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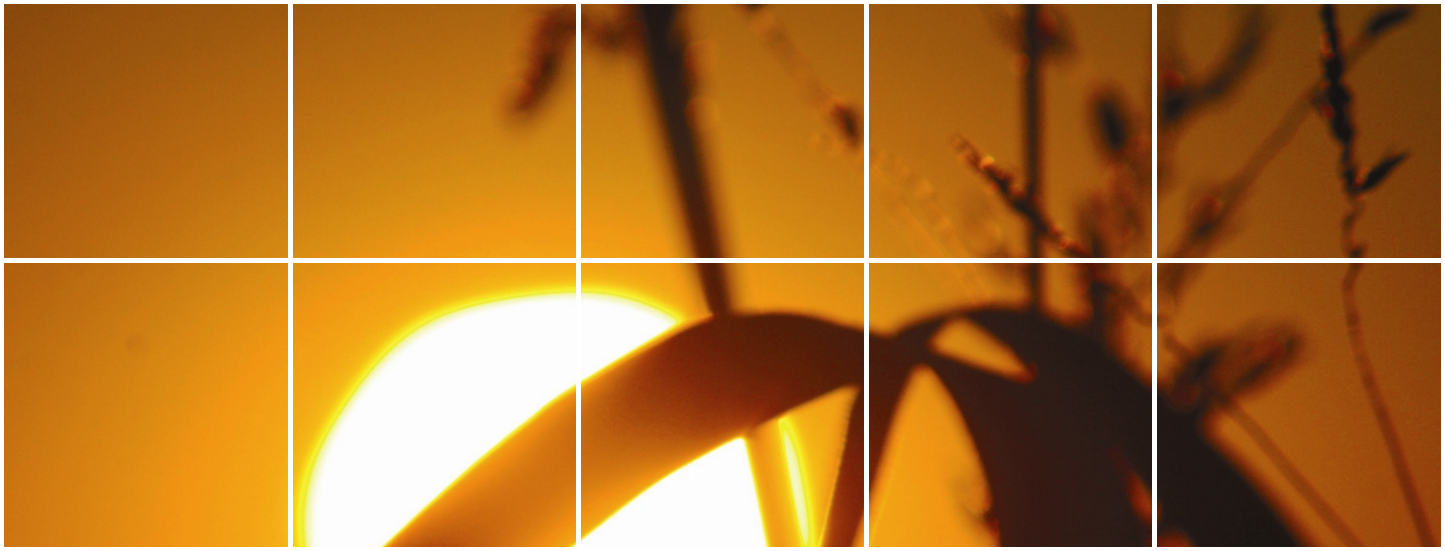

The Status of Biofuels in Yorkshire and the Humber

Final Report to the Yorkshire and Humber Regional Energy Forum
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Executive summary

This work was commissioned by the Yorkshire and Humber Assembly – acting on behalf of the Regional Energy Forum - to evaluate the current situation on biofuels in the Yorkshire and Humber Region and to assess the potential opportunities to further develop the biofuels industry and market in the Region.

The biofuels considered are liquid biofuels for transport. This comprises bioethanol, biodiesel and second-generation biofuels.

Overall Context

The EU and the UK Government wish to develop biofuels because they believe they can contribute to the following policy objectives

- Climate change mitigation
- Diversity and security of energy supplies
- Rural development

However, biofuels are currently more expensive than petrol and diesel to produce. The EU and UK Government have therefore introduced a range of incentives to encourage the uptake of biofuels.

The EU Biofuels Directive and the UK Renewable Transport Fuels Obligation (RTFO) set minimum levels of biofuels to be placed on the market. These measures work on a volume basis, and encourage uptake of the cheapest available biofuels, currently bioethanol and biodiesel from starch/ sugar and oil crops respectively.

It is recognised that these biofuels are not the most effective for Greenhouse Gas (GHG) emissions reduction, and the long-term policy is to move towards second-generation biofuels with higher GHG savings potential and ultimately to fuel cell vehicles. GHG savings compared with petrol or diesel are typically 40-70% for biodiesel from oil seed rape and 30-70% for bioethanol from wheat, compared with savings of 86-93% estimated for second-generation biofuels.

It is also recognised that there are sustainability issues connected with production of bioethanol and biodiesel. The main issues are destruction of habitats of high biodiversity and conservation value to create plantations for energy crop production and the effect on food prices and access of using food crops for biofuel production. In the UK the RTFO is planning to address these issues by having sustainability reporting included in the scheme. This will track the source of all feedstocks, including imported feedstocks. However, at present the RTFO does not prescribe that a feedstock should be from a sustainable source.

In future the policy instruments may change to reward higher levels of GHG savings, and require that minimum sustainability criteria are met.

Second generation biofuels are currently at the demonstration and early commercial adoption stage, The UK is behind the USA and some EU countries in the development of second-generation biofuels. Until recently there was little support for development in the UK. However, second-generation biofuels are now a priority area for UK Bioenergy funders and there is increased involvement with the EU biofuels programmes, for example the DTI is a member of the Bioenergy ERA.

The concept of a Biorefinery, where a variety of biomass feedstocks are converted and extracted into a spectrum of valuable bio-based products is also gaining ground in the UK, and research is underway to see how best to take this model forward.

Biofuels in Yorkshire and the Humber

Yorkshire and the Humber has a number of attributes that make it attractive to potential biofuels developers and for biorefineries:

- *Local feedstock supplies*- wheat and OSR, also experience of perennial energy crops.
- *The Humber ports*- experience of handling biomass, grain, oils- capacity to expand biofuels imports
- *Land available around the ports* at reasonable cost, with transport connections.
- *Two local oil refineries*- already interested in purchasing biofuels and taking output from operating plant
- *Local chemical industry* interested in opportunities from biofuels
- *Skilled workforce* available in area.

The existing infrastructure and local OSR and wheat feedstock availability make the Yorkshire and Humber Region a strong contender for further development of first generation biofuel plant.

There is already Biodiesel production in the Region at all scales. At the large scale the Greenergy plant at Immingham docks has a capacity of 100,000tpa, and uses UK grown and imported vegetable oils as feedstock. At the medium scale the RIX Biodiesel plant in Hull has a capacity of 50,000tpa and uses Recovered Vegetable Oil (RVO) as a feedstock. At the small scale the Region has a number of schemes producing 10-1000tpa Biodiesel from RVO.

Our analysis suggests that another large scale Biodiesel plant and more small scale Biodiesel plants would be feasible for the Region utilising a substantial proportion of locally sourced feedstocks. Additional large scale plant would be possible, but would rely heavily on imported feedstocks.

There is no current bioethanol production in the Region. Five large scale plants are currently proposed, all in the South Humber bank area. All these plant intend to use locally produced wheat, but also intend to import a substantial proportion of their wheat feedstock. Our analysis suggests that the port location is the best location for these plants, and that two plants could be supported using 50% wheat feedstock readily available from the local area. If wheat were also sourced from adjacent areas, then up to 5 plants might be supported. Further plants would be possible, but would rely more heavily on imported feedstocks.

Possible constraints on additional bioenergy production might be

- *Amount of land available for crop production*- in addition to ensuring that food supplies are maintained, land is also required to develop energy crops for electricity and heat production and for other novel agricultural enterprises.
- *The need to consider environmental issues* both in feedstock production and in project development around the Humber Estuary, which is an internationally important wildlife area. In particular the biodiversity issue is important if substantial areas of set aside or temporary grassland are used for energy crops, and there is a need to find a way forward that meets both environmental and economic considerations in the Humber Estuary. ***We recommend that a strategic way forward should be developed collaboratively between all interested parties to take account of both environmental and economic considerations. We believe this will facilitate appropriate development in the area.***
- *Road transport* in the rural areas of the Region.
- *Port capacity*- currently there is sufficient capacity to import and store feedstocks, but this may be constrained if there is a large expansion in the area.
- *Regional funding* available to support biofuels projects.

We believe the Humber area would be a good location for development of a second-generation biofuels plant in the UK. Second-generation plant will require the same infrastructure and markets as first generation plant, and so will be attracted to the area. In addition second-generation technology has more synergies with the chemical industry, and in particular companies developing other bio-based products. Second-generation plant will also require large quantities of wood, perennial energy crops and crop residues as feedstocks. A supply chain for these is already developing in the area due to the use biomass for co-firing, but further support to consolidate reliable large scale supplies of biomass will be required to support a second generation biofuels industry in the Region.

Threats to development of the bioenergy industry are thought to be

- *Sustainability of biofuels production*- first-generation biofuels may be less attractive if the sustainability issues lead to imports of palm and soya oils being constrained and/or price increases for these feedstocks.
- *Second-generation technologies continue to be developed in USA/ other EU countries* and not attracted to Humber Region.
- *Cheap imports* mean local suppliers do not gain benefits
- *UK Competitors* offer better location packages and projects are not attracted to the Humber area.
- *Planning approval* is slow/ onerous so projects are lost.

We believe the prospects of developing a long term biofuels industry in the Yorkshire and Humber Region are good. The existing infrastructure and feedstock supply chains for wheat and OSR make the Region ideal for further development of first generation biofuels plant. The Region is a strong contender for development of second generation technologies due to the infrastructure, and Research, Development and Demonstration base in the Region. However, further development of the currently fragmented lignocellulosic feedstock chain is required.

Development of such an industry can help towards policy objectives of GHG emissions reduction, inward investment, skills development and rural development.

We recommend the following actions which we believe will enable the opportunities to be realised.

- *Increase RVO collection and utilisation at the local level,* especially around large centres of population.
- *Encourage the use of biofuels in local Government transport fleets*
- *Encourage all farmers growing crops for biofuels to enter Environmental Stewardship schemes* and to follow Best Practice Guidelines for production of energy crops.
- *Support supply chains to supply local wheat and OSR to energy projects.*
- *Continue to develop supply chains for perennial energy crops for supply to both power plant and second generation biofuels plant/ biorefineries*
- *Foster a partnership approach* to agree a strategic way forward to develop the South Humber Bank to take into account both environmental and economic objectives.
- *Establish up to 2 each large scale bioethanol and biodiesel plant around the Humber Estuary.* Enhance economic viability of these plant by best use of by-products for both heat and power generation and for extraction of added value products.
- *Immediate opportunities for the chemical industry to become involved in processing of by-products* e.g. glycerol, into higher value products.
- *Take forward the biorefinery concept.* Extend current biofuels interest group to include oil, chemical, power generation industry and research institutes in the area, to discuss best use and development opportunities for all possible products from bioenergy plant.
- *Attract R&D activities in biofuels* to the Yorkshire and Humber Region. Universities and Institutes in the Region are already active in the bioenergy field. Apply to DTI ETI and BBSRC and EU for involvement and funding for second generation biofuels projects, with a view to establishing a centre of excellence in the area.
- *Act to encourage siting of pilot plant for second generation biofuels in the YH Region.*

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1 Contract Brief

The purpose of this report is to evaluate the current situation on biofuels in Yorkshire and the Humber and to assess the potential opportunities to further develop the biofuels industry and market in the Region.

The project objectives are:

- To evaluate the current situation on biofuels in the Region, considering current fuel production, planned fuel production, raw material potential from indigenous production and imports
- To evaluate the potential opportunities to develop the biofuels industry and the market in the Region and the likely implications of this including an assessment of the potential for biofuels to become a significant contributor to energy supply of the Region
- To consider and report how existing or near to market biofuels technology will influence the biofuels industry
- To consider and evaluate how best to ensure that biofuels, whether from indigenous production or imports, are obtained from sustainable sources.

The work has been undertaken on behalf of the Yorkshire and Humber Assembly – acting on behalf of the Regional Energy Forum - to inform further discussions on the opportunities for biofuels in the Region.

