underpin significant private sector investment in the development of such facilities in the UK.

The aims of the competition are to:

- Allow the UK to make progress in meeting its 2020 RED target, whilst uncertainty remains over the extent to which conventional biofuels may contribute towards this target;
- Reduce GHG emissions from transport (to and beyond 2020);

- Increase manufacturing and economic activity in the UK; and
- Increase innovation and intellectual property (IP) development in the UK.

2.2. Aims of the study

The aim of this feasibility study is to provide the Government with sufficient information to develop, launch, and manage a competition that delivers demonstration scale advanced biofuel plants that will support the development of a UK industry. The specific requirements of this study are therefore to:

- Outline the current status of advanced biofuels development, and make recommendations for a working definition of advanced biofuels.
- Describe the business case for the competition, including potential benefits to the UK, barriers to commercialisation, and existing funding schemes.
- Identify what the competition should support, based on project eligibility criteria and other practical considerations.
- Provide details on the viability of the competition, including details of potential bidders, an assessment of risks, and a timeframe for the competition.
- Provide views on competition design, including funding options, state aids implications, options for competition delivery, and requirements of delivery partners.

The consortium have gathered information from other projects, reviewed existing schemes and legislation, and gathered stakeholder comments via interviews and a dedicated workshop held on Friday 29th November 2013.

2.3. Definition of advanced biofuels

There is no industry-wide agreed definition of the term “advanced biofuels”. The term is generally used to describe biofuels from technology pathways that have not yet reached commercial status, biofuels produced from residues, wastes or non-food feedstocks considered to be more sustainable than the biofuel crops commonly used today, or “drop-in” biofuels whose molecules fit the existing fuels infrastructure. When launched, the Competition must provide a clear definition of eligible biofuels to ensure it attracts appropriate applications that meet the Department’s objectives. This section outlines the current status of feedstocks and conversion technologies for the production of advanced biofuels, considers which definitions are most compatible with the competition objectives, and makes recommendations for a working definition of “advanced biofuels” for the purpose of the Competition.

2.4. Current status of technologies

There are a large number of conversion technologies under development for the production of biofuels. The main conversion technologies and possible process routes are illustrated in Figure 1. Two process routes are operating at commercial scale and have reached mass deployment; trans-esterification of vegetable oils and waste oils and fats to produce FAME biodiesel, and yeast or bacterial fermentation of C6 sugars (from sugar or starch crops) to produce ethanol. Two other process routes are operating at commercial scale with more than one technology provider deploying early commercial scale plants; hydro-treatment of vegetable oils, and waste oils and fats to produce HVO (diesel and jet fuel), and anaerobic digestion of crops, agricultural residues and wastes to produce biogas with subsequent upgrading to biomethane. A first-of-a-kind commercial plant producing methanol from glycerine is operating in the Netherlands – although this does not involve gasification of solid feedstocks.

The remaining conversion technologies are at different stages of development from applied research to full-scale first-of-a-kind commercial plants, and the following section discusses the status of conversion technologies not yet operating at commercial scale and the prospects for demonstration in the UK. Development status is discussed in terms of technology readiness level (TRL); a relative measure of the maturity of evolving technologies. TRLs are measured on a scale of 1 to 9, where TRL 1 corresponds to basic research on a new invention or concept, and TRL 9 corresponds to a fully commercialised technology. The definitions of each TRL are given in Table 1.

Annex 1 provides a high level description for each process route, and details of planned and operational plants, potential feedstocks, current actors, and innovation needs reported by the Bioenergy Technology and Innovation Needs Assessments (TINA) (Carbon Trust, 2012) , and updated for this study. This information forms the basis of the following review.

Table 1: Technology readiness levels definitions (E4tech, 2012)

TRL	Definition	Plant stage
1	Basic principles observed and reported	Basic research
2	Technology concept and/or application formulated	Theoretical research
3	Analytical and experimental critical function and/or characteristic proof of concept	Applied research
4	Technology component and/or basic technology sub-system validation in a laboratory environment	Bench-scale test rig
5	Technology component and/or basic sub-system validation in a relevant environment	Pilot plant
6	Technology system/subsystem model or prototype demonstration in a relevant environment	Small-scale demonstration plant
7	Technology system prototype demonstration in an operational environment	Full-scale demonstration plant
8	Actual technology system completed and qualified through test and demonstration	First commercial plants
9	Technology system “qualified” through successful mission operations	Mass deployment of fully commercial plants

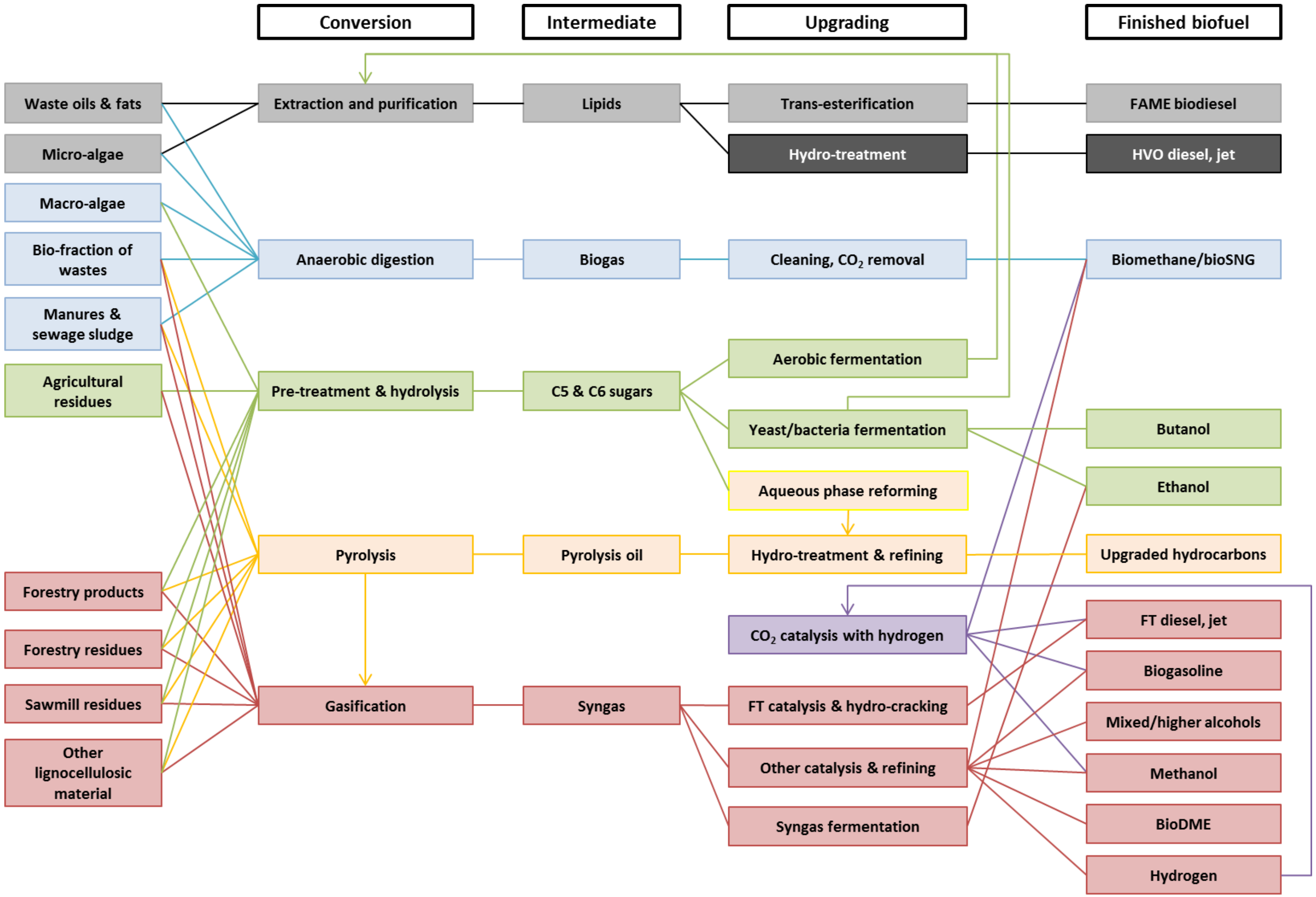

Figure 1 Potential conversion technologies and routes for the production of biofuels from non-food crops

2.4.1. Fermentation of C5 and C6 sugars to alcohols

Ethanol

There are around six technology providers operating or planning full-scale demonstration plants in Europe and around nine in the US. In addition there are a large number of technology developers at an earlier stage of development. The UK does not currently have any lignocellulosic ethanol demonstration or commercial plants under development. TMO Renewables operated a pilot plant in the UK from 2008 until recently, when the company entered receivership.

Commercialisation is dependent on the successful commissioning and operation of the full-scale demonstration plants under construction; development and demonstration of improved pre-treatment technologies to enable higher conversion efficiencies; maximisation of co-product revenues; and optimisation of hydrolysis and fermentation for C5 sugars. Further work is also required on reducing capital costs and successfully demonstrating consolidated bio-processing techniques.

The first full-scale demonstration plant came online in 2013 with several expected to follow in 2014. Many European plants plan to use wheat straw as either the sole feedstock or along with other agricultural residues. The opportunity to transfer the technology to the UK following successful demonstration elsewhere in Europe is therefore seen to be high. LC ethanol plants may be operational in the UK by 2020, provided the right conditions for investment are established. This is not to say that this technology should be excluded from the competition, as the UK has strong research strength in fermentation technologies, and there are a number of technologies and players at earlier stages of development. There may be value in supporting the development of such technologies, in particular where value to the UK could be realised through IP development, improved efficiency and/or reduced production costs.

Butanol

There are three main technology providers operating pilot or small scale demonstration plants for the conversion of lignocellulosic feedstocks to butanol: Green Biologics, American Process and Cobalt Biofuels. Green Biologics is a UK based company commercialising technology developed at Oxford University. The UK does not have any LC butanol plants, but does have a pilot butanol production plant producing butanol from starches and sugars, the Butamax plant in Hull (Butamax is a Joint Venture between BP and Dupont). Both Butamax and Gevo intend to build plants using lignocellulosic sugars in the future.

If current development activities are successful and learning from LC ethanol development is applied to LC butanol, it is possible that the commercial development of LC butanol may follow LC ethanol (a few years behind), in which case commercial plants could be operating in 2020.

While the high feedstock availability and the opportunity to co-locate with existing fermentation plants may make other regions such as the US and Brazil more attractive for LC butanol production, there is a case for the deployment of UK IP globally.

2.4.2. Gasification and catalytic synthesis

Technology providers active in the supply chain include biomass gasification developers, and syngas clean-up and catalyst providers. A number of pilot and small scale integrated demonstration plants are operating in Europe, including REPOTEC/CTU and ECN producing bioSNG, and Chemrec and Bioliq producing bioDME. Velocys have demonstrated their FT-micro channel reactor technology producing FT diesel and jet fuels in Gussing, and have installed their first commercial units in GTL plants. BioMCN have a first-of-a-kind commercial plant in the Netherlands, cracking crude glycerine to syngas, and synthesis of methanol. At 250 ML/yr, this is the largest advanced biofuel plant in the world – although this does not involve gasification of solid feedstocks.

In North America, Enerkem are constructing a large-scale mixed alcohols demonstration plant, and Haldor Topsoe & GTI have produced FT liquids at pilot scale. The UK has some leading catalyst technology providers including BP, Johnson Matthey and Velocys (previously Oxford Catalysts), but no providers of large-scale biomass gasification technology suitable for liquid fuels synthesis.

There are several full-scale demonstration plants planned in Europe (several with NER300 funding) and in North America, including FT liquids, bioSNG, bioDME, methanol and mixed alcohol production. In the UK, British Airways have partnered with gasification providers Solena to develop a FT jet fuel project based on wastes; however no investment decision has been reached on the project. Advanced Plasma Power, in collaboration with National Grid, have plans to build a demonstration plant producing bioSNG from waste, the project has been awarded £1.9M of funding from Ofgem's Gas Network Innovation Competition. Air Products are constructing a waste gasification plant, that will initially generate electricity, but they have expressed an interest in the future to consider hydrogen production.

The key to achieving commercial deployment is the successful commissioning and operation of integrated full-scale demonstration plants. The different component parts have been demonstrated at pilot scale, hence the integration of these technologies and demonstration of reliable operation and output is the next stage for commercialisation. In addition, improvements in catalysts and syngas clean-up will improve reliability, reduce production costs, and improve the economics of small scale plants.

The UK has the opportunity to deliver a large scale gasification and FT-synthesis project by 2020, as illustrated by the interest and activity of Solena and British Airways.

2.4.3. **Gasification with syngas fermentation**

There are three main actors working on all or part of the syngas fermentation route. INEOS Bio is the most advanced as its full-scale integrated demonstration plant (using vegetable and wood waste) completed commissioning in 2013 in Florida, US. INEOS Bio previously had plans to build a 30 million litre plant in the UK, but this prospect seems unlikely to progress, as the company is now focusing its efforts on other markets.

Lanzatech are initially working on converting industrial waste gases to ethanol. The fuels produced are not bio-based, but were included in some of the RED proposals, and so it is yet to be seen if these fuels will be eligible to contribute towards the RED transport targets. Coskata is in a similar position, as it is currently only focusing on natural gas and fossil feedstocks.

Commercialisation is dependent on the successful ramp-up and operation of integrated demonstration plants. Similar to the catalytic synthesis routes, improvements in gasification and syngas clean-up will improve reliability, reduce production costs, and improve the economics of small scale plants – syngas fermentation also would benefit from yield and productivity increases, plus reduced parasitic energy consumption. There is still an opportunity for the technology to be deployed in the UK by 2020.

2.4.4. **Pyrolysis and upgrading**

Several companies have demonstrated fast pyrolysis processes, and a smaller number of developers are developing the upgrading of pyrolysis oil to transport fuels, which is currently operated at pilot and small demonstration scales (either via stand-alone plants or integrated into existing refinery infrastructure). The majority of activity is in the US. In the UK, Future Blends is developing pyrolysis and pyrolysis oil upgrading at pilot scale with funding from the Carbon Trust's Pyrolysis Challenge.

The next stage for pyrolysis upgrading is (full-scale) demonstration, and commercialisation will depend on the ability to demonstrate reliable operation, and improved bio-oil stability and quality. There is potential to develop a UK demonstration plant based on pyrolysis, however, the ability of the technology to deliver commercial quantities of fuel in 2020 is limited.

2.4.5. **Novel sugar based routes**

Other novel synthesis routes to produce transport fuels include biological catalysts (e.g. LS9), heterotrophic algae fermentation (e.g. Solazyme, BP-DSM), or modified yeast (e.g. Amyris), and aqueous phase reforming to produce a mixture of alcohols, ketones, acids and furans (e.g. Virent). Many actors are currently using sugars produced from sugar cane or corn, there is however opportunity to use sugars derived from lignocellulose in the future. Some of the routes produce chemicals that require further upgrading to reach a transport fuel (e.g. lipids into biodiesel, hydrogenation of farnesene, ketones and acids).

The majority of these technologies are at research or pilot stage development (TRL 3-5). However, Amyris and Solazyme are operating or building demonstration plants at TRL 6. Most actors working on novel sugar based routes are active in the US and Brazil. BP is the only actor with origins in the UK; however its sugar-to-diesel operations are based in the US.

2.4.6. **Considerations from technology status review**

The current status of biofuel conversion technologies is summarised in Figure 2. There are a small number of technologies at full demonstration stage (TRL 7), including LC ethanol and syngas fermentation. A larger number of conversion technologies are between TRL 5 and 6, including biological, thermochemical and hybrid pathways. These pathways will be looking to establish demonstration plants as the next stage towards commercialisation.

The UK has strong technology companies and other service providers operating across the majority of advanced biofuel pathways reviewed in Annex 1. However, it is likely that any advanced biofuel conversion pathway would be delivered by an international collaboration of technology providers. It is evident that the majority of UK technology companies are focussing their interest in developing advanced biofuel conversion technologies elsewhere, particularly in the US, and Brazil, where a combination of clear markets, financial support and existing infrastructure has made these regions more attractive.

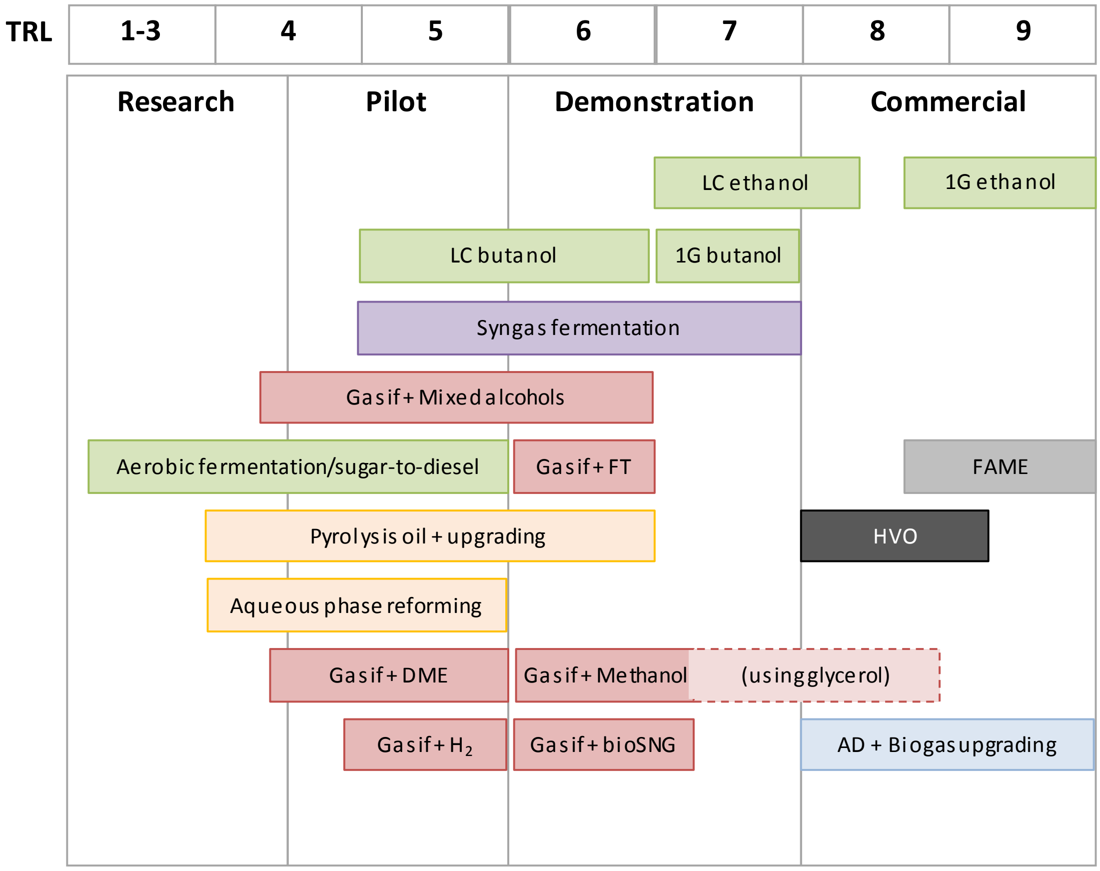

Figure 2: Current TRL status of the main conversion technologies (E4tech, 2013a)

2.5. Feedstocks

To count towards the UK's renewable energy targets, biofuel must be derived from feedstocks that meet the sustainability criteria defined under the RED. The current debate and negotiations on the impact of indirect land use change (ILUC) and potential mitigation measures mean that it is possible that biofuels will be subject to more stringent sustainability criteria to contribute to the 2020 RED target, and any renewable energy targets or GHG emissions targets that are set beyond 2020.

In a move to promote greater harmonisation between Member States, the European Commission has proposed a list-based approach for defining feedstocks that are proposed to count double (or quadruple) towards national renewable transport targets, and/or count towards a possible 2020 sub-target for advanced biofuels. There are approximately 28 feedstocks included in the Annex IX lists (depending on the version) covering the vast majority of wastes, residues, lignocellulosic and non-food cellulosic materials plus other potential (non-bio) sources.

Only Used Cooking Oil (UCO), animal fats and crude glycerine are currently used in commercial biofuel facilities within Europe. The rest of the Annex IX list comprises feedstocks that require conversion via technologies yet to be successfully scaled-up and commercialised, except for waste converted to biomethane via AD.

Due to the failure in recent months of the European Council, Commission and Parliament to reach a compromise and agree on a way forward on the ILUC issue, these Annex IX proposals remain unimplemented proposals with no legal weight. However, the Annex IX feedstocks are expected to form the basis of feedstocks submitted for evaluation by Competition entrants, and therefore the recent sustainability assessment of Annex IX feedstocks carried out by E4tech for the DfT is highly relevant to the Competition (E4tech, 2013a). The recommendations made in this study are outlined below.

2.5.1. **Sustainability assessment of 'advanced' feedstocks**

The Annex IX study recommended the following hierarchy of questions to determine the eligibility of feedstocks for additional policy support (illustrated as a flow diagram in Figure 3), and it is recommended that the same process is used to evaluate the feedstocks for the Competition:

1. What is it classified as: a waste or processing residue (non-land using), or alternatively, an agricultural/forestry residue, co-product or product (land using)?
2. If land using, what type of land does it come from? Has the conversion of high biodiversity, high carbon stock or peat land been avoided?
3. What are the key competing uses, and potential substitute resources? Would diversion to biofuels result in a high risk of unacceptable carbon, cost, environmental or social impacts – such as the knock-on use of more fossil fuels or land? (These risks can be volume and location dependent). Alternatively, for new non-food crops, is there a risk of competition for land with food?
4. Are the lifecycle GHG emissions savings of producing biofuel from the feedstock high enough (versus a suitable fossil comparator) to be supported? A threshold higher than 60% could be chosen by policymakers. The project estimated that all feedstocks are able to save at least 70% (many routes are around 90%), with the exception of micro-algae and macro-algae, which are around 60% (using the current comparator). Technical innovation leading to increased yields and lower energy inputs may lead to lower GHG emissions for algae routes.
5. Would use of the feedstock for biofuels be economically viable without support, and hence likely to be deployed? Or would deployment only occur with support, due to the lack of commercial readiness of the conversion technology, infrastructure investments required or other reasons? How does the £/tCO_2e saved compare between different routes?

2.5.2. **Suitability of Annex IX feedstocks for the Competition**

Applying these criteria across the whole of the Annex IX list leads to the following conclusions.

- Several feedstocks have a significant uncollected resource that could be diverted from current disposal, produced without indirect impacts, or sustainably extracted with limited competition. MSW, C&I wastes, manures, forest residues, small round-wood, and algae are likely to need further support to be economically viable or help to commercialise conversion technologies. UCO may not require additional support, depending on infrastructure investments to access domestic supplies, and should therefore not be considered a priority for the Competition.

- A few feedstocks may not be suitable for sustainable biofuel production, as they have multiple competing uses with high risks of indirect impacts – given current market dynamics and policies, these are likely to include crude glycerine, grape marcs and wine lees.
- Some feedstocks, such as animal fats, nut shells, husks, sawdust & cutter shavings, tall oil pitch, and brown & black liquor, should only be considered if the industries involved can show replacement of the missing energy demands with low carbon, sustainable alternatives – otherwise there is a risk of increased fossil fuel use offsetting any GHG savings.
- Other feedstocks face higher levels of competition, and hence only a smaller unused fraction of the total supply is likely to be at low risk of causing indirect impacts. This includes straw, cobs, sewage sludge, bagasse, and empty palm fruit bunches. The quantity of feedstocks required for demonstration activities is relatively small and therefore the risk of negative impacts on competing markets low, however applicants should take appropriate consideration of competing markets when estimating the potential for commercial deployment of the conversion technology.
- Energy crops and short rotation forestry have longer-term potential (post 2020), but will require enforcement of ILUC mitigation measures to ensure the land grown on avoids food competition as well as being low risk. Mitigation measures could include combinations of: use of land not in competition with food, promoting beneficial use of co-products, protecting high carbon stock land, above baseline yield increases, supply chain efficiencies and farming system integration. Again applicants should demonstrate appropriate consideration of these constraints when evaluating the potential for commercial deployment.

Regardless of the level of competing uses and substitute resources, additional sustainable feedstock supplies could be found for biofuels production if processes in competing use sectors are able to improve their efficiency, thereby releasing biomass material whilst still meeting the same system demands. This effect can apply to almost every feedstock, but will be particularly important for captive feedstocks such as black & brown liquor, waste carbon gases, palm oil mill effluent, animal manures and sewage sludge, along with those feedstocks with major uses in the heat & power sectors. Applicants may be able to provide evidence to demonstrate such improvements.

In terms of the Competition, we are therefore recommending that the findings of the Annex IX study are implemented to support conversion technologies with the potential to use sustainable feedstocks, taking into consideration the possibility to mitigate against indirect effects for those feedstocks that have a risk of increasing fossil emissions or land use (if diverted to biofuels), or use land directly (if new growth feedstocks such as energy crops).

Industrial waste carbon gases, whilst not bio-based, were included in some of the RED proposals. At present the fuels produced from industrial waste gases are not eligible to contribute towards the RED transport targets and it is yet to be seen if they will be included in future revisions. However, these routes may contribute towards GHG emissions savings in transport and are included in the Call for Evidence on Advanced Fuels. These routes would achieve some of the objectives of the Competition, particularly where the technology could in the future be applied to bio-based feedstocks. For these reasons the Department may wish to include such feedstocks in the Competition, in which case the competing uses of industrial gases must also be considered.

2.5.3. Feedstock location, and UK economic activity

Developing domestic supply chains would have several UK economic benefits, although any change in GHG savings compared to imported biomass and biofuels will depend on supply chain efficiencies, volumes, distances and transport modes – UK feedstocks are not necessarily lower emission than imports.

For the demonstration project, it is crucial to have a secure supply of feedstock(s) this may be best achieved using domestic or imported feedstocks, depending on the feedstock(s). In assessing the potential for commercial exploitation of the technology, applicants should consider the potential for deployment inside and outside of the UK. In respect to achieving the Competition objectives, projects with significant potential for UK deployment could be prioritised. Workshop participants agreed that UK feedstocks should be preferred over imports in the evaluation criteria, but not made a requirement.

2.6. Recommendations on a working definition of advanced biofuels

In order to ensure the Competition achieves its stated objectives and contributes more generally to sustainable road transport, it is necessary to clearly define the scope of the Competition and provide criteria to assess the eligibility of proposed projects. This includes defining “advanced biofuels” for the purpose of the Competition. The definition most compatible with the Competition objectives is:

Biofuels delivering high GHG emissions savings produced from sustainable, non-food[1] feedstocks via not yet commercial conversion technologies.

The Feasibility Study has focussed on biofuels, defined as fuels derived from plant or animal material, including the appropriate fraction of wastes, and not fuels produced from non-biological wastes, including waste gases, tyres and plastics. Processes for the conversion of these materials are gaining momentum, and the current Call for Evidence on Advanced Fuels seeks information on the potential for such products to contribute to carbon reductions in the transport sector. However, it is currently unclear if these fuels will contribute to the 2020 RED transport target.

The next section looks at the business case for supporting advanced biofuel development and considers the specific focus for the competition with regard to overcoming deployment barriers.

[1] A key aim of the Competition is to promote an increase in biofuel production capacity, whilst the debate over ILUC continues. In light of this, it is advisable that food-based feedstocks, which may in the future be subject to ILUC factors or to a cap, are excluded from the Competition. However, there is an argument that the development of new technologies based on food feedstocks or non-bio-based feedstocks could in the future be applied to wastes, residues and other lignocellulosic materials.

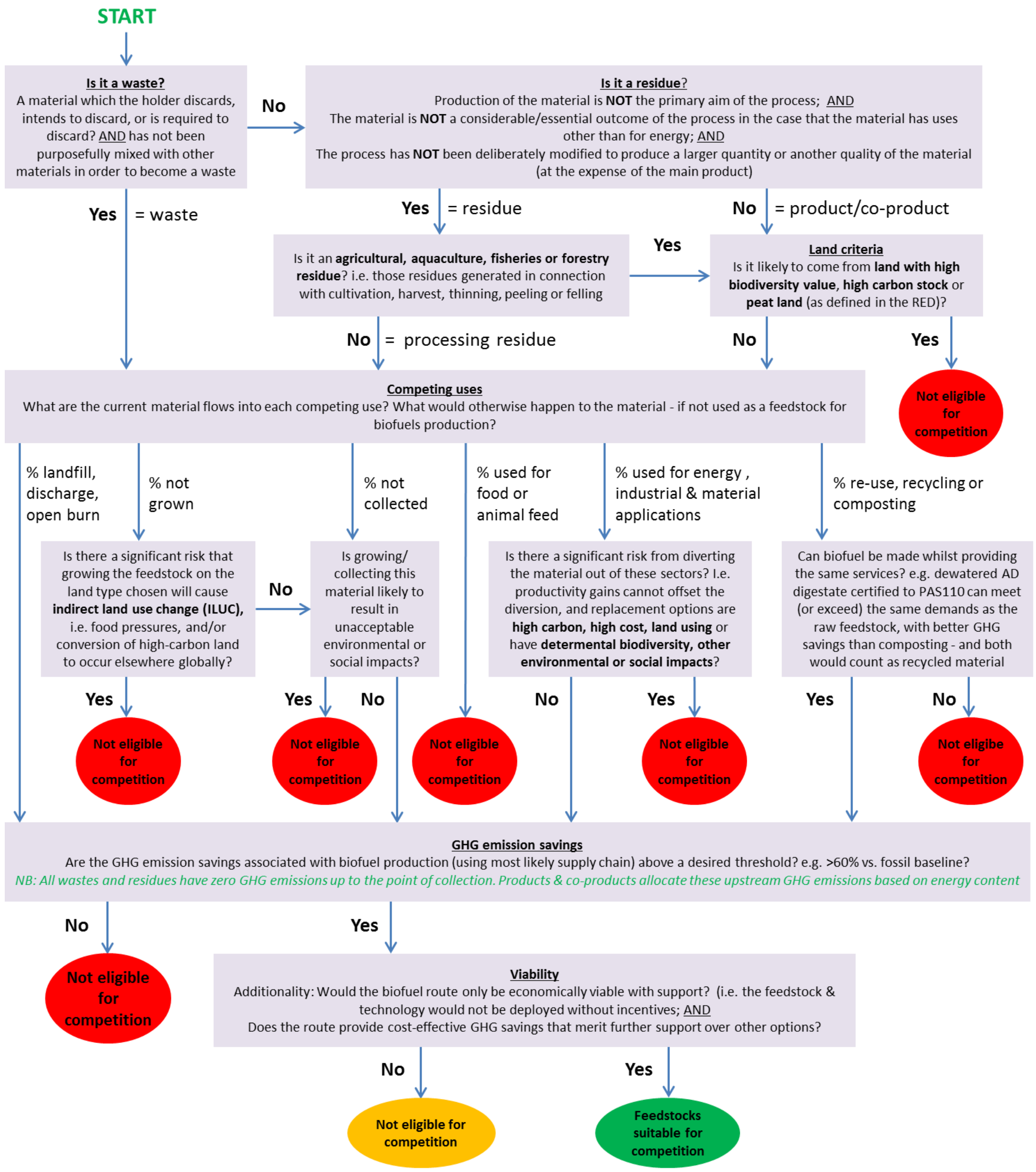

Figure 3: Flow diagram for the analytical framework, showing the choices and risks to be considered

3. Business Case

The following section aims to support DfT in determining and developing a business case for a competition to support the demonstration of advanced biofuel production in the UK. This will be achieved by outlining the potential benefits of a UK advanced biofuels industry, current market failures, and deployment barriers. To assess current international activity working to address barriers to deployment, we have reviewed past and present programmes that could potentially encourage the development and demonstration of advanced biofuels across the world, and considered advanced biofuel projects funded under such schemes. A summary of the existing schemes review is presented in this section. The business case concludes by proposing a mission statement for the Advanced Biofuel Demonstration Competition, which reflects both DfT objectives and the industry's needs.