2 Introduction to Biofuels

2.1 What are Biofuels?

There are four main classes of road fuels:

- Gasoline
- Diesel oil
- Liquefied petroleum gas, and
- Compressed (or liquefied) natural gas.

These are all derived from fossil fuels. Biofuels are transport fuels derived from plant or animal material.

Biofuels can access the main transport markets in two ways; firstly if they can be blended into the bulk supply; alternatively if they can be used directly with minimal modification to the engine. The most common biofuels on the market are:

- *fatty acid methyl esters* (FAME or Biodiesel) produced from vegetable oil crops such as rape seed, palm or soya or from the conversion of waste materials such as cooking oil. These are targeted at the diesel market,
- *bioethanol,* produced using fermentation of starches and sugars from crops such as sugar beet and wheat. These are targeted at the gasoline market as a blending component, and
- purified and liquefied biogas targeted at the natural gas market.

Bioethanol and biodiesel can be blended with mineral petrol and diesel respectively, and currently blends of up to 5% biofuel are warranted for use in vehicles in the EU. These biofuels are the most likely to be produced and sold in the UK up to 2010.

There are also a range of biofuels under development. These include bioethanol from lignocellulosic feedstocks, biobutanol, Fischer-Trop diesel and hydrogen. There is increasing interest in development of these 'second generation' biofuels and research programmes are in place in the USA and Europe.

2.2 Rationale for Biofuels

Currently the UK is heavily dependent on fossil fuels for transport, with 98% of fuels derived from oil. The Government is currently actively seeking alternative sources of transport fuels. A number of options are being explored, including compressed natural gas (CNG), electric cars, fuel cells and hydrogen fuels. However both CNG and hydrogen fuels require separate distribution infrastructure. Fuel cells are still in development, and are not projected to make a major contribution to transport until after 2020.

The importance of the liquid biofuels biodiesel and bioethanol is that they can be blended with existing fuels and utilised in existing engines. The technology for producing biodiesel and bioethanol is also mature, and the feedstocks for their production are well understood and internationally traded. Biodiesel and bioethanol are therefore the only renewable transport fuels that can be utilised on a wide scale now.

2.2.1 National Policy Drivers

The main UK national policy objectives for introducing biofuels are:

- **Climate change mitigation**

Greenhouse gas emissions can be reduced by replacing transport fuels based on oil with those derived from plant material. Burning biofuels produces CO_2 which is a greenhouse gas. However, the carbon released is carbon that has been absorbed recently during the growth of the plant from which the biofuel is being produced. Using biofuels therefore does not add new quantities of CO_2 to the atmosphere - unlike the burning of fossil fuels, which releases carbon which has been stored within the earth for millions of years. However, some fossil fuel is required to produce and transport the feedstocks and to process the feedstocks into biofuels. There is therefore some net greenhouse gas release; the quantity depending of the way the feedstock is produced and the conversion process.

In general, greenhouse gas savings are lower for bioethanol and biodiesel than for second generation biofuels or for electricity and heat produced from biomass. However, the UK Government and the EU take the view that these are the only realistic options for greenhouse gas emissions reduction in the transport sector at the moment, so their development should be pursued. The longer term policy is to develop the more effective second generation transport fuels and ultimately to move to fuel cell vehicles.

- **Security and diversity of fuel supply**

The road transport sector accounts for 30 per cent of energy consumed in the EU. The sector is heavily dependent on oil (98 per cent), a significant proportion of which is imported from outside the EU. The EU sees it as strategically important to develop new sources of transport fuels, both by producing biofuels within the EU and by sourcing biofuels from other suppliers around the world.

- **Opportunities for rural development.**

The EU's Common Agricultural Policy (CAP) was reformed in 2003, changing the way EU farmers are supported financially. The reform aims to cut the link between production and subsidy, in order to encourage farmers to produce to market demand rather than set quota. The emergence of an EU biofuels market is perceived as a possible route through which farmers can enter this new, competitively-focused, agricultural landscape.

2.2.2 EU Policy and legislation

Although there are good policy reasons for introducing biofuels in the EU and the UK, biofuels are not economically competitive with fossil fuels. The cost of biofuels supply is discussed in some detail in the various documents issued by the European Commission in January 2007 as part of its renewable energy roadmap [1]. The extra cost of using biofuels depends on the cost of oil, the share of imports and the competitiveness of agricultural markets. According to the EU Strategy for Biofuels [2], with the technologies currently available, EU-produced biodiesel breaks even at oil prices around €60 per barrel, while bioethanol becomes competitive with oil prices of about €90 per barrel. A range of measures have therefore been adopted in the EU and the UK to encourage the uptake of biofuels

- **Biofuels Directive**

In 2003 the European Commission adopted a Directive aimed at promoting the use of biofuels and other renewable fuels in the transport sector [3]. Under Article 3 of the Biofuels Directive, Member States must ensure that a minimum proportion of biofuels and other renewable fuels are placed on their markets, and that national indicative targets are set to achieve that effect. The EU recommends a "reference value" for these targets calculated on the basis of energy content, for all petrol and diesel used in the transport sector. These reference values are set at 2 per cent by 31 December 2005 and 5.75 per cent by 31 December 2010. 12 EU countries, including the UK, have not yet set targets equivalent to the EU "reference values".

- **Biofuels Action Plan and Strategy for Biofuels**

In December 2005, the EU adopted a Biomass Action Plan [5] aimed at increasing the use of energy from forestry, agriculture and waste materials. The Biomass Action Plan was followed in February 2006 by the Commission's EU Strategy for Biofuels [6]. This sets out clearly the Commission's view

that there must be a coherent approach to the reduction of the EU's dependency on imported oil and gas. The EU is strongly promoting EU action plans for biomass and biofuels. An ERA-NET has been set up for biofuels, and DTI are representing the UK. This is a network of government agencies responsible for co-ordinating and funding national research efforts in bioenergy. ERA-NET provides an opportunity to keep up to date with bioenergy research programmes throughout Europe, and to set up collaborations where appropriate.

- **Review of Biofuels Directive**

It seems highly unlikely that the Biofuels Directive in its current form can provide the necessary impetus for the EU to reach the 2010 target of 5.75% market share. The European Commission recognized this in its recent review of the Energy Policy. The Commission therefore proposes reinforcing the legislative framework, with a 10% minimum for the market share for biofuels in 2020. The overall EU target will need to be reflected in binding targets on individual Member States. The Commission also recognizes that some practices in biofuels production can lead to low levels of carbon emissions savings and to environmental problems. The Commission proposes the introduction of an incentive/support system to avoid this and to encourage the development of second generation biofuels.

2.2.3 UK Policy and Legislation

The UK Government has pinpointed climate change mitigation as the primary reason for promoting biofuels in the UK, whilst recognising the other benefits of security of fuel supply and rural development. The UK has been slow to embrace biofuels, and consequently is behind other EU countries such as Germany and France in production of biofuels and technology development. The UK is one of 12 EU countries that have not yet set targets equivalent to the EU "reference values".

However, biofuels have now become a priority in the UK, and the UK Government has set indicative targets for biofuels of 0.3% for 2005 and 3.5% by 2010. These targets are set on volume rather than energy content, and are lower than the EU indicative values on the basis that the UK is starting from a low base of biofuels production. Government recognises that biofuels are not commercially competitive with fossil fuels and that support measures are required to reach the targets. Fuel duty incentives are the UK Government's means of support for biofuels at the current time. The UK Government introduced a 20 pence per litre duty differential on both biodiesel (in 2002) and bioethanol (in 2005). This policy has stimulated a growing market for biofuels in the UK but has proved insufficient to stimulate a mainstream market. In the April 2007 budget the Chancellor announced that the 20ppl duty incentive for biofuels will now be extended to 2010. HMRC are also proposing to relax requirements for small scale biofuels producers to register and allows returns to be made quarterly.

The UK Government announced in December 2005 that, subject to State aid approval, it will introduce an enhanced capital allowance scheme for biofuel processing plants that meet certain qualifying criteria which make a good carbon balance inherent in the design. The scheme will allow 100% of the first year cost of capital assets to be written off against taxable profits. The 2006 Budget Report announced that the Government has now applied for State aids clearance and, subject to that, envisages the scheme being in place early in 2007.

The UK Government announced the "Renewable Transport Fuel Obligation" (RTFO) in November 2005. The RTFO will place a legal requirement on transport fuel suppliers to ensure that a specified percentage of their overall fuel sales is from a renewable source. When introduced, the RTFO will be the UK's primary mechanism to deliver the objectives of the Biofuels Directive. The buy-out price for companies failing to achieve their RTFO is now set at 15ppl until 2009/10.

The Chancellor has also commissioned Nicholas Stern and Julia King to undertake a review to examine the next generation of low carbon fuels and vehicles likely to be available in the next 25 years. The review will assess the scope of the UK to benefit from the transition to a low carbon road transport system, and how a shift to low carbon options can best be achieved. The Government anticipates using the report's recommendations to refresh and refine its strategy.

2.3 Current Production of Biofuels

2.3.1 Biodiesel and bioethanol

EU bioethanol production intended for vehicle use amounted to almost 500,000 tonnes in 2004, an increase of 15.6 per cent on 2003 production. Spain is the leading bioethanol producer, a success which can be explained in part by the Spanish government's decision not to collect tax on bioethanol.

Biodiesel accounted for nearly 80 per cent of EU biofuel production in 2004. Production was close to 2 million tonnes compared with 1.5 million tones in 2003 - a 29.6% growth in a single year. Germany produced over half of the EU's biodiesel, with production above one million tonnes for the first time. This can be explained by very favourable legislation that permits a total tax exemption for biofuels whether they be pure or mixed with fossil fuels. Among the new Member States, the Czech Republic is the biggest biodiesel producer.

Sales of biodiesel and bioethanol in the UK are shown in table 1 below.

Table 1: Biofuels sales (2005)

	Total Sales in 2005 (million litres)	**As a percentage *by volume* of Total Fuel Sales**	**As a percentage *by energy content* of Total Fuel Sales**
Biodiesel	33	0.07	0.06
Bioethanol	85	0.17	0.12
Total Biofuels	**118**	**0.24**	**0.18**

Sales of biodiesel have increased from 3 million litres in 2002 to 33 million litres in 2005. The majority of biodiesel sold in the UK is produced in the UK, so this shows a large increase in production. Total diesel sales in 2005 were 23,233million litres.

Sales of bioethanol were first recorded in 2005, when they were 85 million litres. No bioethanol is currently produced in the UK, so this shows imports. Total petrol sales in 2005 were 25,608 million litres.

Table 2: UK biodiesel production plant

Company	**Current output t/a**	**Projected output t/a**	**Existing/ projected plant locations**	**Source of feedstock**
Greenergy		100,000 2007 200,000 by end 2007	Immingham	UK/ Imported oils
Biofuels Corp Ltd		250,000	1 plant at Seal Sands, Teeside now operating at reduced capacity.	UK/ imported oils
D1 Oils	8,000	220,000 by end 2007	1 plant under construction in Middlesborough	Imported virgin edible/inedible oil
Argent Energy	50,000		Motherwell	RVO/ animal fats
ESL Biofuels	2,500	100,000	Northwich, Cheshire	RVO/ virgin oils
INEOS		500,000 by end 2008	Grangemouth	Not known
RIX biodiesel	50,000		Hull	RVO
PDM Group	45,000		London	RVO
Green Biodiesel	25,000		Walsall	RVO
BIP Ltd	25,000		Oldbury	RVO
Eurobiodiesel	15,000		Harlow	RVO

The table shows that there is a large planned expansion of biodiesel production in the UK. There are 5 large scale plant that are currently being commissioned or under construction. These have capacities in the range of 100,000tpa-500,000tpa, and most plan to use a mixture of UK and imported virgin oils as feedstocks. They are situated near ports to allow ease of imports.

There is a similar number of medium scale biodiesel plant based on RVO. These have capacities of 10,000tpa-50,000tpa and are situated near centres of population. The amount of RVO in the UK is constrained, and it is unlikely that another plant the capacity of RIX would be viable in the Yorkshire and Humber Region.

Biodiesel can also be produced at the small scale. This can range from less than 5tpa up to 10,000tpa. These are often community based schemes operating on locally recovered RVO. It is estimated that there are up to 800 such schemes in the UK, but that they have a low combined capacity.

Table 3: UK bioethanol production plant

Company	Current output t/a	Projected output t/a	Existing/ projected plant locations	Source of feedstock
Bioethanol Ltd		100,000 2007-09	Immingham	UK grain
Losonoco		50,000 for 1st plant	4 UK plants proposed, first 2 at Teeside and Merseyside	Wheat, moving to Lignocellulosic waste
Green spirit fuels (Wessex Grain)		100,000 each for first 2	5 UK plants proposed 1st Henstridge, Somerset, 2nd Humberside	UK wheat
British Sugar		55,000	1 plant at Wissington, Norfolk due for Feb 2007	UK sugar beet
Roquette		95,000	Corby	UK wheat
ENSUS		400,000 (2008)	Wilton, Teeside	Imported wheat
Vireol plc		150,000 (2009)	Grimsby	Wheat
Abengoa		400,000 (2009)	Humberside	Wheat

Table 3 shows there is no current production of bioethanol in the UK. All the proposed plants are large scale, which is necessary to make the production economic. Most of the plants are based on wheat feedstocks, with a mixture of UK produced and imported wheat. The plants are therefore sited near to ports to facilitate import of the feedstocks.

The British Sugar plant is based on sugar beet, and will be sited close to the British Sugar production plant at Wissington.

Other biofuels currently proposed for UK production are biobutanol and ethanol from lignocellulosics, but the technologies for these has not yet been proven commercially.

These plant are located near ports to allow both import of feedstock and export of biofuels and by-products by ship. These plant are often co-located with existing UK oil refineries. This gives a local market for the biofuel, and enables transport of the biofuel to the refinery by pipeline, the most cost effective transport route.

2.4 Biofuels Production Technologies

These can be broadly classed as chemical or biological conversion.

Chemical conversion
The chemical conversion routes can be subdivided again into those that use esterification and those based on synthesis gas.

Esterification and Trans-esterification are simple processes for converting oils and fats into a diesel substitute – biodiesel or FAME (Fatty acid Methyl Ester). They operate at low temperatures and involve mixing the oils with an acid or alcohol and a catalyst and physically separating the resultant product. This is a simple, well-developed process with no significant technical barriers remaining. It is used widely in Germany, Austria, France and the US.

The latest generation of installations have installed extra pre-treatment equipment that allows them to process waste fats and oils. Using these feedstocks is both more cost effective and environmentally beneficial, because they have much lower fossil input to the fuel chain.
Modern plants incorporate a product distillation stage to guarantee a quality suitable for modern diesels.

Figure 1 below shows the process proposed for the Biofuels Corp project in Immingham.

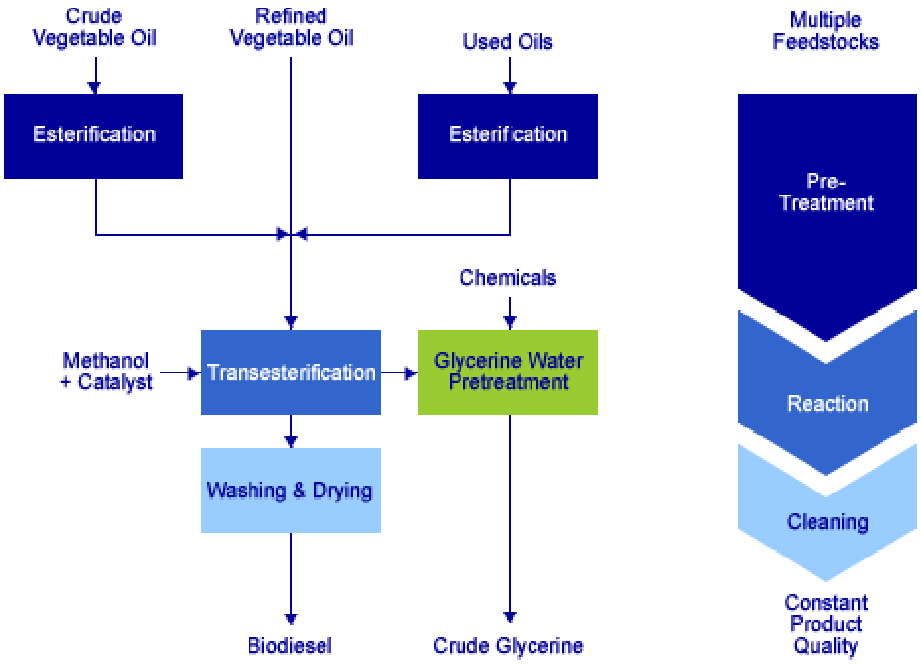


Figure 1. Schematic of Biofuels Corp plant at Immingham

Routes based on synthesis gas are most applicable to ligno-cellulosic materials. The process is to first gasify the feedstock in a high temperature process and then upgrade the resulting gas to clean feedstock with fixed proportion of hydrogen and carbon monoxide – synthesis gas.

This synthesis gas can then be converted to methanol, methane, esters or alkanes (synthetic biofuels) by variations of the Fischer Tropsch process. Demonstration plants are being built in Germany and Sweden but commercial production is some way off. This route has been used a number of times with coal feedstocks in the past by siege economies such as South Africa during the Apartheid policies and Germany during World War II. It is not yet at the point of commercial deployment with biomass feedstocks, but will almost certainly be within the next decade, particularly if waste feedstocks prove suitable.

Biological conversion
The main biological processes are based either on the fermentation of sugars to ethanol or the anaerobic digestion of organic matter to methane.

Fermentation of simple sugars and starches. The technologies for the production of bioethanol from simple sugars and starches are fully commercial and widely deployed in Brazil, USA, Sweden and other countries. Sugars can be fermented directly by yeasts or microbial strains.

Starches comprise strings of glucose molecules that must first be released by the action of water, hydrolysis, before they can be fermented by yeasts or microbial action. In commercial processes hydrolysis is carried out at 70 – 80 deg C with the addition of enzymes at various temperatures to speed up the reaction. A schematic of fermentation of simple sugars and starches is shown in figure 2 below.

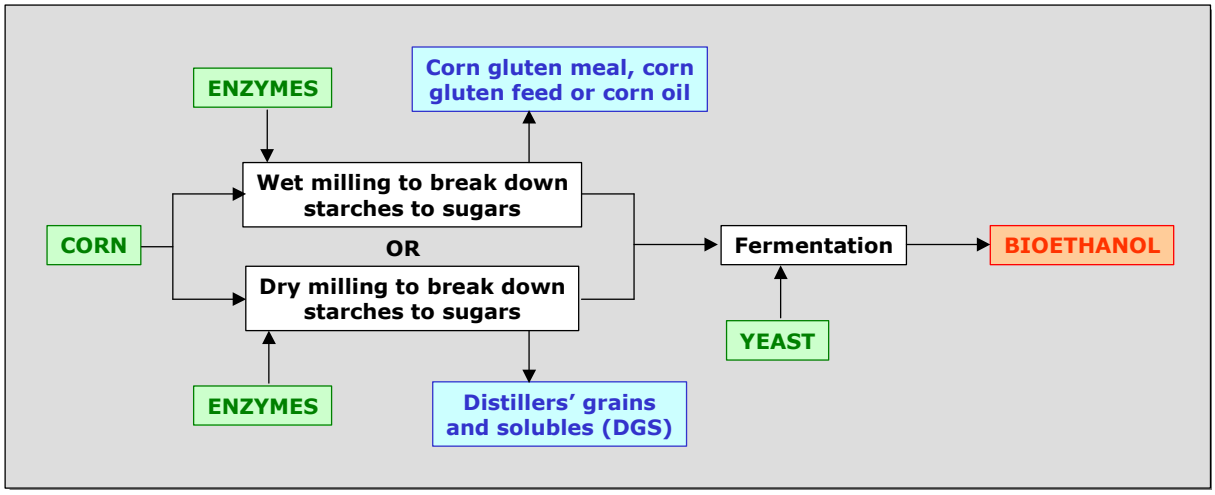


Figure 2. A schematic of fermentation of simple sugars and starches.

Fermentation of sugars extracted from lignocellulosic material.
The structure of lignocelluose material comprises two sugars in polymer form, cellulose and hemi-cellulose, enclosed by lignin, a compound with no sugars that gives the plant its structural strength. To obtain fermentable sugars we need to break the cellulose and hemi-cellulose free from the lignin and then hydrolyse them to simple sugars. This requires a much more aggressive process than is used with starch.

Pretreatment. Normally the breaking of the structure is achieved by a pre-treatment stage that will break the lignin free and at the same time hydrolyse the hemi-cellulose to principally Xylose and 5 carbon sugars. Physical methods have also been proposed for pre-treatment, the most common being steam explosion where the slurry in the pre-treatment stage is flashed to low pressure through a choke causing the cell structure to burst.

This pre-treatment is followed by either a second acid hydrolysis stage, or an enzyme hydrolysis stage, to convert the cellulose.

Acid based secondary hydrolysis processes have been proven for many years but only now are demonstrations being planned in the USA and UK. This lack of progress is due to the expensive equipment necessary and the low price of ethanol from sugar and grain.

Enzyme based secondary hydrolysis processes are still in the development phase but offer the prospect of being economically more attractive than other options if their further development is successful. Demonstrations are planned in Canada and EU. The key development necessary for commercialisation is to reduce the cost of the enzyme cellulase by an order of magnitude. Following hydrolysis the process will include neutralisation with lime if acid has been used and separation stages to wash out the sugars and remove fermentation inhibitors

Fermentation. The sugars from hydrolysis contain five and six carbon atoms and need to be fermented in a microbial process rather than the yeast process used for simple sugars from beet and grains. Typically these are proprietary recombinant organisms whose metabolisms have been tailored to the sugars in the process.
A by-product of all hydrolysis processes is lignin, which is removed as a solid cake and used as a fuel for power generation and process steam.

Figure 3 below shows the Losonoco process that has been proposed for use with MSW in the UK.