3.1. UK value and jobs analysis

Significant growth is expected in advanced biofuels markets globally. UK deployment of advanced biofuel facilities will support UK revenue generation and jobs, but innovation and demonstration support could also create additional economic value by helping UK-based businesses to develop competitive advantages and compete successfully in non-UK markets. We have therefore developed a simple set of calculations and assumptions to estimate the value to the UK of keeping pace with EU deployment, and taking a small share of the global advanced biofuels market.

E4tech's EU Auto-Fuel project was used to provide global and EU deployment ranges for 2020 and 2030, based on potential technology ramp-up rates and bottom-up estimates of international development activity (E4tech, 2013b). These cumulative production capacity figures to 2020 are based on operational and planned facilities, with projections to 2030 made based on assumed build rates and plant sizes. Low, Medium and High scenarios were validated with a consortium of automakers and oil majors during 2013, and form the underlying basis of this UK value and jobs analysis.

Global deployment figures are used to estimate the potential net value added (NVA) contribution to the UK economy across the various supply chain options, from feedstock, through technology construction and operation, to downstream distribution of finished fuels. These estimates give 400 to 680 commercial-scale advanced biofuel plants built by 2030 (mostly in the US, Brazil and EU), producing 16 – 31 Mtoe/yr of biofuel.

Global turnover figures are calculated by using expected technology costs (£20-35/GJ in 2020 falling to £15-30/GJ by 2030). This ranges from **£10 – 39bn** a year by 2030, with feedstocks accounting for around 40-45% of this value, technology capex and opex 42-50%, and downstream distribution 10-13%.

The methodology for calculating the value to the UK and jobs is adapted from the Bioenergy TINA for Carbon Trust and outlined in Annex 2. The successful capture of global advanced biofuel business opportunities could generate millions of GBP in value for the UK. The UK net value added of global exports from the different possible technology choices is estimated at **£27 – 102m** a year by 2030 (including displacement effects), with the large majority of the value found in the design and development of conversion technology components – since these are more exportable, protectable through IP and well-aligned with the UK's academic and commercial strengths.

In addition to a global market, development of a domestic industry will also provide significant value to the UK. UK deployment figures are estimated based on a share of EU production, estimated at 18% due to the relative sizes of the UK and EU transport sectors (53 Mtoe/yr vs. 288 Mtoe/yr). These estimates give 9 to 18 commercial-scale advanced biofuel plants built in the UK by 2030, producing 0.5 – 1.0 Mtoe/yr of biofuel (providing 1-2% of UK transport demand, ignoring any multiple counting). UK turnover figures are then calculated to range from **£320 – 1,300m** a year by 2030.

Based on these assumptions, the successful establishment of a domestic UK advanced biofuels industry could generate a NVA of **£52 – 202m** a year by 2030 (including displacement effects), approximately double the UK export market in advanced biofuel technology. Combined with the NVA from global exports, the total size of the prize for UK advanced biofuels could reach **£80 – 300m** a year by 2030, based on underlying EU Auto-Fuel deployment scenarios.

The successful establishment of a domestic UK advanced biofuels industry could generate **1,000 – 3,900** new jobs within the UK by 2030, with a strong focus on feedstock supply. Increased exports for the assessable global market could generate another **310 – 1,110** UK jobs by 2030, leading to a total employment opportunity of **1,320 – 5,010** UK jobs within the advanced biofuels sector by 2030.

We note that UK deployment figures for 2020 are a good match to those estimated by NNFCC when including a 2 year delay to account for the lack of plant development progress between 2011 and 2013 (NNFCC, 2011). This bottom-up source estimates 2 commercial plants might be built by 2020 in a Modest Development scenario, and up to 5 in a Strong Development scenario.

3.1.1. Impact of DfT's Advanced Biofuels Demonstration Competition

The above analysis gives possible ranges for the deployment of advanced biofuels in the UK, EU and globally. However, whether the UK values (particularly for 2020) are realised depends on whether a handful of planned projects go ahead, and which developers are successful in demonstrating their technology, raising finance and scaling up.

The value of the Competition is therefore framed around the successful UK demonstration of one technology in the 2016-2017 timeframe, which could then lead to the development of one commercial scale plant by 2020 in the UK. Greater levels of additional deployment could be stimulated by the Competition, but this is likely to be post-2020 given the timings involved. We assume that 1 – 3 further commercial plants could be built by 2030 as a result of the Competition.

Based on an unknown technology choice, one demonstration plant (producing 5-40 ktoe/yr) and one commercial plant (producing 35-130 ktoe/yr) could lead to turnover of approximately £33 – 250m a year by 2020. Adding 1 – 3 new commercial plants by 2030 increases the cumulative deployment unlocked by the Competition to 75 – 560 ktoe/yr, and turnover to approximately £47 – 700m a year. We note that the deployment assumed to result from the Competition represents 15% - 86% of the deployment scenario derived for the UK based on the EU Auto-Fuel work (proportional share of existing and planned EU plants) (E4tech, 2013b). Therefore, a successful Competition could provide significant impetus to the UK industry in keeping pace with our European counterparts.

The NVA and employment impacts potentially resulting from the Competition are shown in Table 3, based on only considering non-tradable UK portions (and no global export figures), due the deployment being assumed to be in the UK.

Table 2: Summary of the potential UK value and jobs from the advanced biofuels industry (Low – Medium – High)

	2020	2030
Global deployment (Mtoe/yr)	6 – 8 – 10	16 – 23 – 31
EU deployment (Mtoe/yr)	1.5 – 1.6 – 1.6	3.5 – 5.0 – 6.4
UK deployment (Mtoe/yr)	0.2 – 0.2 – 0.2	0.5 – 0.8 – 1.0
UK deployment (% of transport fuel demand)	0.4 – 0.4 – 0.4	0.9 – 1.5 – 1.9
Global number of plants	150 – 180 – 220	400 – 530 – 680
EU number of plants	24 – 26 – 27	58 – 82 – 104
UK number of plants	3 – 4 – 4	9 – 14 – 18
Global turnover (£m/yr)	5,300 – 6,360 – 8,500	11,000 – 15,000 – 20,800
EU turnover (£m/yr)	1,280 – 1,340 – 1,370	2,360 – 3,340 – 4,270
UK turnover (£m/yr)	150 – 160 – 166	340 – 520 – 690
UK GVA from exports (£m/yr)	70 – 84 – 110	140 – 200 – 270
UK GVA from domestic (£m/yr)	53 – 57 – 59	120 – 185 – 250
UK GVA total (£m/yr)	120 – 140 – 170	260 – 385 – 520
UK jobs from exports	310 – 375 – 500	640 – 885 – 1,220
UK jobs from domestic	690 – 740 – 770	1,570 – 2,240 – 3,210
UK jobs total	1,000 – 1,110 – 1,270	2,210 – 3,300 – 4,430

Table 3: Summary of potential Competition impacts (Low – Medium – High)

	2020	2030
Deployment (ktoe/yr)	40 – 75 – 170	75 – 195 – 560
Deployment (% of transport fuel demand)	0.1 – 0.1 – 0.3	0.1 – 0.4 – 1.1
Number of plants	1 demo & 1 commercial	additional 1 – 2 – 3 commercial
Turnover (£m/yr)	33 – 79 – 250	47 – 160 – 700

NVA domestic (£m/yr)	6 – 14 – 44	9 – 30 – 130
Domestic jobs	100 – 230 – 740	160 – 530 – 2,260

3.2. Demand for advanced biofuels

The market for biofuels in the UK is driven by European legislation and Government policy. Under current legislation there is no obligation on Member States to use advanced biofuels, although their use is encouraged by double counting towards the RED target. Recent proposals for amending the RED have included sub-targets for advanced biofuels within the overall 10% target for renewable energy in transport. There has been considerable debate over the appropriate level for a sub-target, with positions including no sub-target, 1% or 2.5% mandatory sub-targets, or levels to be implemented at each Member State's discretion. At present no agreement has been reached on the inclusion of a sub-target and it is not clear when an agreement will be reached or the timetable for implementing any changes. Under these circumstances it is unclear what the size of the market for advanced biofuels will be in 2020 and beyond, as there are currently no mandated renewable transport energy targets beyond 2020 (overall renewable energy targets for the EU in 2030 are to meet 27%, but are yet to be determined by each Member State).

Different approaches have been taken to evaluate the demand for advanced biofuels in the UK in 2020, based on different policy scenarios and constraints regarding biofuel availability and uptake.

Firstly assuming no sub-target is included in the RED, it is possible to estimate the volume of advanced biofuels required to meet the 10% renewable energy in transport target, under constrained first generation biofuel supply and assuming the mass blending of biofuels up to B7 and E10 blend walls. Analysis by NNFCC estimates that, under these conditions, the UK demand for "drop-in" biofuels is 0.5 – 1.6 Mtoe in 2020, equivalent to between 0.2 and 0.7% of the RED target for renewable energy in transport (NNFCC, 2011).

Alternatively, we can consider the proposals presented by the European Commission in October 2012, European Parliament in September 2013 and the European Council in October 2013, which included a cap on the contribution of food-based biofuels to the RED target, and/or a sub-target for advanced biofuels in 2020. E4tech's analysis of the impact of these proposals, indicate that the uptake of advanced biofuels in the UK in 2020 would have to be between 0.8 and 1.8 Mtoe.

3.3. Barriers to deployment

In the UK, there has been some interest in demonstration projects or early commercial scale plants, including the development of prospects by INEOS Bio, and BA & Solena, but to date no projects have progressed to construction. The barriers to development of these and other advanced biofuel technologies have been widely reported and include technical barriers, supply chain constraints, market instability, and access to finance.

3.3.1. Technical barriers

The specific innovation needs for each process route are outlined in Annex 1. The most common (or severe) technical barrier across routes is the need to demonstrate the integration of the component processes and optimise the integrated processes to improve efficiencies and reduce production costs. This barrier is not specific to the UK; however some regions, including the EU, US and Canada, have attempted to address this barrier by providing funding in the shape of grant funding, loans, and guarantees, to support the construction of demonstration plants. The UK could benefit from existing EU programmes, including ERANET Plus, NER300, FP7 and Horizon 2020, to support the construction of bioenergy demonstration plants, but to date no UK based advanced biofuel projects have applied to these schemes. UK technology companies may apply to schemes in other regions directly, or more likely in partnership with local companies. For example INEOS Bio received a $75M loan guarantee to support the construction of its integrated full-scale demonstration plant in Florida under the Biorefinery Assistance Program, in addition to the RFS certificates it will receive for each gallon of cellulosic biofuel it produces. Other specific technical barriers, for example the development of new catalysts with greater selectivity or higher tolerance to contaminants, the development of robust bacteria strains to improve fermentation pathways and increase yields, require further research. In the absence of sufficient market pull for such research due to the early stage of the industry, this may require public funding. In the UK, there are several sources of funding for R&D activities including TSB, EPSRC, and BBSRC. Specifically, there are targeted programmes to support SMEs in accessing academic research. Many projects have been undertaken in the advanced biofuels sector, and relevant calls for project applications remain open, particularly in the areas of industrial biotechnology (IB) and biorefining.

3.3.2. **Supply chain constraints**

There are supply constraints for almost all advanced biofuel feedstocks including forestry, agricultural residues, wastes, processing residues and purpose grown energy crops. The most severe barrier is feedstock availability. For bioenergy projects in general, securing adequate feedstock supply contracts has required significant effort and expense, either due to there being no existing market and therefore resources are not cultivated, or not collected and aggregated; or due to the development status of the technology proving too high risk to compete against existing technology, for example in the waste industry. The large volume of feedstock required for individual large scale advanced biofuels plant is also a serious constraint within the UK due to the diffuse nature of the feedstock supply and transport costs. This leads to issues in siting of plant and logistics.

Other constraints relate to the quality, consistency, and homogeneity of feedstocks, and a lack of specifications and standards, which may impact plant performance and guarantees. Feedstock specific barriers include:

- Agricultural residues: material may be collected for existing markets; resource is diffuse and there is a lack of supply chain actors aggregating resources due to current market demand; significant additional resource may be extracted, but farmers must be engaged in supplying this market; difficult to mobilise the existing resource before biofuel plants are under construction. High ash content can be problematic for certain thermo-chemical routes.
- Forest residues: material is collected for existing markets; additional resource may be extracted sustainably, although little is reported on the cost of this additional extraction.
- Process residues: currently collected and aggregated, however much of the resource may have competing uses, and therefore risk indirect impacts.
- Wastes: materials are currently collected and aggregated, however local authorities have a strong preference for demonstrated technology and it may be necessary to partner with a waste management company in order to access this resource; short

term waste contacts are typical in the commercial and industrial waste disposal sector, so there is opportunity for advanced biofuels. However, the scale of waste generation and commercial biofuel plants may not be complementary for some technologies.

- Products grown specifically for bioenergy markets: the existing resource is small, and planting rates are increasing very slowly – growers want to see the plant operational before committing to planting, but the plant will not typically get funding without feedstock supply contracts. There are vertical integration options for biofuel producers, but this may increase operational risk. Further demonstration of the establishment costs and yields for energy crops is on-going, but the industry requires support.

Conversion technology demonstration may partially address supply constraints, if designed to provide a demonstration of the value chain for agricultural residue, forest residues, and energy crops. A number of waste gasification projects are emerging in the power sector - successful completion and operation may improve confidence in advanced technologies, and in time lead to a revision of Best Available Technology guidance providing a regulatory push to use advanced technologies (or potentially a redefinition as recycling, instead of energy recovery in the Waste Hierarchy).