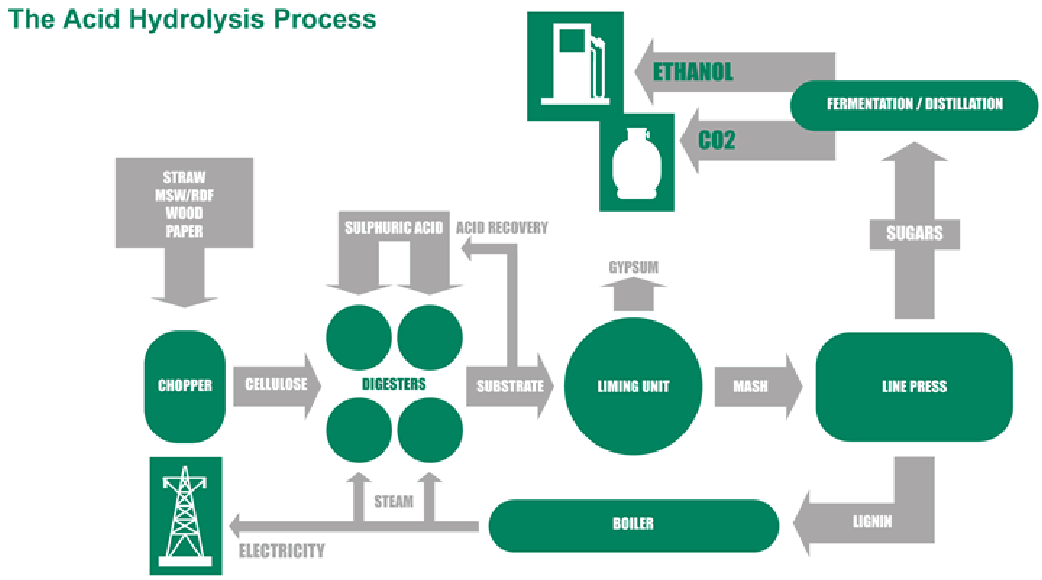


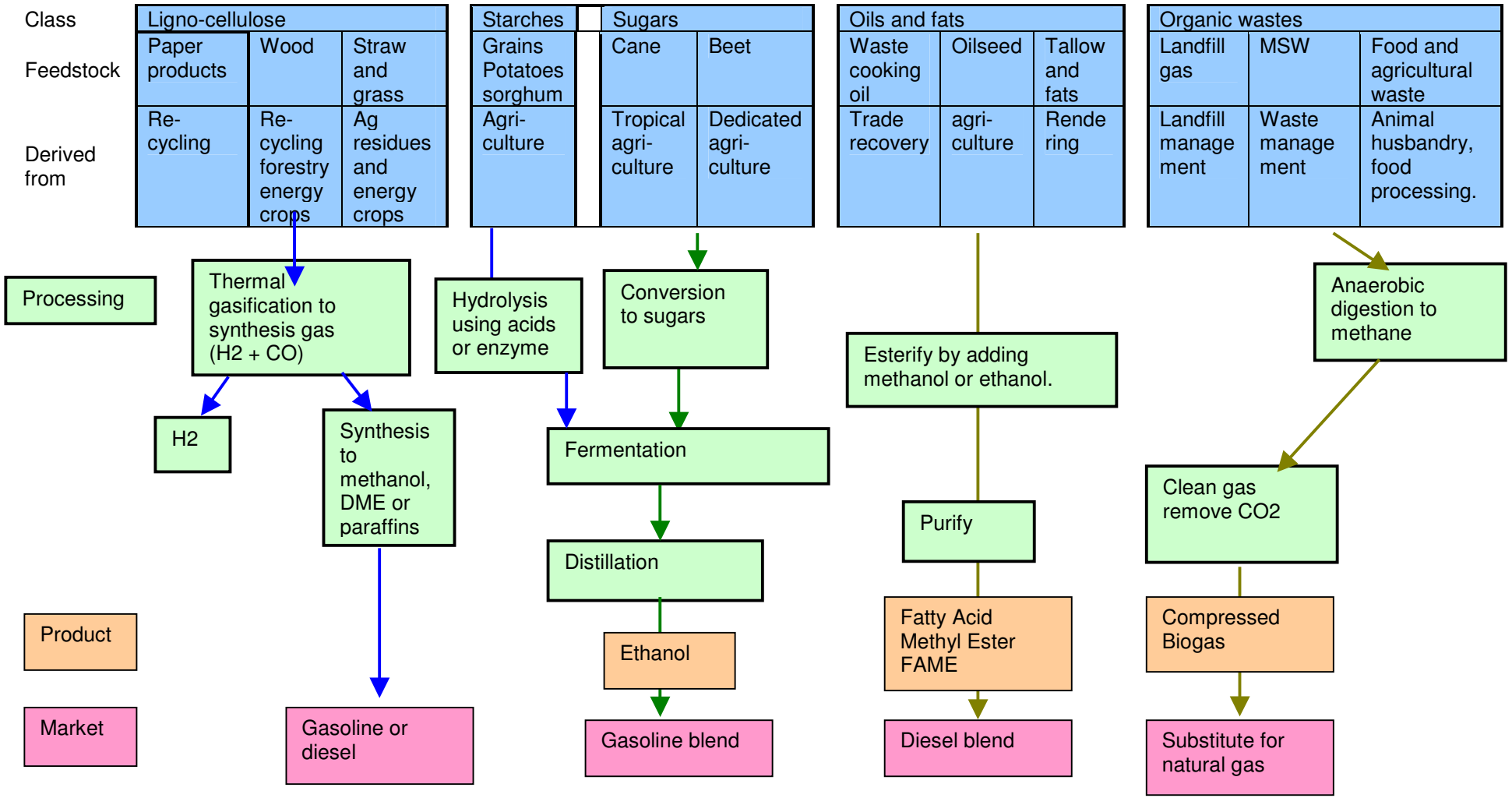
Figure 3 The Losonoco process that has been proposed for use with MSW in the UK.

Landfill gas. In oxygen free environments colonies of microbes develop that excrete methane. This can be collected, cleaned and used as a fuel. This happens in landfill sites and in the controlled conditions of anaerobic digesters. In landfills the gas is collected from wells and collection pipes buried in the waste. Normally the gas will contain 50% methane, with the balance carbon dioxide and various contaminants. The contaminants must be removed before compression and use in transport applications. Some local schemes are in operation in Sweden to power buses and waste collection vehicles.

Anaerobic digestion for biogas is the microbial decomposition of organic material. The products are essentially the same as landfill gas but should have a lower level of contamination. Digesters are widely used in the water industry for sewage sludge where the gas is used for CHP or heating. Animal manure is digested in most countries in the EU to provide farm heating and, for larger units in Denmark, CHP. This practice is not used in the UK to any meaningful extent. Digesters are increasingly used to reduce the biological oxygen demand of effluent from intensive animal rearing units, food processing, abattoirs and the liquid draining from landfill sites. There are a few examples of digesters for MSW in Switzerland, Netherlands and Belgium. The Landfill directive is expected to create a market for further digesters in the UK.

We have summarised the main routes from feedstock to fuel in Figure 4.

Figure 4 Overview of the routes to Biofuels



Biofuels production technologies are often described as **first** or **second** generation technologies. First generation technologies are those that are currently commercially available, and examples above are production of biodiesel from oils, production of bioethanol from starch or production of biogas via AD.

Second generation technologies should lead to some or all of product performance, economic and environmental advantages over first generation technologies. For example, Biomass-to-liquids (BTL) and cellulosic bioethanol described above both allow the use of cellulosic feedstocks, which are more abundant and cheaper than oil and starch feedstocks. These processes also show higher greenhouse gas savings and in the case of BTL give a higher specification diesel product. However, second generation technologies are still under development and have not as yet been commercially proven. They are therefore expensive at this time.

The term 'biorefinery' is also often used in relation to production of biofuels. A recent report defines biorefineries in terms of the flexibility of the feedstocks to the process, and the flexibility of the outputs [5]. A biorefinery is an overall concept of a processing plant where biomass feedstocks are converted and extracted into a spectrum of valuable products. The report identifies three levels of biorefinery

Type 1 Biorefinery: Almost no processing flexibility e.g. a dry-milling ethanol plant which uses grain as a feedstock or esterification plant using plant oils, has a fixed processing capability and produces a fixed amount of fuel, and co-products.
Type 2 Biorefinery: Flexibility in end product production e.g. wet milling technology using grain feedstocks which can produce various end products depending on demand. Products include Ethanol, starch, high fructose syrups, oils and meals.
Type 3 Biorefinery: Flexibility of feedstocks and end products i.e. uses various types of feedstocks and processing methods to produce products for the industrial market.

The existing biodiesel plant in the UK are type 1, using specified feedstocks and producing a fixed amount of biodiesel and co-product.

However, the operators of these plant are now looking to improve the economics of their operations by searching for higher value co-products and better quality product. They are also looking to utilise co-products for process heat and electricity generation. They are therefore moving towards type 2 biorefineries. These moves are to be encouraged as not only do they increase the economic viability of the plant, they also offer opportunities for other local businesses in converting the co-products to higher value products, and increase the overall effectiveness of the feedstock usage and greenhouse gas savings.

Introduction of second generation biofuels technologies offers more possibilities for development of type 3 biorefineries. A greater range of feedstocks can be accommodated, and in principle there is more flexibility in the range of products produced. To get the most out of these opportunities it will be necessary to consider all the possible bioproducts, not just those concerned with transport fuels and heat and electricity generation. NNFCC published major studies on the opportunities for BTL and biorefineries in the UK in June 2007.

The discussion above relates to the large scale production of biodiesel and bioethanol, In general first generation bioethanol and second generation biofuels can only be produced at the large scale for economic reasons. However, first generation biodiesel can be produced at any scale. In addition to the commercial operators there are a large number of small sale biodiesel production units, many based on local collection of RVO. These are often community groups or concerned individuals, whose motivation is to take used vegetable oil and turn it into a useful product. Utilisation of RVO in this way is environmentally beneficial in reducing the amount of RVO going to landfill. However, there are concerns about the fate of the glycerol produced in these small scale operations, particularly since it is often contaminated with unreacted methanol. There is a need to ensure that appropriate procedures for disposal of glycerol are in place and enforced.

2.5 Feedstocks for biofuels production

The feedstocks available fall into five classes.

- *Ligno-cellulosic material*, this is the fibrous structure of plants – wood, straw etc and the products that we make from them such as paper. This is the most abundant and cheapest resource.
- *Starches from grains* such as wheat, barley and potatoes.
- *Simple sugars* extracted from beet and sugar cane.
- *Oils and fats* - from virgin oilseeds and plants such as rape and palm, or recovered from frying oils, animal rendering and drainage traps.
- *Putrescible and other biodegradable material* in household and trade waste, and animal manure.

As well as the domestic production within these categories feedstocks can also be imported to the UK in the form of palm, other vegetable oils, tallow and other animal derived fats and oils, talloil from paper production, sugar, wood chips and other solid biofuels.

The first generation biodiesel plant operating and proposed for the UK will use home grown oil seed rape (OSR), a range of imported vegetable oils and recovered vegetable oils (RVO). The RVO is a limited resource and requires additional pre processing, but is cheap to purchase and use as a biofuel means it does not require disposal.

The first generation bioethanol plant proposed for the UK use home grown wheat or sugar beet, and imported wheat.

In 2005 about 2.5 million tonnes of UK produced wheat was exported and 1.2 million tonnes imported giving a surplus of 1.3 million tonnes. The production of OSR could be increased. However, there is not sufficient capacity to feed all the proposed plant in the UK, and all the proposed plant plan to import a substantial fraction of their feedstocks. Forward contracts for wheat for biofuels and current tight global supply of wheat have stabilised the price of wheat in the UK, which is good for UK farmers. In the longer term, if the proposed large UK bioethanol capacity comes on line, there are concerns that the price of wheat may increase which will impact on the viability of the biofuel plants and also on food prices.

Second generation biofuels plants will be able to use lignocellulosic feedstocks. These are the same feedstocks as required for electricity and heat production from biomass. There is a potential competition for the supply of these feedstocks, but also an opportunity to integrate fuel and power production to make the best use of the feedstocks.

There is considerable current support for development of fuel supply chains for energy crops in the UK. This is mainly directed at biomass for electricity and heat, but such developments will benefit the second generation biofuels plant.

2.6 Greenhouse gas emissions savings

A number of studies have shown that the most cost effective way of using purpose grown energy crops to generate greenhouse gas emissions savings is currently by using perennial crops such as SRC and miscanthus to generate heat and power. [14,15,16]

The main reason for this is that the wheat and OSR crops used in production of biodiesel and bioethanol using first generation technologies require considerable inputs of agrochemicals derived from fossil fuels in their cultivation, and that only part of the crop, seed or grain, is utilised for biofuels production. However, biofuels do offer GHG emissions savings in the transport sector, and so are being pursued.

The GHG savings in biodiesel and bioethanol production depend greatly on:

- *cultivation practices*, particularly the amount of nitrogen fertiliser used which impacts on emissions of nitrous oxide;
- *the source of energy used in the biofuel production plant.* GHG emissions can be greatly reduced by utilising harvest and processing by-products such as rape meal or wheat straw for heat and/or electricity.

As a result of these different factors, there is a wide range of GHG savings in the literature. Most sources calculate a 40-70% saving for biodiesel produced from oilseed rape, 80-85% for biodiesel from recovered vegetable oil and 30-70% for bioethanol from wheat.

Estimates of the GHG emissions from the production and transportation of palm and soya oil could not be sourced, so for the purposes of this exercise the calculations assume that all biodiesel is produced from OSR grown in the UK.

Given this and the other uncertainties in cultivation practices and source/s of energy particular to each existing and proposed biofuel plant, we can only give here an indicative range of GHG savings, with the lower estimates considered more likely (unless biofuels producers employ innovative measures such as the use of CHP powered by biofuels by-products to further reduce emissions). The challenge is to maximise both the economic and greenhouse gas savings benefits.

The amount of energy in bioethanol is around 60% that of petrol and biodiesel 90% of diesel, meaning that more fuel will be consumed to deliver the same amount of energy. Therefore the amounts of biofuel in the table below have been converted to petrol/diesel-equivalent tonnes to give a GHG saving of producing biofuels compared with producing petrol or diesel of the same amount of energy. Bioethanol has octane enhancing effect when added to petrol at low percentage blends, which can lead to fuel efficiency effects. However, these are highly dependent on the fuel blend, engine type and driving conditions, and so we have not attempted to account for them here.

Table 4 - Indicative greenhouse gas emission savings from the use of biofuels

	Biodiesel from OSR	**Bioethanol from wheat**
GHG saving %	40-70%	30-70%
Potential biofuel t/a produced in Y&H	300,000	1,220,000
Fossil-fuel equivalent t/a (energy value)	270,000	732,000
Potential GHG* saving t/a	302,400 – 529,200	505,080 – 1,178,520

*CO_2-equivalent

It can be seen that annual GHG emissions would be reduced by around 300,000 tonnes as a result of biodiesel production and 500,000 tonnes by bioethanol production if all existing and proposed plants in the Region were producing at capacity. The GHG savings could be increased by producing biodiesel from RVO rather than oilseed rape, although the amount of available RVO is likely to be very small in comparison to the available oilseed rape resource.

Much better greenhouse gas savings are predicted for second generation biofuels using lignocellulosic crops as feedstocks. GHG emission reductions from second generation biofuels are in the range of 75 to 93%, compared with diesel and petrol.

The production of second generation biodiesel from wood results in GHG savings of 86-93%. A wider range of estimated savings was found for second generation ethanol produced from lignocellulosic biomass. Most studies estimated the GHG savings as 82-86% for wheat straw and 75% from farmed wood.

2.7 Sustainability of biofuels production

Biofuels are being promoted globally and at the EU level as a substitute for current fossil based transport fuels. Biofuels offer the following benefits:

- Security of fuel supplies
- Reduction of GHG emissions
- Opportunities for rural development.

It is important to ensure that biofuels are developed in such a way that these benefits are realised, and that any unintentional negative effects of promoting biofuels are recognised and assessed. In particular concerns have been raised that although biofuels are produced from renewable feedstocks, the way in which these feedstocks are produced and utilised may not be sustainable.

The definition of sustainable development adopted by the UN Commission on Sustainable Development is 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. When considering sustainability, social, economic and environmental aspects should all be taken into account, the effect over the entire bioenergy value chain, from production to use should also be evaluated.

A number of sustainability criteria have been suggested [17,18].

Social

- Land rights
- Labour conditions and human health
- Food supply and food security
- Ensuring a share of proceeds
- Leakage effects

Environmental

- Prior land use
- Impacts on soils
- Impacts on water
- Impacts on biodiversity
- Minimisation of GHG emissions
- Waste reduction and recycling

Economic

- Long term economic and financial viability
- Cost of carbon savings
- Impacts on markets

A short description of each criterion and an indication of whether it is an issue for imported/ UK produced feedstock/ biofuels is given in the table below.

Table 5 - Summary of sustainability criteria suggested for biofuels

Criterion	Description	Issue for UK produced feedstocks?	Issue for Imported Biofuels/ feedstocks?
Social			
Land rights	Legal and customary rights of local people should be respected.		√√√
Labour conditions	Pay and conditions should meet minimum standards and be sufficient to meet basic needs. No child labour, harassment or discrimination. Proper health and safety provision.		√√√
Priority for Food supply and food security	Food security is a basic human need which should not be compromised by bioenergy development.	√	√√√
Ensuring a share of proceeds	There is a danger that the profits will go to the biofuels processors rather than producers.		√√√
Environmental			
Prior land use	Change of land use can lead to loss of habitat/ biodiversity. Also to degradation of soil quality, and release of stored carbon.	√	√√√√√
Impacts on soil	Loss of soil carbon. Soil erosion.	√	√√
Impacts on water	Water use of crops. Water quality.	√	√√√
Impacts on biodiversity	Loss of habitat.	√√	√√√√√
Minimisation of GHG emissions	The amount of GHG emitted in the production of biofuels varies widely according to the feedstock, management practices and conversion technology options chosen. It is important to assess these emissions and minimise them to ensure GHG savings projections are met.	√√√√√	√√
Economic			
Long term economic and financial viability		√√√√	√√
Cost of carbon savings		√√√	
Impacts on markets		√√√√	√√
Effect of instruments		√√√√	
Continuous Improvement	Activities are monitored and action taken to improve key operations.	√	√√
KEY √ = low relevance √√√ = medium relevance √√√√√ = high relevance			

The table shows that the emphasis for concerns relating to sustainability is different for UK produced biofuels and imported biofuels. A summary of the main issues for each is therefore discussed separately below.

Summary of issues for imported feedstocks

- *Prior land use.* This has been the most high profile concern regarding importing of palm oil and soya for use in biofuels production. There is concern that increased demand for palm and soya are leading to rainforest and savannah being cleared for palm and soya production. This can be either direct clearance of the land for oil production, perhaps in combination with logging, or a leakage effect, where land currently in food production is taken over for biofuels production, leading to clearance of alternative land for food production. This is damaging because
    - It leads to loss of habitat and biodiversity.
    - There are concerns that local people are being forced from the land.
    - Clearance of these areas leads to large GHG emissions, and there is a subsequent reduction in ability to sequester carbon, which works against the objective of biofuels to reduce GHG emissions.

  However, if plantations are established on degraded soils, they can help to improve soil fertility and condition. There are investigations into certain inedible oils that can grow in degraded soils.

- *Labour conditions.* The main reasons for importing feedstocks for biofuels production are availability on world markets and price. Imported oils are considerably cheaper than home produced OSR, both due to higher yields achieved and to lower production costs. However, it is important to ensure that we are not benefiting from cheap oils at the expense of the local producers. In a sustainable system people at all points in the value chain should be able to make a reasonable living out of biofuels production.

- *Priority for food supply and food security.* Food supply can be affected by the use of land currently used for food production being converted to biofuels production. Food security can be influenced by the effect of the biofuels markets on the price of feedstocks that are used for both food and fuel. There are already concerns that the price of maize and soya has increased due to biofuels production.

- *Local use of biofuels feedstocks v export.* Export of oils raises revenue for producer countries. However, the oils could also be utilised locally to produce transport fuels and reduce the fossil oil imports required for the producer countries. This may lead to greater benefit to the producer country overall. It would also improve the long-term viability of the feedstock production, as exports are dependent on the continuing demand for oils, which are subject to policy decisions and technology developments in the importing countries. In particular, the policy goal is the EU to move to second generation biofuels which will use lignocellulosic feedstocks.

Summary of issues for feedstocks produced in the UK

- *Prices:* The demand from the 1st generation biofuels producers has led to a stabilisation in the price of wheat and OSR in the UK, which is welcomed by farmers after years of depressed prices.

- There has been concern from other users of wheat and OSR that the biofuels markets may lead to shortages/ price increases and this is being monitored by the EU and UK Government. A recent report from the EC [26] suggests that a biofuels target of 10% by 2020 would lead to an increase in cereal process of 3-6% by 2020. However, this assumes that a significant proportion of the biofuels would be second generation biofuels, using lignocellulosic feedstocks. If second generation biofuels are not available, more wheat and OSR feedstocks would be required, giving predictions of significant imports to the EU and significantly higher feedstock process.

- *The long-term financial viability* of biofuels processing plant is dependent on the support regime which is dependent on EU and UK policy. The viability of first generation plant is dependent in the short term on the availability of acceptable feedstocks and in the longer term may be threatened by the shift to second generation biofuels.

- *Concerns about the environmental impact of production of wheat and OSR* for biofuels in the UK. There is little difference in the impact on soil, water and air of growing wheat and OSR for biofuels or for food, although research is progressing to reduce the inputs of agrochemicals and operations required for production of energy crops [25]. The concerns relate to increasing the area of wheat and OSR, which are already dominant crops in the landscape. The area could be increased by replacing other crops, utilising set aside or replacing grassland. Replacing other crops is not desirable, as a variety of crops is good for biodiversity and crop health. Utilising set aside is the most likely option, and the environmental impact of this can be minimised by farmers entering the Environmental Stewardship scheme when using set-aside for biofuels, preferably at the higher level stewardship, which will result in new measures being introduced on farm to offset the loss of diversity [27]. Sufficient funding would have to be secured through Natural England to make this possible if large areas were devoted to biofuels. Replacement of native habitats and permanent grassland is subject to an environmental impact assessment under current support schemes for production of energy crops, due to the loss of biodiversity and sequestered carbon which could result.

- *Limits to domestic supply.* Estimates show that only a small proportion of the required bioenergy feedstocks can be produced in the UK. This will come from current surplus of wheat plus some additional wheat production, and diversion of some current OSR production to biofuels plus additional OSR production. Biofuels may be competing with perennial energy crops required for heat and electricity production for utilisation of set aside land.

- *Feedstocks required for second generation biofuels will be lignocellulosic.* These can come from perennial energy crops, or annual crop/wood residues. These are the same crops that are being promoted for electricity and heat production. The sustainability of the production of these feedstocks has been extensively researched in the UK. It is generally felt that production of energy crops and use of forest residues is beneficial and sustainable provided the existing Guidelines are followed. [27]

- *Cost-effectiveness.* The main sustainability issues for biofuels production in the UK are whether biofuels are a cost effective measure to reduce GHG emissions, and related to this whether production of biofuels feedstocks is the best use of set aside land. More cost effective carbon savings can be achieved by producing electricity and heat from biomass than by production of first generation biofuels. The perennial crops used for heat and electricity production require lower inputs of agrochemicals, and offer biodiversity benefits in the landscape. In terms of overall GHG savings and environmental benefits, the argument is clearly in favour of heat and electricity production. However, the argument for first generation biofuels is that this is a way of reducing GHG emissions in the transport sector, and that development of a market for biofuels will lead to development of second generation biofuels, which will provide more cost effective GHG savings in the transport sector from non-food crops and residues.

Ensuring sustainable bioenergy production

Whether or not biofuels are produced in the UK, the UK will be obliged to include a percentage of biofuels in its road fuels sales as a result of the EU Biofuels Directive and the RTFO being implemented in the UK. In practice it is expected that a proportion of biofuels will be produced in the UK and a proportion imported. It is therefore important to ensure as far as possible that the biofuels, both UK produced and imported, are produced sustainably.

In order to ensure that biofuels are produced sustainably the criteria for sustainability must be agreed and then the whole biofuels value chain must be assessed against these criteria using a transparent procedure.

Currently there is acceptance at all levels that biofuels should be produced sustainably, and that it is necessary to certify that the production is sustainable. The challenge is to implement this.