3.3.3. **Market demand**

Policy uncertainty in the EU is a major cause for concern for biofuels deployment, with mounting evidence that it has stifled investment over the last few years, in both conventional and advanced biofuel sectors. In addition, the current policy framework provides a biofuels market to only 2020, but not beyond, and hence does not offer adequate security for new projects which may not be operating until 2017 or later, due to project development and construction times.

Currently, support for advanced biofuels in the UK and EU comes from the allocation of double credits – which have successfully brought forward UCO and animal fat supplies utilising conventional biodiesel technologies. However, there are strong doubts regarding the ability of the double counting mechanism to trigger investment in advanced biofuel demonstration plants. Industry stakeholders have indicated that multiple counting cannot be reliably factored in when making investment decisions on novel technologies because of the difficulty in estimating the economic value (i.e. any additional revenues) that multiple-counting creates. The value of a double-counting biofuel depends on the price of the fossil fuel baseline and the price of other competing biofuels, all of which can be highly variable. Multiple counting also necessarily reduces the size of the total market and GHG savings achieved – hence other world regions are seen as having more attractive incentives.

Whilst the Competition may succeed in stimulating investment in advanced biofuel demonstration, further investment in commercial scale biofuel production capacity and related infrastructure will require a supportive policy framework to 2020 and beyond. In the UK, options for future policy mechanisms to support the use of advanced biofuels are discussed in the current Call for Evidence on advanced fuels.

3.3.4. **Access to finance**

Access to project finance for demonstration and early commercial plants is a severe barrier to advanced biofuels development in the UK and the rest of the world. Many investors including private equity and institutional investors are too risk-averse to provide funding at this stage of development, while less risk-averse venture capital investors do not generally invest the amount of capital required. This creates a funding gap for demonstration plants. In addition, a lack of progress in demonstrating technologies at scale, failed demonstration projects, and construction and commissioning delays, has resulted in a lack of confidence from the investment community. This is in addition to the general environment across the financial services and investment industry where issues such as increased regulation are resulting in a lack of availability of finance for riskier projects.

There are several options for overcoming access-to-finance issues including government support in the form of capital grants, loans, guarantees, and equity finance; and strategic investors such as oil majors. Various programmes for supporting demonstration activities have been implemented in the EU, US and the rest of the world, and these are discussed in the following section.

3.4. Existing funding schemes

A high level review of existing support schemes revealed 32 programmes that have supported 124 individual biofuel projects in Europe, North America, Australia and Japan. Most programmes have been designed with a broad remit for renewable energy development, environmental, or economic goals, and frequently include a longer term aim of developing technologies that are capable of contributing to meeting GHG emissions reduction targets set by national and international policies. Since 2010 there have been an increasing number of dedicated biofuel programmes designed to address the specific barriers facing the biofuel industry. Targets in these dedicated biofuel production demonstration programmes are typically focused on the amount of energy produced rather than GHG reductions.

Table 4 lists each of the programmes or funding schemes identified in the review. Further details of the funding mechanism and rules for a selected number of schemes are included in Table 5. The majority of programmes support a proportion of total project costs, via grant funding of loans, with the remainder of total project costs met by private financing.

Table 4: Existing schemes that support or have supported biofuel projects

Region	Funding Scheme	Scheme Status	Funding type	Award value
UK	The Energy Entrepreneurs Fund Scheme	On-going projects	Grant	>£1M
UK	UK Government Infrastructure Guarantee	Closed scheme	Loan	£75M
UK	UK On Farm Loan Fund	On-going projects	Grant & Loan	£10k-400k
UK	SUPERGEN	On-going projects	Grant	£3.5M (overall)
UK	The Carbon Trust: The Pyrolysis Challenge	On-going projects	Grant	>£5M
UK	Technology Strategy Board (TSB): various calls	On-going projects	Grant	£5k - 400k
UK	Energy Technologies Institute (ETI): various competitions	On-going projects	Grant	£5 - 25M
EU	ERA-NET Plus: Bioenergy Sustaining the Future (BESTF)	Call open	Grant	Up to €24 M
EU	NER 300	Current call closed, applications under review	Grant	€22.3 - 199M
EU	Horizon 2020	Call open	Grant, loan, loan guarantees & equity	€5 – 20M Grant funding awards
EU	Biobased Industries PPP	Future	Not yet known	Not yet known
EU	EU CORDIS FP7	Closed superseded by Horizon 2020	Grant	€3 - 8.5M
EU	EU CORDIS FP6	Closed superseded by FP7	Grant	€0.5 - 8M
EU	European Regional Development Fund (ERDF)	On-going projects	Grant	up to €11M
EU	Wetland Biomass to Bioenergy	On-going projects	Grant	>£41k
EU	INTERREG IVA Programme	Closed	Grant	£5M
Denmark	Energy Technology Development and Demonstration Programme (EUDP)	On-going projects	Grant	€2.5 - 50M
USA	Biorefinery Assistance Program	On-going projects	Loan guarantee	$99-232.5M
USA	Financial Assistance for Integrated Biorefinery Projects	On-going projects	Grant	>$45M
USA	Innovative Pilot And Demonstration Scale Production Of Advanced Biofuels	On-going projects	Grant	$5-7M
USA	Advancements in Sustainable Algal Production (ASAP)	On-going projects	Grant	$1-8M
USA	Advancements in Algal Biomass Yield (ABY)	Future	Grant	>$5M
USA	The Advanced Research Projects Agency (ARPA-E)	On-going projects	Grant	$250K and $10M

Region	Funding Scheme	Scheme Status	Funding type	Award value
Canada	NextGen Biofuels Fund	On-going projects	Loan	Up to $74.9M
Brazil	Joint Plan for Supporting Industrial Technological Innovation in the Sugar-based Energy and Chemical Sectors (PAISS)	On-going projects	Grant & Loan	Not known
Japan	(CREST) Core Research for Evolutionary Science and Technology	On-going projects	R&D funding	Not known
Japan	Precursory Research for Embryonic Science and Technology (PRESTO)	On-going projects	R&D funding	Not known
Japan	ALCA: Advanced Low carbon Technology Research and development	On-going projects	R&D funding	Not known
Japan	Science and Technology Research Partnership for Sustainable Development (SATREPS)	On-going projects	R&D funding	Not known
Japan	Strategic International Research Program (SICP)	On-going projects	R&D funding	JPY 5M - 10M per year
Japan/USA	US National Science Foundation and Japan Science Technology Agency	On-going projects	Grant	Not known
Australia	Australian Renewable Energy Agency (ARENA)	On-going projects	Grant	$1 – 6M

Table 5: Details of funding mechanisms and rules for selected existing schemes

Scheme name	Financial rules
NER300	Plans to fund projects up to 50% of project costs (up to a maximum award of €270M)
EU CORDIS FP7	Funds up to 50% of eligible costs for research and for demonstration activities, with a top up of up to 25% for research activities for SMEs, public bodies, secondary and higher education establishments and non-profit research organisations.
Horizon 2020	Up to 100% for R&D projects, and up to 70% for innovation project (100% for not for profit legal entities)
Energy Technology Development and Demonstration Programme (EUDP)	Funds up to 50% of development and demonstration projects with up to 90% support for R&D projects
Biorefinery Assistance Program Loan	Loan guarantees of up to $250M, and not more than 80% of project costs (except in exceptional circumstances)
Australia's Next Generation Biofuels Research and Development (2Gen) Programme	Provided matching grants ranging between $1-5M for advanced biofuels projects
NextGen Biofuels Fund	Loans of up to 40%, repaid over 10 years
European Regional Development Fund (ERDF)	Grant funding of up to 50% of the project costs
Technology Strategy Board (TSB)	Grant funding of between 25-100% of the project costs. Not for profit organisations involved in purely research projects may receive 100% funding
Energy Technologies Institute (ETI)	Grant funding of up to 100%, dependant on project, partners and the IP likely to arise from project
Financial Assistance for Integrated Biorefinery Projects	Grant funding of 50-60% of total costs
Innovative Pilot And Demonstration Scale Production of Advanced Biofuels	Grant funding, the proportion of private investment required not released

3.4.1. **Potential sources of funding for UK projects**

ERANET Plus BESTF

The ERANET Plus call Bioenergy Sustaining the Future 2 (BESTF2), was launched in December 2013 under the European Industrial Bioenergy Initiative (EIBI). BESTF2 aims to provide financial support to pre-commercial bioenergy projects that demonstrate collaboration, innovation and industry focus, and encourage collaboration across the EU, by bringing partnerships together to deliver demonstration projects, and encourage commercialisation. The call is restricted to seven value chains including biomass gasification, lignocellulosic fermentation, and the production of renewable hydrocarbons via biological or chemical synthesis.

The activity is implemented in seven Member States including the UK, Germany, Denmark, Netherlands, Spain, Sweden and Switzerland. In the UK, applications are coordinated by DECC and TSB, and the total UK budget for eligible projects is £5M.

Projects must address the last steps prior to commercial operation (TRL 6-8), and can include new demonstrations of innovative conversion technologies, or innovative technological modifications of existing demonstration plants. Projects may also include research and economic studies which are firmly integrated into the demonstration activities.

Projects must include at least two active participants from two participating Member States. The deadline of outline proposals is February 2014, and projects are expected to begin by January 2015 and must be complete by August 2018. Due to the project schedule, it is expected that the majority of funding will be used for operational costs.

Horizon 2020

The Horizon 2020 Programme for Research and Innovation forms part of the European Commission's Innovation Investment Package and will operate from 2014 to 2020.

Horizon 2020 provides a range of funding measures, including grants, debt finance and equity. Debt finance includes loans of €7.5M to €300M and loan guarantees of up to €7.5M, available to research institutes, SMEs and larger companies, for research and innovation activities. Loan finance may be used to support large scale projects with a certain degree of risk, including 1st of a kind commercial scale projects. Loans will be made available via the European Investment Bank (EIB), and applicants must demonstrate that, in principle, repayments can be met. Applicants are also encouraged to seek other sources of funding, and loans may be combined with national or EU grants, and are not subject to state aids regulation. Equity finance is focused on early stage seed finance for start-up companies, or for the development of pilot facilities, and is placed through the European Investment Fund (EIF).

The grant funding arm of Horizon 2020 launched a call for proposals demonstrating advanced biofuel technologies in December 2013. The competition also focuses on the seven value chains identified in the EIBI Implementation Plan, and aims to support demonstration projects that move technologies that already reached TRL 5-6 to TRL 6-7. The Commission expect awards in the region of €5m to €20M, which may contribute up to 70% of eligible direct costs and 25% of indirect costs. Funding is limited to companies from EU Member States, and projects must include a minimum of three distinct partners from three different Member States.

Green Investment Bank (GIB)

Discussions with the GIB as part of this study confirmed that they would typically not take any significant scale up risks, but may under the right circumstances, consider a first-of-a-kind commercial plant (TRL 8), but this is not normal practice. The GIB does fund smaller-scale projects via private equity investment, through related organisations linked to the GIB (but not funded by the GIB).

3.4.2. **Review of existing schemes**

To date, the predominant form of support offered to the industry has taken the form of capital grants that cover a proportion of the overall project budget. Some initiatives have offered grants of up to 100%, for R&D projects, and typically up to 50% for demonstration projects. More recently, loans and loan guarantees have also been awarded in the USA, Canada, and Brazil, and a scheme recently launched in Europe. Loan and loan guarantee schemes are typically aimed at first-of-a-kind commercial scale plants.

In Europe, there have been a number of successful advanced biofuels projects supported under FP6 and FP7. Often technologies have been supported through each stage of development, from pilot to all scales of demonstration; and several have made successful applications to NER300 for large scale demonstration or first-of-a-kind commercial scale installations. Many technologies have also been in receipt of national funding, including R&D funding and capital grants, demonstrating that targeted national funding can leverage other investment and promote technology development.

Not all approaches have been successful, regardless of the amount of public capital provided for projects. One documented failure occurred in the US in relation to the Department of Energy's (DOEs) Financial Assistance for Integrated Biorefinery Projects which provided grant support of up to 50% of project costs. Whilst the programme reported meeting its 2012 goal to have three integrated biorefineries, a subsequent audit commented that the biorefineries were not commercial scale facilities. 15 demonstration scale and commercial scale projects were originally funded, of which six were mutually terminated by the Department and recipients (after expending more than $75M in government funds), and nine were completed, although they are reported to have experienced technical and/or financial difficulties as a result of projects not being at the level of technical readiness needed for commercial development, poor market and financial conditions, and planning issues (e.g. ethanol produced not meeting technical specification requirements, problems acquiring industry partners, and extended environmental reviews).

From the UK perspective, there has been limited involvement of UK companies in recent applications for FP7 and NER300 funding, and there is strong competition from consortia from other Member States. However, Horizon 2020 and ERANET Plus offer new opportunities to UK companies for innovation and IP development, supporting demonstration projects and first-of-a-kind commercial scale plants, and may promote investment and demonstration activities in the UK. However, these programmes provide no specific focus on UK based manufacture and jobs. To be eligible, UK companies are required to partner with companies from other EU Member States, this may limit interest from UK companies who have to date formed more partnerships with companies in the rest of the world.

Funding from within the UK, via TSB and Carbon Trust, has to date targeted earlier stages of technology development; from R&D to pilot and early demonstration scale.

3.4.3. **Review of publically funded biofuels projects**

Seven biofuel projects funded through existing schemes were selected for further research. Projects were selected based on the current status and stage of development (TRL), and so that in combination they represented a cross-section of characteristics relevant to this feasibility study, such as technology, feedstock, project type and range of funding mechanisms. Details of these projects are included in Annex 3, and a summary of the project scope, funding and timeframes is provided in Table 6.

Projects supported include the construction of demonstration plants, production at existing demonstration facilities, and expanding existing plant from pilot to demonstration or demonstration to commercial scale. Funding awards for demonstrator projects have been found to range from €10 million to €59 and have been complemented by additional funding from other programmes, or national governments (e.g. GoBiGas).

Demonstration projects have also been found to involve industry partners from throughout the supply chain, including feedstock producers. There is still, however a strong academic or research facility presence in the projects examined even at later stage demonstration projects (e.g. KACELLE) but some of the projects examined were purely industry led (e.g. Project Alpha and Vanerco).

It is too early to assess if the projects supported under NER300 and BESTF will be successful, as these projects are still in development or construction. However it appears that successful applicants to NER300 have been able to demonstrate a history of technology development at small scale, a consortium encompassing feedstock suppliers, technology and engineering companies and a convincing business plan for replication of the technology and marketing the biofuel produced.

3.5. Rationale and ambition of the competition

The aim of the competition is to prove that the production of advanced biofuels is technically viable, and may be economically viable at commercial scale. And the ambition is to pave the way for a first-of-a-kind commercial scale plant, by reducing the associated technological risk. The approach demonstrated should have the potential for significant economic and environmental impact, in terms of job creation, economic growth and the supply of low carbon sustainable fuels.

Existing grant support schemes in other countries and in Europe have been successful in supporting the development of advanced biofuel technologies from pilot through to demonstration stage, and as a result of this support, first-of-a-kind commercial scale plants are now being developed in other countries. However, there is added value to the UK from delivery of the Competition, which specifically focuses on delivering a UK based demonstration plant and would enable technology partnerships that may not progress under the existing European programmes.

Table 6: Advanced biofuel pilot and demonstration: examples of project funding

Project name	BEST	GoBiGas 2	EuroBioRef	KACELLE	BIOLIQ	Project Alpha	Vanerco
Location	Crescentino, Italy	Göteborg, Sweden	Sarpsborg, Norway	Kalundborg, Denmark	Karlsruhe, Germany	North Carolina, USA	Quebec, Canada
Total project investment	>€200M	Not published	€36.9M	€54M	€60M	$200M (€145M)	Est $975M (€707M)
Public funding contribution	€28.4M (NER300)	€58.8M (NER300)	€23M (FP7)	€9.1M (FP7)	€11M (ERDF & National funding)	$99M (€71M) loan guarantee (BAP)	$734,500 (€532K) loan potential further $79.8M (€57.8) (NextGen)
Time from award to start of construction	1 year (Pre-existing plant: previously supported by FP7: €8.59M funding)	Not known (scale up of existing facility)	Not known (scale up of existing facility)	Dec 2007 (Design & engineering phase) Summer 2008 (Construction phase)	Construction already underway	2 years (est)	N/A
Time from start of construction to operation	2 years	Not known	Not known	> 2 years	6 years to fully operational (with interim testing)	N/A	N/A
Duration of funded project	5 years 2013 – 2018	5 years 2016 - 2021	4 years 2010 – 2014	4 years 2009 – 2013	Unknown 2009 – on-going	Unknown construction starts 2014	Unknown announced in 2013
Consortium	2+ partners	2 partners	29 partners	6 partners	6 partners	4+ partners	2 partners
Project type	Demonstration plant activities	Up-scale to commercial plant	Pilot conversion with demonstration of crop production	Up-scale to commercial plant	Pilot demonstration activities	Commercial plant construction	Commercial plant construction
Conversion technology	Hydrolysis and fermentation	Gasification and methanation	Biorefinery concept, including sulphite pretreatment	Enzymatic hydrolysis and fermentation	Flash pyrolysis, high-pressure entrained-flow gasification, & liquid synthesis	Enzymatic hydrolysis and fermentation	Gasification and catalytic synthesis to alcohols
Capacity	75M litres p/a	Adding 80 MW to reach a total of 100 MW gas	Not known	5M litres p/a	Not known	90.9M litres p/a	38M litres p/a

Project name	BEST	GoBiGas 2	EuroBioRef	KACELLE	BIOLIQ	Project Alpha	Vanerco
Feedstock	Giant cane, wheat straw & rice straw	Forest residues	Agriculture & forest residues	Agricultural residues (wheat straw)	Straw & wood waste	Non-food biomass	Non-recyclable waste (C&I and C&D)
Proprietary Technology	Beta Renewables' PROESA™ engineering & production technology-	Gussing Indirect gasification	BALI technology	IBUS concept (Integrated Biomass Utilization System)	Bioliq	PROESA Technology	ENERKEM thermochemical process
Fuel and other products	Bioethanol, Lignin	Bio-SNG	Aviation biofuels & chemicals	Bioethanol, lignin pellets & C5 molasses	DME, diesel & petrol	Bioethanol	Bioethanol
History of technology development	2006 – 2009 PROESA™Technology testing 2009 Pilot plant testing 2010 plant development starts 2013 fully operational demo plant	2005 Preliminary studies 2006 – 2010 Technology testing & assessment 2010 – 2013 Construction of demo plant 2013 Demo plant operational 2016 Commercial plant to be operational	Dec 2007 - First lab experiments Jan 2011 - Funding secured 2012 Demo Plant operational Early 2013 - Fully commissioned	2002 – 2006 FP5 funded project develops IBUS technologies 2008 – plant construction begins 2009 – Kalundborg pilot plant operational 2009-2013 KACELLE project to demonstrate plant activities	2005 plant construction planning starts 2008 – 2009 first construction phase commissioning activities - plant produced the first test fuel outputs in 2010 2010 secured, further funding for Bioliq II 2011 – 2013 final construction phase	2006 – 2009 PROESA™Technology testing 2009 Pilot plant testing	2003 pilot facility operational 2007 demo plant announced 2008 announce agreement to build commercial plant. 2012 announce plans to build full-scale commercial cellulosic ethanol plant 2013 project consortium announces plans to build the plant integrated with GreenField's existing ethanol plant in Varennes, Quebec.

4. Considerations for demonstration projects

4.1. Project specification options

For the Competition to be delivered efficiently it is necessary to specify the type of projects that the Competition seeks to fund. This section describes the scope of the competition and sets the project eligibility criteria, first establishing what development is feasible, based on the current status of development, and considering how different options would contribute towards the DfT's objectives, and then exploring practical considerations relating to project delivery.

4.1.1. TRL 7: full scale demonstration

TRL 7 refers to prototype demonstration in an operational environment. In the context of advanced biofuel production, this is interpreted as a fully integrated process prototype, operating on real feedstocks, with a high availability, producing fuels to a valid specification.

Figure 2 illustrated that there are only a handful of processes currently operating at TRL 7; examples include lignocellulosic ethanol and syngas fermentation processes. Processes currently operating at TRL 6 may be suitable for progression to TRL 7 via the Competition; examples include lignocellulosic ethanol and butanol, gasification with FT, methanol, mixed alcohol or bioSNG synthesis, and pyrolysis oil upgrading.

The scale and investment costs for a full scale demonstration plant will vary by technology, feedstock and site specific factors, such as existing infrastructure. Integrated large scale demonstration plants may operate at a capacity in the range of 1/2 to 1/10 of the size of a first of a kind commercial scale plant. Indicative demonstration plant scales and cost are presented in Table 7.

Table 7: Indicative TRL 7 plant scale and costs

	Capacity M litres per year	Total Investment Costs £M (2013)
TRL 7	20 - 50	80 - 200

The timeline for the delivery of a demonstration plant will vary depending on the technology and scale of operation as well as the time to secure finance and planning and permitting. An illustrative example of project delivery is shown in Table 8.

It is estimated that commissioning of the demonstration plant may be completed between three and five years from the competition award. Assuming projects are awarded in early 2015, the demonstration plant would be expected to complete commissioning between 2018 and 2020. The shorter timeframe is likely to reflect projects that have selected sites, submitted planning applications and/or secured the remaining funding.

Provided demonstration activities are successful, a commercial plant may begin operation two to eight years following commissioning of the demonstration plant. A robust commercialisation plan will be necessary to evaluate the timeframe for individual processes. A demonstration project of the scale shown in Table 7 could optimistically result in commercial scale deployment by 2020 and contribute towards RED targets.

Table 8: Indicative timeline for a route being demonstrated at TRL 7 through to development of a first-of-a-kind commercial scale-plant (TRL 8)

Date	Activities	Milestone
2014	Application	Competition award (by early 2015)
1 – 2 years	Detailed design, procurement, planning, permitting, close out finance	Demonstration plant build commences
2 – 3 years	Ground works, construction and commissioning	Commissioning complete
Up to 2 years	Sufficient operating hours and process optimisation to inform commercial plant design	Sufficient operating hours and final investment decision for commercial plant
Up to 2 years	Detailed design, procurement, planning, permitting, close out finance	Construction of commercial plant commences
2 – 4 years	Ground works, construction and commissioning	Commercial plant commissioning complete

4.1.2. **TRL 6: small scale demonstration**

TRL 6 is defined as a system or sub-system prototype demonstration in a relevant environment. In the context of advanced biofuel production this may refer to a prototype of a complete or partial conversion process at a scale significantly smaller than that envisaged for a commercial plant, and operating on representative feedstocks that may not exhibit the same variability and degree of contamination as actual feedstocks. There are several technology providers currently operating at this level, as outline above. A wide range of technologies may be suitable to progress from pilot scale operations (TRL 5) to small scale demonstration (TRL 6), for example sugar-to-diesel routes, aqueous phase reforming, gasification and DME synthesis (solid biomass) and gasification and hydrogen production.

The timeframe for TRL 5 technologies to progress to TRL 6 and on to commercial scale (TRL 8) is subject to greater uncertainty as a range of technical issues may arise and an additional sub-commercial scale plant (at TRL 7) is likely to be required. It is unlikely that such technologies will deliver commercial scale plants by 2020, but it may be possible by 2025. The operating scale for TRL 6 plants may vary widely within the advanced biofuels sector. There are several plants operating at the 1-6 ML/yr scale, particularly among lignocellulosic ethanol technologies, which equates to between 1/10th and 1/50th of the scale of a first of a kind commercial plant. Indicative small demonstration plant costs are presented in Table 9.

Table 9: Indicative TRL 6 plant scale and costs

	Capacity M litres per year	Total Investment Costs £M (2013)
TRL 6	1-6	Up to 50

4.2. Considerations for plant scale

Stakeholder feedback on the size of plant that would best meet the Department's objectives has been mixed. There are a few large-scale demonstration projects (TRL 7) under development that may meet the objectives of the competition and be able to submit a project proposal in 2014. However, stakeholders also expressed concern that a competition limited to this scale would severely restrict the number of potential applicants, and may exclude SMEs from leading consortia.

4.3. Considerations for project delivery

The success and timeliness of project delivery is dependent on a number of practical considerations, such as securing permissions to build and operate, feedstock supply, site selection and infrastructure. This section provides an outline of these practical considerations and recommendations on how they may be implemented in the project selection process.

4.3.1. **Feedstock**

There is a risk that public money could be used to support conversion of only one feedstock with limited scale-up potential, and therefore limited potential to contribute towards future GHG emissions or renewable energy targets. To prevent this, it is advisable that competition entrants are required to provide a list of those feedstocks each technology is able to accept, plus data on actual and forecast feedstock availability in the UK[2].

It is important to note that feedstock availability should not be a reason to exclude the feedstock from the competition. Niche volume feedstocks could still provide benefits provided they meet sustainability criteria, and could also be used as mixed feed input to biofuels plants with other larger streams. There is minimal opportunity cost associated with allowing these feedstocks to be eligible, and it may also help promote innovation in different routes. However, if a certain technology is only capable of using feedstocks with limited potentials, then the technology may be marked down in the competition evaluation criteria, due to limited scale-up potential.

Applicants must also ensure that there is a reliable source of feedstock of the appropriate quality for the demonstration plant, and that they have secured access to this resource for the duration of the project.

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[2] To go further, DfT may wish to impose eligibility criteria such that the combined UK supply potentials (of all the feedstocks suitable for that technology), if all converted to biofuel, can meet at least 1% of UK transport demand. For wastes and residues with a static supply potential, this analysis can be based on today's potential – whereas for those feedstocks grown specifically for biofuels (e.g. energy crops), DfT may wish to choose a particular date (e.g. 2030) upon which to base these supply potential figures to allow sufficient time for realistic expansion in these industries.

As an indication, UK transport demand in 2012 was 53.248 Mtoe (DUKES, 2013). This equates to 2,229 PJ/yr, hence 1% of this demand would equal 22 PJ/yr. This production level is equivalent to 0.5 million tonnes/yr of diesel, or 641 million litres/yr. As an example, using gasification and Fischer-Tropsch diesel technology, producing this volume of diesel would require ~3.7 million tonnes/yr of wood pellets.

4.3.2. **GHG emissions savings**

Under the current RED, the GHG emissions saving from biofuels produced in installations built from 2017 must be at least 60%, in order to count towards national renewable energy targets, renewable transport targets and receive financial support. The GHG emissions savings from many advanced biofuels may comfortably exceed this threshold. E4tech recently estimated direct GHG emissions for biofuels produced from the proposed Annex IX feedstocks finding that all feedstocks are able to save at least 70% (many routes are around 90%), with the exception of micro-algae and macro-algae, which are around 60% (using the current comparator).

Technical innovation leading to increased yields and lower energy inputs may lead to lower GHG emissions for all routes, including algae based routes, and it is therefore essential that GHG emission estimates are robust, are correspond to expected process improvements.

It is recommended that the eligibility criteria include, as a minimum, projected GHG emission saving of 60% or 70%, and applications are evaluated based on their potential to achieve high GHG emission savings on commercial scale operation.

The RED calculation methodology does not include emissions from indirect land use change (ILUC), nor the emissions from changes in soil carbon stocks or fertiliser use (to replace any lost nutrients or organic matter). However the DfT is keen to ensure that biofuels result in genuine GHG emission reductions including indirect impacts. It is therefore necessary to ensure feedstocks are selected to ensure low risk of indirect emissions, and that market potential is calculated with due consideration of competing markets and indirect impacts.

4.3.3. **Location and permissions to operate**

There are a number of areas which are actively seeking investment in new industrial plant, such as enterprise zones. Some of these, particularly with a history of chemical industry operation, are targeting the bioenergy sector (e.g. the Humber and Teesside). Developing on existing industrial sites can ease the planning process, and existing infrastructure may reduce project development costs. For smaller scale plants, there may be opportunity to locate at existing research centres, for example those associated with Universities[3].

Planning permission

Issues with obtaining planning permission can delay project development timescales and are closely linked to site selection. Both completion of a planning application and the consultation and decision phase are time-consuming processes. The process will take more than a year, with a full 12 months potentially dedicated to the examination, recommendations and consideration of an application once it has been submitted. Local government and resident opposition can delay and influence decisions, and generally early engagement with the local community and government is recommended to mitigate such risks, and appropriate site selection may mitigate the risk of public opposition.

DfT may require that proposals demonstrate that the consortium have an adequate understanding of the planning process, including the steps and timelines involved in gaining planning permission, and to take sufficient account of this process within the project plans (if permission has not already been granted). Identification of a suitable site with good chances

[3] The Pyroformer™ technology, developed by the European Bioenergy Research Institute (EBRI) is located at Aston University

for obtaining planning permission should also be considered favourably when evaluating proposals. The department may choose to state that preference will be given to sites that have already obtained planning permission or have identified a site that aligns with the local authority's objectives, however this would limit the number of applications received due to the up-front investment required to do so.

Environmental permitting

Environmental permitting must be properly taken into account during project design and site selection. In this instance, it may be necessary for proposals to identify or provide details of an arrangement with a specialised construction contractor with an understanding of the permits required for construction phase. It may even be desirable for such a contractor to be involved as a partner in the project consortium. Failure to obtain the appropriate operational permits may cause delays if sufficient time is not allowed. Non-compliance with the conditions of permits could lead to loss of licence to operate, fines, reputational damage to the project partners and the advanced biofuels industry. The project application could require that applicants have identified all necessary permits and undertaken a detailed risk assessment, with mitigating actions in place. All necessary permits should be applied for, understood and adhered to. Demonstration of an understanding of what this entails and/or is likely to require could be requested in funding call proposals.

Infrastructure

Project proposals may also be required to demonstrate appropriate assessment of the required infrastructure, and availability at the proposed site. Some infrastructure requirements are assessed under the planning process, including site access and impacts on local traffic. The cost of services can have a significant impact on project costs, and must therefore be included in proposals.

Availability of suitable contractors and workforce

The construction and commissioning of a demonstration plant, including innovative technologies or processes, may require specific expertise, or highly experienced engineering contractors. The availability of such personnel may impact on both the timeframe and cost of project delivery. Consideration of the availability of suitable contractors should be included in the project proposal as a minimum, and to mitigate the risk of being unable to secure such service, the consortium may include engineering partner(s).

To a lesser extent, the availability of a suitably skilled workforce for the operation of the demonstration plant should also be considered, as this may impact site selection.