A Dutch study on Governance of the emerging bioenergy market [23] has set out the following conditions for any assurance scheme:

- All stakeholders should be on board
- Must be consistent with current trading laws/ agreements
- Must be independently verified
- Should be simple and progressive

There are a number of current initiatives:

- The UK is a world leader in developing sustainability requirements for biofuels, with sustainability reporting to be part of the RTFO requirements. Development of the sustainability reporting is being undertaken by Ecofys [22]. The reporting will cover the whole biofuels production chain.
- Palm oil and soya have their own international multi-stakeholder initiatives [19,20], the Roundtable on Sustainable Palm Oil (RSPO) and Roundtable on Sustainable Soy. These are focussed on certifying the oils as sustainably produced, and will be relevant to all markets for these products, including biofuels.
- An International Biofuels Forum has been launched in March 07 [21]. The forum is a joint project between Brazil, China, India, USA and the EU, and wishes to promote the sustainable use and production of biofuels around the world.

The difficulties in developing a certified system for sustainable biofuels development are:

- Developing a certification scheme which is compatible with existing WTO trade rules
- Timescales to reach binding International Agreements
- Lack of data on all aspects of the value chain.

In order to facilitate all of these points, current thinking is that standards for biofuels will as far as possible make use of existing international or UK standards. For example RSPO certification could be accepted for palm oil production, and adherence to the Assured Combinable Crops Scheme in the UK accepted for OSR and wheat production.

Working with the RTFO scheme is likely to be the best way to assess GHG savings and sustainability of biofuels in the UK market. The current weaknesses in the RTFO scheme are:

- There are no minimum requirements for sustainability or GHG savings - the requirement is to report on these issues.
- Entry of very high level or scant data is acceptable to the system.
- The RTFO offers no financial incentive to improve sustainability or GHG savings.

The UK Government has however, stated its intention to promote the use of only the most sustainable biofuels with a low carbon intensity towards meeting the RTFO [24]. In particular it is working with the EU and International bodies to develop environmental standards for biofuels. These may be incorporated into the RTFO at a later date e.g. by specifying minimum environmental and social standards in production for a fuel to qualify for the RTFO and/or linking the number of RTF Certificates issued to carbon savings achieved.

How could Yorkshire and the Humber ensure that biofuels are obtained from sustainable sources?

There is currently no internationally agreed definition of a ‘sustainable biofuel’, nor is there any internationally agreed methodology for calculating the precise GHG savings from biofuels. It is the Government’s view that trying to impose such standards on imported biofuels in advance of development of international standards may be successfully challenged as a barrier to trade.

However, much work is being put into development of sustainability reporting and GHG savings estimation methodologies. These methodologies could be used as a basis for developing interim sustainability criteria for use by the Region.

Potential purchasers of biofuels could ask to see a sustainability statement and GHG emissions savings statement from suppliers. Many companies already have these, and all will be required to have them once the RTFO is running. The Region can compare these with internal criteria for

sustainability prior to agreeing to purchase, and can therefore choose to purchase from a sustainable source.

It is more difficult to ensure that first generation biofuels plant built in the Region will source their feedstocks from sustainable sources and produce biofuels with acceptable GHG savings. We suggest that parties within the Region:

- Ask for sustainability and GHG savings assessments as part of planning applications for plants. Compare these with internal assessment criteria. In particular look at feedstock supply issues and production process enhancements which improve GHG savings.
- Encourage companies who are looking to continuous improvement and second generation biofuels.
- Lobby Government for minimum sustainability standards and carbon savings from biofuels production.
- Engage in RTFO consultations to influence direction of development of RTFO.

2.8 R&D requirements

First generation biofuels are mainly mature technologies. Some research on improving crops for use as biofuels could be useful, particularly to increase yield and decrease agrochemical inputs to improve the carbon balances of production.

Research to make optimal use of co-products is required to improve both the economics and environmental impact of the production process. For example some work is currently in progress funded by the DTI EET programme to produce added value products from rape meal. In other parts of the EU uses for crude glycerol have been developed, and this would also be a priority for the UK.

Following on from this, the biorefinery concept needs further definition and then development in the UK, with companies thinking beyond just the production of transport fuels.

Second generation biofuels are still at the demonstration or research stage. So far little work has taken place in the UK, and the UK is behind the USA and is not engaged in the EU effort. Currently German, Spanish and French companies are at the stage of building large-scale demonstration plant.

The UK research to date has been small scale and has concentrated in the development of micro-organisms for advanced fermentation technologies. The UK needs to build on its bioscience knowledge and to engage with the EU in development of lignocellulosic technologies and BTL.

2.9 UK support for Biofuels

RTFO
From April 2008 the Government's main support for biofuels will come in the form of a Renewable Transport Fuels Obligation (RTFO), which requires all transport fuel suppliers to ensure that, by 2010, five per cent of their total aggregate fuel sales is made up of biofuels.

Fuel Duty Incentives
The UK Government introduced a 20 pence per litre duty break for biodiesel in 2002 and bioethanol in 2005. This level of incentive is guaranteed until 2010/11. However it only applies to oil that has been transesterified; biofuel made from waste oil, known as Straight Vegetable Oil (SVO), does not qualify for the duty break until it is converted to biodiesel by transesterification.

Enhanced Capital Allowances (ECA)
Subject to State aids clearance from the European Commission, the UK Government is planning to introduce an ECA scheme in early 2007 for biofuel processing plants that meet certain qualifying criteria and make a good carbon balance inherent in the design. The scheme will allow 100% of the first year cost of capital assets to be written off against taxable profits.

Regional Infrastructure Grant Programme
The programme was launched in August 2005 and provides grants towards the cost of installing alternative refuelling points, including for hydrogen, electric, bioethanol, natural gas and biogas. Although not exclusively aimed at biofuels, the programme has attracted interest from a range of organisations considering the installation of E85 bioethanol refuelling points.

Support for Growing Energy Crops
In the UK, support for the growing of biofuels crops depends on whether the crops are grown on set-aside or non set-aside land:
Set-aside land: EU farmers (except for very small-scale producers) must set aside a stipulated percentage of their land in order to be eligible to receive aid payments. A range of non-food crops, including oilseed rape and cereals, may be grown on set-aside land, with strict rules. Otherwise no cash crop may be planted. The Single Payment Scheme under the EU Common Agricultural Policy applies to crops grown on grown on set-aside land. The amount of payment depends on the number of 'entitlements' each farmer has according to EU rules (a flat rate plus an addition based on any historic reference amount);
Non set-aside land: the Energy Aid Payments Scheme which started in 2004 enables aid to be claimed for crops where the main use is for the production of energy (for heat, electricity or transport fuels) on non set-aside land. The payment in 2006 was 45 Euros per hectare.

R&D Support

Currently Central Government support is from;

DTI Emerging Energy Technologies Programme- 2nd generation biofuels and Biorefineries are current Priority Areas. However, only small scale projects are currently ongoing.

Defra – concentrating on development of perennial energy crops and supply chain assessment and development.

BBSRC- until recently has funded small scale projects. Recently announced a programme for capacity building in Bioenergy research worth £20M.

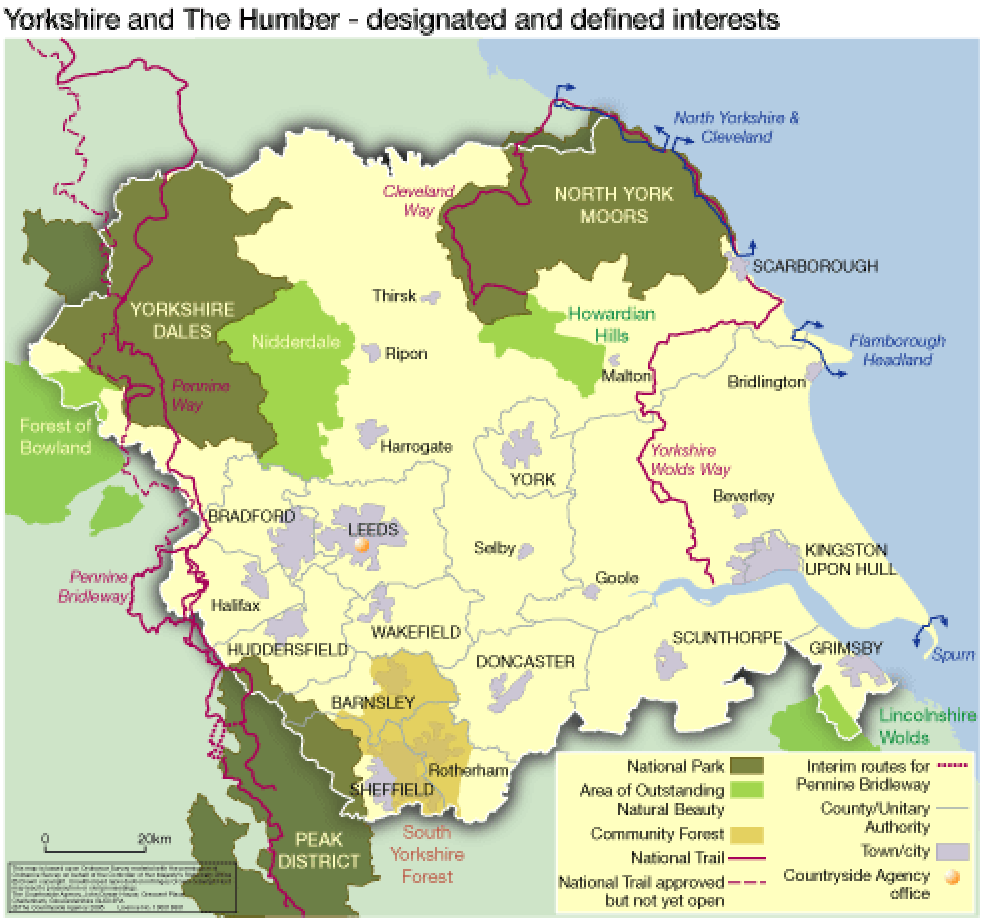
Research Councils Energy Programme- includes the SUPERGEN Programme which now has Biorefineries in its list of priorities. Also the TSEC- BIOSYS Programme and the RELU –BIOMASS programme which is investigating environmental issues including biodiversity and hydrology.

The Home Grown Cereals Authority (HCGCA) offers enterprise awards for using cereals, oilseeds or by-products in alternative ways.

3 The current biofuels situation in Yorkshire and the Humber

3.1 Regional Context

Yorkshire and Humber is a diverse Region with a £75 billion economy and a population of over five million. It is home to more than a quarter of a million companies. The Region has five major cities; Leeds, Sheffield, Bradford, York and Hull. The Region also has a significant rural population and has more National Park land than any other Region.



North Yorkshire has a largely rural economy, with low unemployment but a dependency on tourism. The West Yorkshire economy benefits from the growth of financial and business services centred on Leeds, which is now England's second largest legal and financial centre. However, there are still areas of deprivation. South Yorkshire, based around Sheffield, has grown in recent years and moved out of full European Objective 1 status. However, there are still problems as the Region copes with the transition from a mainly manufacturing industry. The Humber has an economy based around its ports, which now account for 13% of UK sea trade. There are still issues of low skills and wages and high unemployment in this area. The Yorkshire and Humber economy has grown faster than the European average in six consecutive years.

The Region has a strong higher education sector with 11 Higher Education Institutions including the universities of Leeds, Sheffield and York.

The main parties involved in the development of Yorkshire and Humber are the Yorkshire and Humber Assembly, Yorkshire Forward and the Government Office of Yorkshire and Humber.

The Yorkshire and Humber Assembly (YHA) is the Region's high level strategic partnership. The full assembly consists of 37 members; including 22 local Authorities plus 14 partners from business, education, crime health and environmental agencies amongst others. The YHA has six major roles; regional planning, regional housing, regional transport, scrutiny of Yorkshire Forward, Sustainable Development and Strategy Integration, Regional influence and leadership.

Yorkshire Forward is one of nine Regional Development Agencies (RDA) established by the Government to further regional economic development, promote business efficiency and competitiveness, increase employment and skills base and contribute to regional environmental sustainability.

The Government Office for Yorkshire and Humber works on behalf of 10 Government Departments to ensure effective regional delivery of Government programmes and to inform policy development.

These organisations have worked together to develop a number of documents relating to their areas of responsibility. The main ones are

Regional Energy Infrastructure Strategy (REIS)
Regional Transport Strategy (RTS)
Regional Housing Strategy (RHS)
Regional Economic Strategy (RES)
Regional Waste Strategy (RWS)

In addition Yorkshire Forward are working with One Northeast and the Northwest Development Agency on the 'Northern Way'. This is an initiative to unlock the potential for faster economic growth in the North of England. As part of this initiative a Hull and Humber Ports city Region development programme has been published.

The organisations believe that biofuels may offer opportunities to further their goals in some of the above areas, in particular the REIS and RES. Indeed the REIS has a key action to facilitate the development of bioenergy production in the area as part of its objective to maximise low carbon energy generation. It has identified that, given the Region's petrochemical industry around the Humber, its agriculture and food processing business, there are considerable opportunities to manufacture biofuels and develop the market for them in the Region.

Biofuels could also potentially contribute to rural development by providing alternative markets for farmers for biofuels feedstocks and to new opportunities for chemical companies to diversify into bio-based products.

3.2 Current production of biofuels

Biofuels are already being produced in the Yorkshire and Humber region, at both large and small scales. The biofuels currently produced are biodiesel and bioethanol from first generation plant. Details of the existing plants are shown in tables 6 and 7 below.

Table 6: Existing large-scale plants – biodiesel

Company	Plant location	Feedstock, annual amount & suppliers	Capacity, tpa	Comments including timescales
Greenergy	Port of Immingham	Oil seed rape: 'Field to Forecourt' contracts for 160,000t (2006) and 250,000t (2007). Imported soya oil, palm oil.	100,000 biodiesel, increasing to 200,000	Began production in February 2007. Second phase should be in construction.

Table 7: Existing biodiesel plants using RVO

Company	Plant location	Feedstock, annual amount & suppliers	Capacity, tpa	Market for biodiesel	Comments
Rix Biodiesel	Hull	RVO	50,000	Rix distributes to independent filling stations including Swan.	
Bradford Biofuels	Bradford	RVO from 100 kitchens	40	"commercial vehicles"	Capital funding for equipment was supplied by a Yorkshire Forward-funded project

There is currently one large-scale biofuel plant in the Region, being the **Greenergy biodiesel plant at Immingham**. It commenced production in February 2007, at a current capacity of 100,000 t/a.
The reasons for locating there are:

- two oil refineries as customers;
- good links with the ARA ports – Rotterdam is the centre of vegetable oil trading in Europe and probably for biodiesel trading going forward;
- sea access to the Thames (including Greenergy's terminal there)
- the Port of Immingham and associated infrastructure.

It is a mixed-feedstock plant, supplied by oilseed rape from UK farmers through 'Field to Forecourt' contracts (30-60%), as well as imported soya and palm oil. The rapeseed oil is sourced primarily from the Hull crushing plant, transported by barge from Hull to the Greenergy site. Soya and palm oil are sourced from several places around the world depending on price.

The majority of Greenergy's biodiesel is sent to major fuel companies for blending prior to retailing. From the Immingham plant they transport biodiesel by ship and pipeline, with smaller amounts by road:

- Ship and barge – to blending terminals in the UK, Greenergy terminals, and ports at Antwerp and Rotterdam.
- Pipeline – to the two large refineries that are also located at the Port of Immingham (Total and ConocoPhillips)
- Road – small amounts for direct use by customers, e.g. 5% blends up to B100. Greenergy blends these and sends in their tankers.

Ship and pipeline/barge are preferred as they are the most economical. These modes are suited to the very large lot sizes sent to major customers for blending (1000-5000 tonnes), i.e. bulk distribution rather than small consignments suited to road transport.

The glycerine by-product is sold to several different customers for industrial use (further refining for a variety of products) and animal feed. The glycerine is transported by road.

Rix Biodiesel are the main producers of biodiesel in the Region using Recovered Vegetable Oil (RVO). Rix supply to both public filling stations at a 5% biodiesel blend, and to private fleets.

In addition there are a number of small scale producers of biodiesel from RVO in the Region, such as **Bradford Biofuels**. In general these small scale producers collect used cooking oil from local canteens and takeaways. The resultant biodiesel is sold locally again, usually directly to customers who have environmental objectives. The size range of these operations is typically tens to hundreds of tonnes of biodiesel per year.

BioPower, a network of companies that process a range of organic fuels for various uses in the UK, has advised that the quality of used cooking oil in the Region is often low, due to use of palm oil and dripping in cooking. This will restrict the amount of RVO which can be used for biodiesel.

The National Industrial Symbiosis Programme- Humber (NISP- Humber) aims to link together different companies to achieve resource efficiency. They have been involved in evaluating the opportunity for using RVO for biodiesel in the Humber area. In addition to looking at the RVO resource they have also been evaluating uses for the by-products from biodiesel production, such as glycerol and DDGS in co-operation with Humber Chemical Focus, and the possibility of farmers producing added value to their feedstock products.

There is the possibility in small scale production that processing by-products are not sold on but disposed of as wastes. Procedures need to be in place to ensure these wastes are disposed of responsibly.

There are opportunities for further development of small scale biodiesel production from RVO in the Region. However, care is required to obtain suitable quality RVO and to ensure that the by-products from the production are sold on or disposed of in accordance with agreed operating procedures. Identification of total resource and further processors could be carried out most efficiently by NISP, who are already active in the area. Most likely locations are centres of population where there are many canteens and restaurants/takeaways.

No bioethanol plants currently operate in the Region.

3.3 Production plant under development

The proposed large-scale biofuels plants in the Region are shown in table 8. Except for the Helius proposal these are all bioethanol plants. As at March 2007, five plants were at reasonably advanced planning stage.

All the proposed plant are large scale bioethanol plant, and all are seeking locations on the South Humber bank. The reasons quoted for this are;

- presence of the port allows import of feedstocks and export of bioethanol and associated by-products by ship.
- crop feedstocks are available in the surrounding area.
- there are two local oil refineries who are interested in buying the biofuels. Transport to these refineries can take place via pipeline.
- there is existing storage capacity and willingness to invest in further storage capacity as required.

In the next chapter we will look in more detail at each of these factors, and other factors that will affect the suitability of this site for biofuels developments.

Table 8: Planned large-scale plants in the Region

Company	Plant location	Biofuel	Feedstock, annual amount & suppliers	Capacity, tpa	Comments including timescales
Abengoa	Stallingborough	Bioethanol	1.1 million t/a wheat from the Region, small amount to be imported. Also imported wine from the "European Wine Lake".	400,000 by 2009	Planning application under consideration.
Bioethanol Ltd	Immingham	Bioethanol	325,000t/a wheat, to be supplied by Centaur Grain, Humber Grain and Velcourt. For 1st phase.	100,000 +2nd phase 100,000	Planning approved. 1st phase operational end 2008.
Green Spirit Fuels	Grimsby	Bioethanol	650,000t/a wheat, to be supplied by Wessex Grain, parent company of GSF.	200,000	Working towards 2009 operations but not yet in planning.
Helius	Stallingborough	Bioethanol Biodiesel	Proposed biomass power generation plant; also seeking consent for co-location of a bioethanol and a biodiesel facility. Feedstocks would be approx. 750,000t/a wheat for bioethanol and vegetable oil (undefined at this stage) for biodiesel.	270,000 bioethanol; 100,000 biodiesel.	Planning application under consideration.
Vireol plc	Humber River bank, near Grimsby	Bioethanol	Approx. 425,000 t/a wheat.	150,000 by 2009	In planning. Planned to be operational by 2009
Ensus	Humberside	Bioethanol	Wheat from UK if available, otherwise imported.	Not known	Ensus currently building a plant at Wilton. They have identified Humberside as a second possible UK site for a bioethanol plant.

3.4 Markets and local utilisation

Biodiesel
There are three main markets for the biodiesel currently produced in the area; sale to oil companies/ blenders for onward sale to public filling stations at 5% biodiesel blend, sales to commercial fleets including local authorities and sales to individuals who have a particular interest in the environmental benefits of biodiesel.

Greenergy has a mix of customers: large amounts are sent to oil companies for blending prior to forecourt sales; smaller amounts to commercial fleets including their own fleet.

Rix Biodiesel supplies commercial customers and independent filling stations. All the filling stations in Y&H listed on www.biodieselfillingstations.co.uk are supplied by Rix Biodiesel, except one by Petroplus (a fuel/biodiesel distributor based in Teeside).

Small scale producers such as Bradford Biofuels tend to sell their biodiesel locally to private individuals.

The *Fuelling the Public Sector* [6] report identified that in 2004, 5 of the 13 interviewed local authorities in the Region (of a total of 20 authorities) used biofuels, mostly biodiesel, at the 5% blend. Local authority fleet managers are able to purchase biodiesel through a number of local suppliers and also through the local purchasing consortia, YPO. In 2004 YPO spend on diesel was circa £13 million per annum and circa 15% of that was biodiesel, supplied by Bayford and Petroplus.

There is a perception within local authorities that biodiesel will be more expensive than fossil fuels and that there may be supply issues. There was also confusion over the environmental impacts and benefits of biofuels, and concern that higher % blends of biodiesel will invalidate vehicle warranties.

There is an opportunity to inform local authorities on these issues and also to encourage more to start using biofuels. There is also an opportunity for Local Authorities to participate in an RVO collection scheme and to be customers for the resultant biodiesel.

Bioethanol
Current planning applications indicate that bioethanol produced in the Region will be sold for blending into petrol, for consumption in the UK.

3.5 Local support

3.5.1 Promotional schemes and awareness in the Region

To date, we understand that there have not been any schemes specifically promoting biofuels in the Region to potential biofuels producers or customers, nor have there been any attitudinal surveys of the public, local businesses or farmers on these issues.

On the supply side, industry groups such as Humber Chemical Focus and NISP are facilitating development of the industry in the Region through working directly with the companies involved.

Yorkshire Forward has recently initiated work on Sustainable Fuels and Feedstocks Development in Yorkshire and Humberside together with Humber Chemical Focus, NISP, NE and North Lincolnshire Councils and UK Trade & Investment, to achieve the following goals:

- Attract investment
- Support existing investors
- Optimise the regional asset base
- Promote academic - business collaboration
- Build regional capacity for emerging sector.

The group is progressing a work plan to support these goals in the areas of marketing, network building and infrastructure/planning issues.

3.5.2 Grants and advice available to the biofuels industry

Support for the industry ranges from direct funding in the form of grants, to advice and assistance in starting up a business, linking businesses in the supply chain, and developing the market.

Central Government support for biofuels across the UK has been described in the first section of the report. In addition the following are applicable to the Yorkshire and Humber Region.

Selective Finance for Investment (SFI) (previously Regional Selective Assistance (RSA))
SFI is the main national scheme of financial assistance to industry. It provides discretionary grants for investment projects that will create or safeguard jobs in Assisted Areas (Tier 1 and 2) - areas designated for regional aid under European Community law. In addition SMEs in Tier 3 are eligible for SFI assistance. There are a number of Tier 1, 2 and 3 areas in Yorkshire and the Humber, although these are currently under review.

A **Regional Selective Assistance** grant helped establish the UK's first major biofuel plant in Scotland, being the INEOS plant at Grangemouth. Its £9 million RSA grant was Scotland's largest to a renewable energy project.