5. Definition of the Competition

5.1. Scope of the Competition

Proposals must apply technologies suitable for the conversion of sustainable, non-food feedstocks to transport fuels in the UK.

The proposed project should increase the TRL of the technology, promoting technologies already at TRL 5-6 to TRL 6-7, and should produce fuels suitable for use in one or more transport modes.

Proposals must include performance and cost targets, IP and technology exploitation plans, and a preliminary business case for the deployment of the technology. They should ascertain the sustainability of the feedstocks used by the technology, including alternative uses of the feedstock and the indirect environmental and social impacts associated with their use for biofuel production. Important considerations in the selection of projects will be the development and exploitation of IP for UK benefit, and the future commercial deployment of the technology in the UK.

The application must be made by a legal entity established in the UK. This does not exclude partnership with legal entities not established in the UK.

5.2. Expected award

DfT anticipate proposals requesting a contribution of between £5M to £25M, but this should not exclude submissions requesting other amounts.

5.3. Ambition

Pave the way for a first-of-a-kind commercial scale plant, by reducing the associated technological risk. The approach demonstrated should have the potential for significant economic and environmental impact, in terms of development or demonstration of IP, job creation, economic growth and the supply of low carbon sustainable fuels.

The aim of the Competition will be to prove that the production of advanced biofuels is technically viable, and may be economically viable at commercial scale.

Where advanced biofuels are defined as biofuels delivering high GHG emissions savings produced from sustainable, non-food feedstocks via not yet commercialised conversion technologies.

5.4. Evaluation of proposals

It is suggested that applications are evaluated based on three criteria appropriateness, impact, and implementation, details of each criteria are outline in Table 10. The appropriateness and impact criteria relate to the ability of the project to meet the Competition objectives, and are weighted equally based on the assumption that the Competition objectives are of equal importance. Implementation relates to the robustness of the proposal and likelihood of successful delivery, this is also equally weighted as successful project delivery is also crucial to DfT achieving its objectives. Value for money, in terms of the proposed project and longer term contribution to the UK economy, are implicit in the impact category.

Table 10: Proposal evaluation criteria

Criteria	Indicators	Weighting
Appropriateness	• Clarity of the proposal and the relevance to the competition scope • Credibility of the technological approach and relevance to the specific challenge • Level of innovation • Soundness of the business case for the subsequent 1st of a kind commercial scale plant	1
Impact	• Effectiveness of the proposal in meeting the ambition • TRL achieved by the proposed project • Environmental and economic performance of the proposed technology • Strengthening the competitiveness and growth of UK companies • Scale of the potential for exploitation and effectiveness of the proposed project to exploit project results • Effectiveness of the proposed project to communicate the project results, and impact on the advanced biofuels sector more widely • Value for money in terms of the level of funding leveraged • Value for money in terms of the potential impact on UK economy and energy and environment policy objectives	1
Implementation	• Coherence and effectiveness of the work plan, including allocation of tasks and resources • Combined expertise and experience of the consortium partners; complementarity of the consortium partners • Appropriateness of the management structures and procedures, including approach to risk and innovation management • Credibility of business case and plan • Realistic estimation of project timescales – for all project stages including time between project award, construction, commissioning and operation.	1

5.5. Consortia

Experience should be considered across the whole consortium and could include a requirement for one (or more partner) to demonstrate credentials in:

- Working with the innovative technology that forms the basis of the plant
- Designing and building a demonstrator plant
- Securing investment
- Track record in commercialising innovation
- Experience of working with the supply chain, or supply chain partners.

6. Viability of the Competition

The following section assesses the viability of the Competition as defined by the previous section. It builds on the review of advanced biofuel technology development and actors, the review of existing support schemes, and stakeholder interviews, to provide a high level outline of prospective applicants and projects, and a detailed risk assessment. This section goes on to provide recommendations relating to the competition delivery.

6.1. Prospective applicants and projects

The following tables provide a high level description of proposals that may be expected in response to the competition, relating to TRL 6 and TRL 7 activities.

Table 11: Profile of TRL 7 proposals

Integrated demonstration plant	
TRL of proposed Competition plant	7
Technology status prior to competition	Validation of a complete or partial process at appropriate scale, using relevant feedstocks, not necessarily integrated. Operations must demonstrate levels of efficiency, reliability and robustness to provide a level of confidence for scale up activities. Technologies are equally as likely to have been developed outside of the UK, with this presenting an opportunity to demonstrate the technology in UK conditions with relevant feedstocks. Project development has made significant progress, including technology selection, identification of preferred suppliers, detailed engineering design, site selection and planning applications may have been submitted.
Example conversion technologies at TRL 6	Fermentation of lignocellulose to ethanol or butanol, syngas fermentation, gasification with FT, methanol, mixed alcohol or bioSNG synthesis, and pyrolysis oil upgrading
Potential applicants	Technology owner or other stakeholder with an interest in developing the conversion technology (e.g. waste management company, fuel user or fuel supplier). Likely to require a consortium with representation across the supply chain (projects reviewed had between 2 and 6 partners). Requirement for match funding may restrict the ability of SMEs to participate. Since the number of technology pathways that may be delivered entirely by UK technology providers is limited, it is therefore expected that consortiums will include (if not be led by) non-UK companies.
Project timeframes	3-5 years from the competition award to commissioning of the demonstration plant, dependent on the scale of operation, and the status of development of the project. The lower range represents a project where significant progress has been made, such as site selection, technology selection and planning applications.

Time to commercialisation	Further 2-8 years following commissioning of the demonstration plant. The lower estimate represents a plant closely linked to the demonstration plant, for example where commercialisation is via extension of the demonstration plant.
Other funding options	ERANET Plus BESTF may be a suitable funding route for such a plant, provided it met national and European criteria, including collaboration with other Member States. The amount of funding available is limited to €25M and may be insufficient leverage the level of funding required. NER300 may apply, however as support under this scheme is linked to production, this may only be applicable where development of the large scale demonstration plant is closely integrated to the commercial scale operation (possibly through extension of the demonstration plant). Although this programme does not provide project finance, it provides additional revenues during operation. Similarly, EIB loans through the Horizon 2020 programme may apply provided revenue streams enable repayment. Horizon 2020 grant funding may be applicable provided the project meets the eligibility criteria. Again, suggested funding awards may be insufficient to support this scale of activity. It may be necessary to combine a number of support schemes to successfully de-risk a project of this size.
Project cost	Reported project costs range from £80M to £200M. At this range the competition may support between 10-30% of the project costs.
Barriers overcome by this approach	Operation of the full scale demonstration plant should be focused on establishing reliable operation and process optimisation, delivering the operating data and proof of revenue streams required to attract funding for a first of a kind commercial plant.

Table 12: Profile of TRL 6 proposals

Small demonstration plant	
TRL of proposed Competition plant	6
Technology status prior to competition	Process components operating at pilot scale, limited operational experience on relevant feedstocks and unlikely to be integrated. Technology components are more likely to have been developed in the UK, however constructing a full process is likely to require technology components from outside of the UK.
Example conversion technologies at TRL 5	Wide range of technologies including biological, thermochemical based processes and novel routes to transport fuels.

Potential applicants	Most likely to be led by the technology developer. Application may be from an individual company or a small consortium with experience across the supply chain. May include SMEs, large companies and/or multinationals.
Project timeframes	2-5 years from competition award to commissioning of the demonstration plant, dependent on the scale of operation, and the status of development of the project.
Time to commercialisation	The path to commercialisation is likely to require full-scale demonstration (TRL 7) before embarking upon development of a first of a kind commercial plant (TRL 8). The timescale for such commercialisation is highly uncertain, and may range from 8-12 years (or greater).
Other funding options	ERANET Plus BESTF may be a suitable funding route for such a plant, provided it met national and European criteria, including collaboration with other Member States. Horizon 2020 capital grant funding may also be applicable, again provided an eligible consortium is formed.
Total Investment Costs	Project capital costs may vary widely depending on the technology, feedstock, scale and site specific details such as existing infrastructure. The reported costs for such projects are typically up to £50M. The competition is more likely at this stage of development to meet 50% of the development costs, in line with contributions promoted by other schemes.
Barriers overcome by this approach	Providing evidence of technology concept beyond pilot scale, bridging the gap between R&D and demonstration. However, access to funding for the subsequent full demonstration project, is likely to act as a barrier to commercial deployment.

6.2. Risk assessment

A detailed risk assessment has been carried out relating to the delivery of the competition. The risks, impacts, level of impacts (based on the overall scheme objectives) and potential mitigation measures are detailed according to the stage of the competition – from competition launch, funding award, project execution and legacy (Table 13 - Table 16).

Table 13: Assessment of risks associated with the competition launch

Risk	Impacts	Level of impact	Mitigation
Limited interest due to the competition scope not addressing industry needs	A low number of proposals	**High** Fewer applications reduce the likelihood of identifying a suitable project, but overall scheme objectives may still be achieved. May indicate that the appetite for risk is lower than expected. It could also indicate a lack of interest and commitment from organisations/partners required to deliver strong consortia and successful projects.	The scheme design presented in the report has taken into account stakeholder views via a stakeholder workshop. Implementing a two stage application process would allow DfT to review at an early stage, and possibly at lower expense, if sufficient numbers of strong proposals are being made.
Limited interest due to funding levels	A low number of proposals	**Medium** Fewer applications reduce the likelihood of identifying a suitable project, but overall scheme objectives may still be achieved. Stakeholder workshop indicated that the proposed funding level was sufficient to support project(s) at the scales and TRL levels discussed.	Appropriate promotion activities targeted toward technologies at suitable stages of development. The review of existing schemes has illustrated that the 'market standard' for grant support for demonstration projects is around 50%. This should be achievable for TRL 6 activities, but the current budget is likely to be insufficient to support TRL 7 activities at this level. Secure a higher total competition budget.
Limited interest due to timescales/milestones.	A low number of proposals	**Medium** Fewer applications reduce the likelihood of identifying a suitable project, but overall scheme objectives may still be achieved.	Early communication of the competition allows prospective applicant to begin engaging with potential partners. Industry engagement during the Feasibility Study has informed the scheme design It is important to ensure that realistic project milestones are set, and these may be set on a project-by-project basis to reflect the specific proposal activities. An experienced selection or advisory panel should facilitate the setting of appropriate milestones.

Risk	Impacts	Level of impact	Mitigation
Industry is more interested in applying for other funding schemes	A low number of proposals	**Low** Projects may be supported by more than one funding scheme	Existing schemes review has identified relevant complementary schemes. There have been very few UK applicants to existing schemes. Ensure that competition rules enable projects to be supported by more than one initiative at the same time. Fully understand the rules of wider EU block exemption.
Applicants do not understand the competition objectives and eligibility criteria	May result in either a higher or lower number of applications	**Low** Application process will reinforce the objectives and eligibility criteria.	Develop and disseminate clear competition scope, eligibility criteria, and evaluation criteria. And provide FAQs and contact details for queries. A two stage application process including an initial brief Expression of Interest would allow for DfT to select appropriate projects to take forward to full application, reducing the effort required by both DfT (or the selection panel) and applicants.
Limited interest or willingness to form consortia, or lack of suitable consortia	A low number of proposals, or weaker proposals	**Low** The biofuels industry has a good track record of working well together in partnership. Consortia should ideally be positioned across the supply chains, limiting competition issues	Stakeholder engagement has demonstrated that the industry understands the need to partner with actors across the supply chain, and the strength of such partnerships in determining feedstock supply and fuel quality, etc. An Expressions of Interest application stage will enable businesses to use a positive response to attract partners into a consortium.

Table 14: Assessment of risks associated with the proposal selection and award

Risk	Impacts	Level of impact	Mitigation
Limited availability of experienced individuals for the selection panel	Unable to launch the scheme due to lack of assessors, or poor evaluation leads to inappropriate project selection	**High** Assessors are required to ensure that the selected proposals are credible	Early identification and engagement with experienced individuals. The responsibility may be passed on to an external programme manager, in which case they should demonstrate that their network of contacts will facilitate assembly of an appropriate selection panel.
Contract negotiations	Negotiations could result in costly delays to the project, delay project inception and place project milestones and objectives at risk.	**Medium** Risks are primarily to project schedules and costs	Early communication of detailed terms and conditions of grant award. Employ experienced contract managers, either internal or external.
Poor or inappropriate applications	Inefficient use of resource to sift out unsuitable applications.	**Low** Poor or inappropriate applications would have minimal impact on the scheme objectives, but may increase the time spent at the evaluation stage.	Make the competition objectives clear and understandable to avoid possible misinterpretation. Develop and disseminate clear competition scope, eligibility criteria, and evaluation criteria. And provide FAQs and contact details for queries. Implementing an Expression of Interest stage will reduce the amount of time required to sift out unsuitable applications.

Table 15: Assessment of risks associated with the project implementation

Risk	Impacts	Level of impact	Mitigation
Unable to leverage match funding from the private sector or other sources	Project cancelled or scope/scale reduced	**High** Match funding will be required to reach competition objectives	Publicise selected projects, and possibly hold event(s) to facilitate networking between project developers and prospective funding bodies. This may be possible after the first phase of a two phase application process, as appropriate matched funding plans may be required for the second phase of applications
Unable to secure licence to build and operate (planning, environmental permitting).	Very long delays to project inception and build.	**High** Unless a suitable location has been identified, it will not be possible for the project to launch.	The DfT may require planning permission to have been sought and gained prior to proposal submission. However, this would limit the number of applicants. Or provide credible risk assessment on planning and permitting process. Higher priority may be given to projects that propose to build on an existing pilot scale demonstration project – where it could be feasible to extend operations.
Failure to secure feedstock in the quantity required for demonstration plant.	Project viability	**High** Feedstock supply will be vital to the performance of a project	Project proposals will be required to take feedstock supply into account. Ideally, the project consortium will feature industry players at all stages of the supply chain. Securing feedstock agreements may be facilitated by a two stage application process, which allows selected applicants in invest more time into the full application.
Technology/ IP ownership or licensing prevents use of technology	Impacts on project viability	**High** Project will be delayed if alternative technology has to be sourced.	EoI process may enable organisations to procure suitable technology in advance – or to ensure no barriers to use of technology. Funding call may encourage participation of the whole technology development process – e.g. include original technology innovators in the form of academic partners or entrepreneurs.

Risk	Impacts	Level of impact	Mitigation
"Scale-down" of commercially proven equipment for custom pilot and demo applications creates unforeseen difficulties	Financial and planned timescale impacts as the equipment is a necessary component for the project.	**High** Redesigns and/or retrofits would delay the project and can costly.	Proposals will be required to demonstrate and prove that specified technical equipment is available and has been proven. Where the equipment is not already available, the proposal should include detailed plans on how consortium will acquire/ develop the equipment and these plans (timescales/ financial/ administrative) should be included in the overall project plan.
Overspend on the project	Consortium partners may experience financial difficulty	**High**	Ensure proposals include accurate project cost estimates, cash flow forecasts, and adequate contingency. This may be assessed by the selection panel (and programme manager). Contracts to ensure that DfT are not accountable for additional costs. Expression of interest procedure may allow applicants to invest more time and resource into full application, and therefore produce more accurate plans. Regular progress reporting and review by scheme administrator (or program manager) in order to ensure that any issues are flagged, logged and mitigated early in the process.
Technology failure	Project delays may arise and result in missed objectives.	**High** One of the wider objectives as part of the scheme (may) be a need to enhance and develop existing technology in order to demonstrate or bring to commercial readiness.	Proposals will be required to provide evidence to demonstrate that their technology readiness levels meet the minimum eligibility criteria. Proposals will be assessed by technical experts with an understanding of the limitations of the technologies involved. Regular progress reporting and review by scheme administrator (or program manager) in order to ensure that any issues are flagged, logged and mitigated early in the process.

Risk	Impacts	Level of impact	Mitigation
Delayed build and commissioning	Impacts on project timescales with repercussions for the achievable plant outputs.	**Medium**	Proposals should include credible work plans, including the allocation of resources and project milestones. These may be assessed by an experienced selection panel. The appointment of a suitable engineering provider and appropriate contracts will ensure timely construction and commissioning, experienced advisors may provide guidance on these arrangements.
Health and safety (H&S) issues	Licence to build and operate may be effected	**Medium**	Plant operators will be required to operate within all relevant H&S regulation. DfT can require that proposals demonstrate an understanding of these requirements.
Withdrawal of consortium members due to lack of engagement, shift in business priorities, or financial difficulty	Practical and administrative impacts to the project and outcomes. Delays while a suitable replace if found. Consortium morale.	**Low – High** The level of the impact could depend on the level of investment and/or the role of the partner	Proposal review process should assess strategic fit with future plans of consortium partners. Redundancy management plans should be required to be built into the consortium.
Availability of skilled workforce available to operate plant.	Delays in plant production, reduced plant availability, and increased costs	**Low** Appropriate site selection should consider labour force requirements Scale of the plant may not require full industrial workforce	Ensure proposed plant location has been carefully considered and discussed within the project proposal.

Table 16: Assessment of risks associated with competition legacy

Risk	Impacts	Level of impact	Mitigation
Limited dissemination of project results; successes and lessons learned.	Impact of the competition limited	**Low** Reporting requirements linked to funding award	Milestone reporting structure can be prescribed to ensure reporting is received throughout the project duration.
Failure to adequately demonstrate technology or meet demonstration targets (performance, availability, yield)	Reduce interest in investing in subsequent 1st of a kind commercial scale plant	**Medium**	DfT to ensure that proposal assessors have a high level of expertise in order to evaluate the readiness of technologies and experience and expertise of project personnel.
Failure to demonstrate a marketable product due to missing target production cost, or sustainability criteria	Limit potential for commercial scale development Potential negative impact on the investor confidence in advanced biofuels.	**Medium**	Project proposal will be required to demonstrate that outputs are in line with overarching government policy and the objectives of the scheme. Careful assessment of credibility of proposed targets.
Petroleum and conventional food-crop biofuel price fluctuations reduce the profitability of advanced biofuels.	Reduced interest in investing in the project – little desire to follow up on project successes.	**Medium** Policies to direct energy requirements away from fossil fuels will continue to help influence development of biofuels as an alternative.	Government national and international policies continue to promote the need for alternative fuel sources for environmental and energy security reasons.

6.3. Recommendations for delivery of the Competition

6.3.1. Application Process

A two phase application procedure is recommended consisting of a first call for Expressions of Interest, and a second stage in which selected applicants are requested to submit a full proposal. The recommended proposal evaluation criteria were outlined in the previous section, recommended questions for the two stages of application are outlined below.

Expressions of Interest

The recommended information requested for the Expression of Interest:

- Process and description, including details of the current stage of development of key technologies/processes, highlighting the innovative aspects and the objectives of the proposed project
- Details of proposed feedstocks, including feedstocks to be used for the demonstration project, and wider range of feedstocks suitable for the technology
- Outline project cost, including the support requested and details of other funding sources (secured or prospective)
- Project milestones
- Route to commercialisation and timeline
- Details of the consortium partners, their capabilities and responsibilities within the proposed project
- Details of the project team, individual experience and expertise

Full applications

The recommended information requested for full applications are outline below; in addition the selection panel may request additional detail or confirmation of information provided in phase 1.

- Proposed concept, and alignment with the competition aims
- Project objectives, products, plant performance and cost targets
- Detailed work plan, including tasks, milestones and allocation of resources
- Outline engineering design, including details of technology selection or selection criteria
- Details of technology providers and construction partners, track record and previous experience
- Detail of feedstock requirements (for demonstration activities), procurement plan or supply contracts (if available)
- Evaluation of the sustainability of the proposed current and future feedstocks, including alternative uses of the feedstocks and the indirect environmental and social impacts associated with their use for biofuel production
- Estimation of the GHG emissions for the proposed current and future feedstocks (gCO_2e/MJ biofuel)
- Cost estimate and spend profile, including appropriate assessment of the accuracy
- Projected cash flow for the lifetime of the demonstration plant
- Details of match funding, including terms and conditions

- Project management, structures and processes
- Project risk assessment
- Business case or feasibility study for a first-of-a-kind commercial scale plant, analysis of the scale of potential exploitation
- Statement on value for money considering the projected biofuel costs (£/GJ), cost of GHG emission savings (£/tCO_2e) at full scale commercialisation
- Technology or IP exploitation plan, including details of the potential value to the UK economy
- Communications plan

6.3.2. **Application evaluation**

The programme manager will be required to appoint a Selection Panel with appropriate experience and expertise to evaluate expressions of interest and full applications. The selection panel as a whole will require the following expertise:

- Technology: knowledge of all advanced biofuel conversion technologies, and the ability to evaluate the degree of innovation, technical risk, engineering design, and scalability
- Feedstock and sustainability: knowledge of all advanced biofuel feedstocks including, resource availability, prices, markets, the composition (feedstock and technology interface), and any regulatory issues
- Economics: ability to provide critical assessment of the robustness of the project proposal and economic analysis of full commercial scale process
- Business plan and strategy: detailed knowledge of biofuel markets, understanding of supply chains, and experience of appraising business plans in this sector

The appropriate range of experience and expertise is critical to correctly evaluating proposals and mitigating many of the risks associated with project execution and competition legacy. Individuals must also be able to respond quickly, in order to prevent delays.

6.3.3. **Application timing**

A further benefit of using a two stage application process is that the initial Expression of Interest phase may be completed quickly, as was the preference of stakeholders consulted.

If the competition is launched in April/May as indicated by DfT, then Expressions of Interest may be submitted by June/July 2014, providing two months for completion. Selected applicants would then require up to six months to submit final applications, which could be submitted by December 2014. The Stakeholder Workshop indicated that industry is keen for the competition to be launched as soon as possible, which would support the spending of grant budget before end-2018.

6.3.4. **Measuring and reporting success**

The Department and/or the Programme Manager will be required to report on the success of the Competition. This may take place a various stages of the Competition including at application stage, contract award and project completion. A suggested measure of success includes the number of applications meeting a minimum threshold in the evaluation, which would provide an indicator of how successful the competition design has been in meeting the needs of the industry, and the effectiveness of the launch. At award stage, the amount of funding leveraged can provide a short term indication of the added value realised by the Competition funding. The Programme Manager will be responsible for regular reporting on project progress to milestones, in order to approve payments. A final project audit, by an independent party may also report on the performance of the competition against the competition aims.

7. The Scheme Design

7.1. Delivery mechanism options

The options for directing public funds to commercial or research organisations include grant funding, loans, guarantees, equity investment and product subsidies. These options are all suitable for near-market developments that expect to attract revenue streams, or that expect to raise other sources of investment. This appraisal of delivery options focuses on capital grant funding, as initial indications from DfT suggest this is the preferred approach, and fits with the schedule and conditions under which funds have been provisionally allocated.

A brief description of other delivery options is given in the following section. However, these other delivery options would not be relevant for pilot or early stage demonstration plant, which do not have a reliable output of biofuel of sufficient quality for sale, as they will have no income stream. For this type of plant, capital grant funding is the most practical way to fund a project.

7.1.1. **Loan and loan guarantees**

If the proposed demonstration project will generate revenues it may be suitable for non-grant funding in the form of loans or loan guarantees. The allocation of debt financing, such as loans is depend on the project (or company) risk profile, and for demonstration plants and first-of-a-kind commercial plants the technical risk profile is by definition high (TRL 7-8) as there is no reference plant on which to base operational assumptions.

Commercial lenders, including banks, typically have a conservative approach to risk, while financial organisation such as EIB and GIB may have a slightly higher tolerance of risk in selected sectors or technologies areas.

Demonstration project that have the potential to generate saleable biofuels (TRL 8, and potentially TRL 7), may be eligible for the following options:

1. Loans that need to be repaid, but are written off if the project fails (this type of loan can only be funded by public sector bodies[4])
2. Soft loans at zero or very low rates of interest (this type of loan is typically only offered by public bodies)

7.1.2. **Tax allowances**

Another option for financing a demonstration scheme may be some form of preferential tax treatment (e.g. 100% capital allowances) for demonstration plants if they are likely to be profitable. This may incentivise large industry players to invest, however the outcome would be a very different scheme to the one being designed under this feasibility study and unlikely to meet the objectives of the DfT. Tax relief schemes are much more complex and long term than capital grant funding. An example of this type of scheme is the Carbon Trust Enhanced Capital Allowance (ECA) Scheme for Energy Saving Technology.

[4] Examples include the CARES project in Scotland, details: http://www.energysavingtrust.org.uk/scotland/Communities/Community-And-Renewable-Energy-Scheme/Financial-support-from-CARES/Pre-Planning-Loans

7.1.3. **Procurement routes**

The TSB Small Business Research Initiative (SBRI) is a specific procurement route for research and development services, which can also cover demonstration projects. This option involves funding 100% of the project capital, usually through a two stage competitive process, where the first stage involves completing a feasibility study, and the second stage is project delivery. Applicants retain ownership of any purchased equipment and IP.

The SBRI funding model is not subject to State Aids regulation, and can be more attractive to SMEs who may struggle to secure matched funding. However, this mechanism would reduce the number projects that DfT may support, compared to a grant funding scheme offering lower aid intensities (matched funding). In addition, if the DfT were to skip the first feasibility stage and proceed directly to funding stage 2, the risk would be substantially increased in comparison to a typical SBRI. DfT has an internal SBRI team and further engagement would be advised to establish the suitability of this route for future funding schemes.

7.2. State Aid

The high profile projects selected for further review in the course of this study have primarily been those funded through EU sources (e.g. NER 300, ERDF and FP7) and the remainder were from countries outside the European Union (e.g. North America and Canada). As such, none of the projects researched revealed a specific national approach to State Aid with the aim of funding a biofuels demonstration project.

Regarding the use of State Aid routes for grant funding, much depends on the timescale for development and launch of a scheme. Longer term programmes (such as those run by the Carbon Trust, TSB and ETI) have all applied for a specific full State Aid exemption using the full notification procedure which allows for maximum control over the design of the scheme, but requires in-depth justification of the requirement for market intervention. Within UK Government Departments, DECC, Defra, BIS and DfT have all used State Aid General Block Exemption Regulations to deliver grant funding schemes with a shorter lead-time[5].

The European Commission's State Aid regulation is designed to prevent Government funding from causing unfair competitive advantages within a given market. In designing a funding scheme to support demonstration projects, there are a number of routes available that will comply with State Aid legislation, including block exemptions and a full notification procedure, which is known as an individual exemption.

General Block Exemption Regulations (GBERs) provide a list of specific conditions under which Member States may launch a funding scheme without being required to complete the full notification procedure. Provided the block exemption conditions are met, the programme manager may simply notify the Commission via a retrospective transparency notice. In the event of a very large individual award being made, a notification must still be made to the Commission – even when the scheme under which the award has been made satisfies all of the requirements of GBER.

If it is not possible to comply with all the conditions of a block exemption, the program manager must apply for an **individual exemption** using the full notification procedure, which

[5] Examples include the DECC Bio-Energy Capital Grants Scheme, and Smart Grid Demonstration Scheme which were both delivered under the GBER for Environmental Protection.

can take at least 3 - 6 months. Using an individual exemption to deliver State Aid means that the Commission must be notified in advance of delivering the financial aid.

7.2.1. **Application process for GBERs**

The Commission's State Aid legislation states that a summary of information on the grant aid scheme must be submitted within 20 working days following the entry into force of the scheme, and a specific template is provided in Annex III of the regulations. DfT would also need to publish information about the scheme on their website, detailing the conditions of the scheme which ensure its compliance with the relevant GBER.

The scheme summary template requires the following information:

- Member State and Granting Authority
- Title of the aid measure, national legal basis and a web link to the full text of the aid scheme
- Duration of the scheme, the economic sectors eligible to receive aid, and the type(s) of beneficiary
- Annual and overall budget(s)
- Aid instrument to be used (for example capital grant)

The scheme summary will be published by the Commission in the Official Journal of the European Union and on the Commission's website.

The following subsections outline two block exemptions that may be relevant to the Advanced Biofuels Demonstration Competition, these exemptions relate to environmental protection, and research and development.

7.2.2. **State Aid block exemption for Environmental Protection**

It is important to note that only the *additional* costs of an advanced biofuels demonstration plant compared to the 'normal' costs of a conventional plant are eligible for calculating aid intensity, not the full cost. Environmental investment aid for the promotion of energy from renewable energy sources shall be compatible with the common market provided the following conditions are fulfilled:

- The aid intensity shall not exceed 45% of the eligible costs. However, the aid intensity may be increased by 20 percentage points for aid awarded to small enterprises and by 10 percentage points for aid awarded to medium-sized enterprises.
- The eligible costs shall be the extra costs borne by the beneficiary compared with a conventional system with the same capacity in terms of the effective production of energy.
- The eligible costs shall be the extra investment costs necessary to achieve a level of environmental protection:

  (a) Where the cost of investing in environmental protection can be easily identified in the total investment cost, this precise environmental protection-related cost shall constitute the eligible costs;

  (b) In all other cases, the extra investment costs shall be established by comparing the investment with the counterfactual situation in the absence of State Aid; the correct counterfactual shall be the cost of a technically comparable investment that provides a lower degree of environmental protection and that would credibly be realised without aid.

- The eligible investment shall take the form of investment in tangible assets and/or in intangible assets.

Box 1. Example of an advanced biofuels counterfactual calculation for eligible costs[6]

The counterfactual should be production of an equivalent fuel. The counterfactual could be based on fossil or renewable sources.

For example, the cost of a bioethanol plant based on lignocellulosic feedstock could be compared with a bioethanol plant based on a starch feedstock.

The eligible costs are assumed to be additional capital costs only. The capital cost of a conventional bioethanol plant is typically about one third that of a lignocellulosic ethanol plant.

We assume:

- the capital cost of a 50 Million litre lignocellulosic ethanol plant is £60million
- the capital cost of a 50 Million litre starch ethanol plant is £20million
- resulting eligible investment costs for environmental protection is £40million
- the grant at 45% of the eligible costs is £18million

7.2.3. **Block exemption for Research, Development & Innovation**

Experimental development means the acquiring, combining, shaping and using existing scientific, technological, business and other relevant knowledge and skills for the purpose of producing plans and arrangements or designs for new, altered or improved products, processes or services. These may also include, for instance, other activities aiming at the conceptual definition, planning and documentation of new products, processes or services. Those activities may comprise producing drafts, drawings, plans and other documentation, provided that they are not intended for commercial use.

The development of commercially usable prototypes and pilot projects are included where the prototype is necessarily the final commercial product and where it is too expensive to produce for it to be used only for demonstration and validation purposes. The experimental production and testing of products, processes and services are eligible, provided that these cannot be used or transformed to be used in industrial applications or commercially. However, experimental development does not include routine or periodic changes made to products or processes, even if such changes may represent improvements.

The aid intensity shall not exceed 25 % of the eligible costs for experimental development. The aid intensity may be increased by 10 percentage points for medium-sized enterprises and by 20 percentage points for small enterprises; and a bonus of 15 percentage points may be added, if:

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[6] As part of the application process the applicant should identify and justify the counterfactual chosen. This approach is also taken in NER300 so there is guidance available on choosing appropriate counterfactuals for advanced biofuels.

a) the project involves effective collaboration between at least two undertakings which are independent of each other,
    - no single undertaking bears more than 70 % of the eligible costs of the collaboration project, and
    - the project involves collaboration with at least one SME or is carried out in at least two different Member States, or
b) the project involves effective collaboration between an undertaking and a research organisation[7], where
    a) the research organisation bears at least 10 % of the eligible project costs, and
    b) the research organisation has the right to publish the results of the research projects insofar as they stem from research carried out by that organisation.

The eligible costs include personnel, instruments and equipment to the extent and for the period used for the research project, buildings and land, contractual research, technical knowledge and patents bought or licensed from outside sources at market prices, additional overheads, and other operating costs, including costs of materials, supplies and similar products incurred directly as a result of the research activity.

7.2.4. **Application process for Individual State Aid Exemption**

Making a State Aid notification, if the financial award proposed does not fall into any of the GBERs or *de minimis* state aid categories, involves a lengthy process. The first step is to make a pre-notification contract with the European Commission. This is carried out by drafting a pre-notification using the State Aid Notifications Interactive System (SANI) which is submitted electronically to the Commission and then developed into a formal notification through discussions with the Commission. Failure to provide a pre-notification may delay proceedings at later stages as the Commission seeks clarification. The formal (or simplified) notification resulting from discussions is then provided for the Commission electronically, who will respond initially within two months of receipt of notification. In cases where the Commission requests additional information, the Member State has one month or 20 working days to respond. If further information is required, the Commission will then have an additional two months to respond on receipt of clarification response. Once the notification steps have been completed and the Commission have no further questions, there may be one of four outcomes;

1. Aid is approved.
2. Aid is approved with amendments or additional conditions.
3. The Commission reaches a negative decision.
4. The Commission opens an Article 108(2) investigation procedure
    - In the event of an investigation procedure, the Commission will officially outline their concerns and seek a response within 20 working days. The Member state must then prepare a response that highlights any inaccuracies or misunderstandings that the Commission have published whilst also lobbying UK and EU contacts to write in support of the aid. This is a lengthy process which may require multiple iterations and still may not guarantee a positive decision.

[7] subcontracting shall not be considered to be effective collaboration

Individual Exemption Notification procedures are avoided by UK Government, with the advice presented in "State Aid: The Basics" published by BIS in November 2013 recommending that if aid does not fall into one of the GBER's, that practitioners should seek help and attempt to find another mechanism through with the support may be offered.

7.2.5. Comparison of relevant State Aid block exemptions

A summary of the relevant block exemptions is outlined in Table 17.

Table 17: Summary of state aid options for grant scheme design

Options	Funding support level	TRL	Benefits	Constraints
Block exemption for environmental protection	Up to 45% (increases for SMEs)	6 -7	Competition may be launched in parallel to notification. May support large scale demonstration.	Supporting TRL 7 would only be eligible for feedstocks classed as sustainable.
Block exemption for R&D	Up to 25% (increases for SMEs and collaboration)	4-6	Competition may be launched in parallel to notification. Supports pilot and small demonstration projects.	Unlikely projects will be installed and commissioned before 2020 so the focus would need to be on 2030. Higher % of funding may be needed to generate interest from UK bidders.
De minimis state aid	100% up to a maximum of €200,000	4-7	No need to notify Commission of the Competition.	Limit of €200,000 applies to all state funding over 3 years, so is likely to be far too low to kick-start investment.

It is possible to combine elements of the State Aid General Block Exemption Regulation (GBER) to form a programme that supports projects under both R&D and Environmental Protection, although it is not common practice. The exact wording from the Commission on this is:

"A State aid scheme containing different categories under the GBER, covered in one national legal basis, can be approved. The national legal basis for the category of aid concerned should be indicated on the information sheets for GBER that must be sent to the Commission. If all the categories are based on the same national legal basis, one information sheet can be submitted, otherwise several information sheets are required. The aid grantor should demonstrate that the maximum aid ceilings are respected for each category of aid (taking into account the cumulation rules in the GBER) and keep separate records for each category of aid. Cumulation is not allowed for partly or fully overlapping [eligible project] costs if such cumulation would lead to exceeding the highest allowable aid intensity applicable under GBER."

7.2.6. Implications of the consultation on updated State Aid Guidelines

The commission launched a consultation on the 18th December 2013 on the implementation of updated State Aid Guidelines for assessing public support projects in the field of energy and the environment. This revision is part of a broader initiative to modernise EU State aid rules. In the main, there are no major implications for the design or delivery of the Competition as the Commission proposes to continue use of the General Block Exemption Regulations outlined above.

If the Competition is not designed under a GBER, the major proposals in the consultation that would affect the design/delivery would mainly relate to the amount and type of evidence that would need to be submitted to the Commission as part of the full notification procedure. The proposed updates are focussed on ensuring Member States have adequate safeguards in place to limit distortions of competition and to avoid subsidy races between Member States.

In relation to advanced biofuels, the proposed updates that would be relevant for a Scheme that <u>is not</u> designed under a GBER are:

- Individual aid granted on the basis of a notified aid scheme remains subject to the notification obligation pursuant to Article 108(3) of the Treaty, if the aid exceeds the following notification thresholds:
    - investment aid: where the aid amount exceeds EUR [7.5] million for one undertaking;
    - operating aid for the production of biofuel: when the aid is granted to a biofuel production installation in sites where the resulting production exceeds [150 000] t per year
- In schemes that are notified: the Member State is required to demonstrate why other potentially less distortive forms of aid are less appropriate.
- Investment aid to installations producing biofuels can only be granted to installations that do not produce biofuels from cereal and other starch rich crops, sugars and oil crops as defined in the Commission´s proposal COM(2012)595
- For biofuels, the Commission considers that in the post 2020 period only advanced biofuels should receive aid. Operating aid for advanced biofuels crops can be found compatible as long as each of the following conditions are met:
    (a) The aid does not exceed the difference between the cost of producing energy from renewable sources and the market price of the form of energy concerned.
    (b) The measure is designed such that it compensates the difference in variable operating costs borne by the beneficiary and the market price.
    (c) Investment aid is deducted from the production costs.
    (d) Aid is only granted until the plant has been fully depreciated according to normal accounting rules.

7.3. Recommendation from initial scheme design review

Following this detailed review of State Aid funding options, our recommendation is to design a scheme to comply with the GBER for Environmental Protection under Article 23 of the Regulation Guidelines. This State Aid route appears to be the most suitable route for DfT to address a number of priorities:

1. Grant funding addresses technology risks and the lack of a guarantee of saleable biofuel output in a manner that is not possible via loan funding.
2. Demonstration projects are the most likely to contribute to 2020 targets.
3. The aid intensity (45% for large enterprises and up to 65% for small enterprises) is higher than in other relevant GBER routes and should prove attractive to developers and investors.

Stakeholder feedback leaves DfT with a clear steer from a credible industry representation for a scheme that would be designed under the criteria of the General Block Exemption for Environmental Protection. The following sections therefore focus on a scheme that supports advanced biofuels under the conditions of the GBER for Environmental Protection.

7.4. Procurement options

The competition will require a Scheme or Programme Manager to coordinate the launch, assessment of applications, and monitor project progress and outcomes. Appropriate experience and expertise is critical to the delivery of the competition. In particular, the key stages of competition delivery and their related expertise are:

- Design of the scheme documentation and launch of the scheme (application form, guidance document, State Aid information): requires knowledge and experience of launching previous schemes and designing application forms to provide all information needed to fully evaluate a proposal, an established network of contacts within the biofuels sector to promote the scheme and encourage consortium building, facilities to manage announcements and queries regarding applications to the scheme.
- Assessment of applications (including eligibility reviews, full technical evaluation and due diligence of business plans): requires knowledge of the status of advanced biofuel technology development worldwide, in-depth technical understanding of biofuel technology, and the markets for feedstocks and biofuel products, experience of managing an expert evaluation team and ensuring a fair and auditable process is completed.
- Draft and negotiate accountable grant agreements: requires experience of grant offer terms and conditions, and appropriate technical experience to negotiate milestone payments that are designed to ensure progress is maintained.
- Monitor project progress and approve payments: requires evaluation and verification experience, and experience of providing strategic support to businesses within the sector.

Our recommendation is that DfT appoint an internal or external Programme Manager with the appropriate experience and sector expertise. In appointing the role, DfT must also consider value for money and the speed at which the role may be awarded to avoid delays. DfT may decide to run the scheme using in-house staff, but here we present a number of options for the procurement of an external Programme Manager, focussing specifically on the timescales for establishment of a contract, and the estimated cost of managing a scheme under the following assumptions:

- Set up and launch of the scheme, to include application form and guidance,
- Technical assessment of 8-10 Expressions of Interest,
- In-depth technical assessment of 4-5 full applications for funding, including due diligence of the business cases for commercial viability,
- Grant award and contract negotiation support for DfT,
- Monitoring of 3 projects over 4 years (2014 – 2018) to include monthly updates, quarterly monitoring visits, and business case support.

In producing this summary, we have held discussions with Ricardo-AEA procurement teams, ETI, Carbon Trust, GIB, the Horizon 2020 team, and TSB in order to give a broad perspective between private and public sector on the types of organisation that could take on the role of the Programme Manager. The following table represents a summary of the information from those organisations that were the best match for this scheme. It is important to note that the figures quoted for the estimated cost of scheme management given below are for illustrative purposes only. Our expectation is that not-for-profit organisations (such as the Carbon Trust) would be able to offer more cost-effective scheme management.

Table 18: Summary of options for procurement options

Option	Timescale for procurement	Estimated cost of scheme management (based on assumptions listed above)	Other comments
OJEU/open tender	4-6 months	£200k - £300k plus DfT time input to complete OJEU process and assessment of scheme management proposals	Due to the likely cost of scheme management, the tender would have to be advertised in the OJEU, although DfT could use a Pre-Qualification Questionnaire (PQQ) to narrow down the bidders for the full Invitation to Tender (ITT). There are a number of private sector organisations that could deliver this service via an open tender.
DfT Frameworks	2-3 months	£200k - £300k plus DfT time input to complete assessment of scheme management proposals	Frameworks would allow for fast procurement, with a number of experienced grant scheme managers in existing consortia within the TRANSPORT – RELATED TECHNICAL AND ENGINEERING ADVICE AND RESEARCH (ROAD TRANSPORT – LOT 2) framework.

Carbon Trust	4-6 weeks plus time to recruit the Expert Panel	A scheme of this nature will typically require 2-4% of the funding budget (£500k - £1M)	The DfT would not have to run a procurement process if it decided to grant fund the Carbon Trust and give it full responsibility for the programme. In grant situations the Carbon Trust acts as a non-commercial entity and would recover its programme management costs on a cost recovery basis (i.e. non-profit).
TSB	3-4 months	General running costs are approximately 3% of the funding budget (£750k) Or for projects added to the existing R&D programme, around £50-60k	TSB have long-running experience in delivering competitions on behalf of UK Government. Securing a slot in their annual competition schedule would be of key importance for DfT. DfT may also wish to consider the level of branding that they would retain.

The options explored here would be suitable for a scheme delivered under any of the State Aid block exemptions, although TSB and Carbon Trust have existing programmes with State Aid clearance under the GBER for R&D, so if this GBER was the chosen route, DfT funding could be delivered through an existing programme at a lower cost.

For a demonstration scheme delivered under the GBER for Environmental Protection, TSB and the Carbon Trust are essentially in the same position as any potential Scheme Manager, as they would need to assist DfT in submitting the scheme documentation to the European Commission to ensure compliance with the GBER, and deliver the demonstration scheme as a new programme.

In summary, there are no major advantages or disadvantages to DfT of pursuing any particular one of the available procurement options, although Carbon Trust would offer the fastest procurement route. The open tender process has the disadvantage of a longer procurement time, compared to the timescales that industry has indicated would be preferable for the launch of a scheme. In either scenario, appropriate experience in assessment and delivery of grant funding and expertise in advanced biofuels will be critical for successful delivery.

7.5. Grant award options

In offering capital grants, DfT would have a number of options for the manner in which the funds are disbursed to grantees:

- **Upfront payments**: capital funds are awarded based on planned spend. This is a risky option, and DfT would need to include provisions for recovery of unspent funds and accrued interest within the grant offer contract.
- **Quarterly payments in arrears**: grant payments are approved on the basis of reported expenditure, supported by evidence of payment, and verified accountant’s reports. This is a less risky option, but does not track or take account of progress towards commissioning of the plant and production of the biofuel.

- **Milestone payments**: grant payments are approved on the basis of expenditure, and progress, supported by evidence of payment, verified by accountant's reports, and other documentary evidence of milestone achievement (e.g. independent commissioning report). The disadvantage of this option is that there may be a large peak in expenditure some time before a major milestone is achieved, causing cash flow issues for smaller grantees. A mitigation option is to agree additional shorter milestones with grantees who predict that cash flow may be an issue.

Our recommendation to DfT is to award grants on the basis of milestones. This ensures that central government funds are being issued not only when spend has been completed, but when technical progress has been made too, i.e. payment by results. To de-couple payments from progress would prevent DfT from holding the grantee accountable for development of the project.

7.5.1. **Allocation of funds**

Applicants should be required to state the amount of grant that they deem necessary to deliver the project, as well as the corresponding amount that they will be match funding. It should be up to the applicant to identify and secure their own sources of funding, although DfT could sign-post to investors. If DfT were to be any more involved in brokering funding agreements, this could be seen as a conflict of interest as the application process will be competitive.

DfT have the option to support one large project using the full £25million, or to support several smaller projects. This decision can best be made as a result of the Expression of Interest stage, where DfT would be able to analyse the various requests from applicants and see what the portfolio of projects might look like.

7.5.2. **Recovery of funds**

In general, the approach of payment by milestones reduces the risk of project failure. If other funders pull out, or the decision is taken not to go ahead with the project due to other issues, this is generally before large volumes of CAPEX have been expended, and therefore few or no grant payments will have been made. The assessment of each application for funding should also review the financial stability of the applicant as part of due diligence, and grants should not be awarded to projects with a high risk of insolvency.

On the rare occasion where a project fails part-way through delivery, in most cases it would not be possible to recover grant funds, as any administrators would look to recover debt from the assets of the organisation. Unlike loan funding, capital grant funding can be written off. If the lead organisation is taken over and the new owners choose not to continue on with the project, it is possible that grant funds paid to date could be repaid to DfT as part of a sale of assets.

8. References

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9. Annexes

1. Technology status update
2. UK value and jobs analysis: Methodology and assumptions
3. Advanced biofuel demonstration projects: Case studies