UK Trade & Investment is the Government organisation that supports both UK companies trading or looking to trade internationally (e.g. if a biofuel producer in Yorkshire and Humber Region was looking to export biofuel) as well as overseas companies seeking to set up or expand in the UK (inward investment, international companies setting up biofuel plants in the Region).

The **UK Trade and Investment Office** directed Abengoa to South Humber Bank for a proposed bioethanol site. A detailed site search was assisted by **Yorkshire Forward** and **North-East Lincolnshire Council.**

The **Invest in the UK** website aimed at inward investment to the UK features Rotherham in South Yorkshire as an example of an EU Objective 1 and Tier 1 Assisted Area – meaning that it offers the highest level of financial support in the EU. The Rotherham Investment and Development Office provides advice and assistance to potential new businesses and there is an Enterprise Zone offering tax and other concessions to businesses, with land available in major business parks. While it is far from the ports and refineries, Rotherham and other inland areas could be attractive for smaller scale production, for example using waste cooking oil.

The **Rural Enterprise Scheme** and other schemes under the **England Rural Development Plan** (EDRP) have closed and are being replaced by the successor to the ERDP, the Rural Development Programme 2007-2013. This will contributes to the delivery of the Government's Strategy for Sustainable Farming and Food. It will do this by helping farmers and foresters to respond better to consumer requirements, and to become more competitive, varied, adaptable and environmentally responsible. It also provides help to rural businesses and communities that need to adapt and develop.

Delivery of the Programme will transfer to Regional Development Agencies, which in the Yorkshire and Humber Region is Yorkshire Forward.

Springdale Crop Synergies, based near Bridlington in Yorkshire and the Humber, received **Rural Enterprise Scheme (RES)** funding under Defra's England Rural Development Programme (ERDP). Springdale specialises in non-food crops - plants that produce oils that can be used for everything from biodiesel to pharmaceuticals. Springdale received RES funding to develop the market for farmers to diversify into this sector. By establishing and securing contracts with processors, Springdale are able to offer guaranteed prices for growers. The funding also helped develop on site demonstration facilities to enable growers and end users learn more about the potential for these innovative crops.

Business Link is a central source of information about support for businesses. It is primarily funded by the Department of Trade and Industry, supported by a number of other government departments,

agencies and local authorities. It provides a Grants and Support Directory, a free searchable database. **Yorkshire Forward** is the contact for Business Link in the Yorkshire and Humber Region.

There is also a free but privately operated searchable database, **GRANTnet**, to which local authorities subscribe (e.g. North Yorkshire).

At a regional and local level there are potentially very many support schemes available to biofuels producers. Many of the schemes are targeted locally and some depend on whether the site being considered is in an EU Assisted Area, Tier 1 or Tier 2 area.

North Yorkshire County Council is providing support to a proposed Clapham Community Co-operative RVO plant through the Council's **Rural Target Fund**.

Yorkshire Forward supports six core programmes of activity that aid the overall start up and growth of a business:

- Business Start-Up Programme – which will focus on encouraging enterprising individuals to establish their own business and then help them to do so successfully.
- Business Improvement programme – designed to help businesses grow and improve their performance.
- Innovation Programme – which will encourage and support businesses to develop new ideas, products and processes.
- International Business Programme – which will support companies in identifying new international markets and help develop strategies that will help them to access these markets.
- Skills Programme – designed to help businesses develop their workforce to help them grow.
- Access to Finance Programme – Designed to help businesses source and access funding that will help them grow.

Yorkshire Forward also contributes to and/or co-ordinates many of the local grant schemes in the Region.

Yorkshire Forward contributed half the funding for the **Centre for Assessment of Technical Competence Humber (CATCH)**, which opened in 2006 at Stallingborough, South Humber Bank. It is the first centre of its kind in the country, replicating the operating practices and complexity of equipment in the chemicals industry. It fills an identified gap in skills training and competency assessment, and can also assist companies with certification and licensing.

Humber Chemical Focus is a private-public partnership, established in 1999, with a membership of over 70 organisations. Through its networks it supports the operation and development of the £6 billion chemicals industry in the Humber Region. It provides linkages between the industry and local authorities, HSE, EA, local Learning & Skills Council, Chemical Industries Association and the Department of Trade & Industry. It has also hosted a range of publicly funded contracts spanning industry surveys, skills programmes, projects and promotions. In December 2006 the Third Regional Chemicals on the Move Conference was jointly hosted by **Humber Chemical Focus**, **The Humber Trade Zone** and The **School of Logistics at Hull University**, focusing on "The Emerging Energy and Feedstock Supply Chains", which considered opportunities for biofuels in the Region.

Yorkshire Chemical Focus provides a similar service for the £2.2 billion chemicals industry in the Yorkshire Region.

4 Opportunities to develop the Biofuels Industry

4.1 Feedstock production for bioenergy

The main benefit to the rural economy of biofuels is a new market for crops and forestry products. The crops required for first generation biofuels plant producing biodiesel and bioethanol are oil crops such as oil seed rape and sugar/starch crops such as sugar beet and wheat respectively.
For second generation biofuels plant lignocellulosic crops such as the perennial crops SRC and miscanthus, agricultural by-products such as straws and forestry products such as small round wood and forestry residues will be required in addition to the crops for first generation plant.

The Yorkshire and Humber Region is well placed to take advantage of these new markets. The Region is largely rural, with 76% of the area used for agriculture:

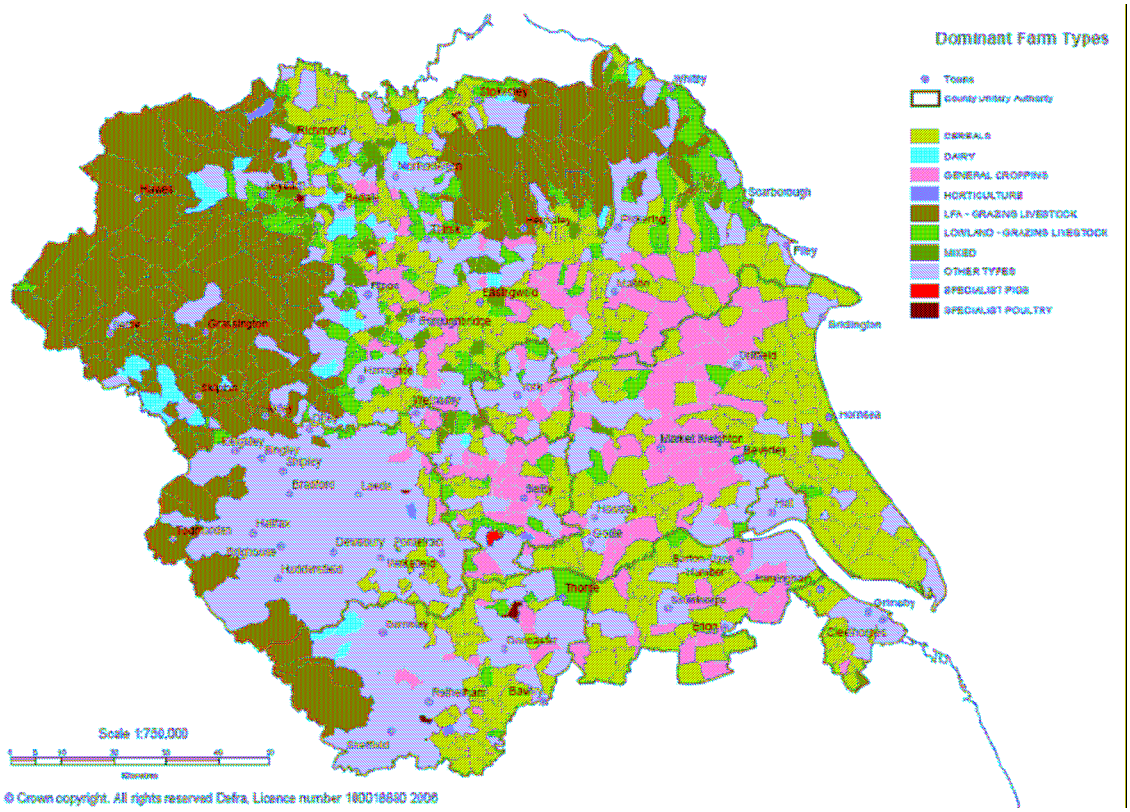
Table 9: land used for agriculture in Yorkshire and the Humber Region:

Total regional land area	1,542,951 ha
Regional agricultural land area	1,095,544 ha
Agricultural percentage	76%

Source: DEFRA - www.defra.gov.uk/erdp/docs/yhchapter/yhsection11/default.htm

Figure 5 shows the uses of this agricultural land, including the main cereal cropping areas.

Figure 5: Dominant farm types in Yorkshire and the Humber Region. Source: Yorkshire and the Humber Regional Implementation Plan (Draft) - Rural Development Programme for England (RDPE) 2007-13. Submission to Defra, December 2006.



4.1.1 Crops for first generation biofuels plant

Taking first the crops required for first generation biofuels plant. Table 9 below shows that OSR, wheat and sugar beet are already widely grown in the Region.

Table 10: Crop areas in 2005, Defra

Crop	Area in YH Region, ha	Area in UK, ha	% in YH area
Wheat	236,649	1,867,000	13
Oil seed rape	65,542	592,000	11
Sugar beet	20,756	148,000	14
Set aside	55,338	559,300	10

Table 11: Biofuels crop data, 2005 figures except where otherwise indicated

	Wheat	OSR	Sugar beet
UK area (ha)	1,867,000	592,000	148,000
UK area grown with Energy Aid Payments on non set aside (ha)	(917)	(187,000)	0
UK area grown on set aside (ha)	(3,000)	74,000 (66,000)	0
UK yield, average (t/ha)	8.0	3.2 3.3 non set aside, 2.7 set aside	58.5
UK total produced (t/a)	14,863,000	1,901,000	8,687,000
Y&H area (ha)	236,649 Total cereals: 334,889	65,542	20,756
Y&H production (t/a)*	1,893,192	**209,734**	1,214,226
E. Midlands area (ha)	348,217	117,021	30,713
E. Midlands production (t/a)*	2,785,736	374,467	1,796,711
UK cost 2005 (£/t)	66 (feed wheat)	155 (ref: SAC 2005)	30.9
UK cost 2006 (£/t)	78 (feed wheat)		23.5
UK surplus or import (t/a)	Surplus typically 1.5-2 million t. 2005: 1.3 million t.	Surplus 2005: 125,000 t	Only refined sugar data, net import.

Main source: Defra January 2007, figures for 2005. Italics: Defra 2005 including Y&H figures. In brackets: NNFCC.
* Calculated from regional area multiplied by UK yield.

Wheat
Table 11 shows that the UK had a surplus of wheat of 1.3 million t in 2005, from a total production of 15 million t/a. In the Yorkshire and Humber Region, production of wheat was nearly 1.9 million tonnes and OSR 210, 000 tonnes. Production of these crops was even greater in the neighbouring East Midlands Region. If we assume that YH has a similar level of surplus wheat to the National Average then about 190,000tpa wheat is surplus in the Region.

3.5t wheat are required to produce 1 t bioethanol. The surplus wheat in the YH Region is therefore currently sufficient to produce about 50,000tpa ethanol. This is about half that required for an average sized bioethanol plant of 100,000tpa.

The planned bioethanol plants in the Region are all proposing to use wheat as the sole or primary feedstock. Abengoa is also proposing to use a small amount of wine in a separate bioethanol plant on site.

If all plants were approved and operating at capacity they would have a capacity of about 1 million tpa bioethanol and require around 3.25 million tonnes of wheat per year. This is 1.7 times the entire wheat yield of the Region and around double the UK's average wheat surplus.

Some extra wheat could be produced within the Region by converting land under other uses to wheat production. The NNFCC has suggested that at least some set-aside land and temporary grassland could be used for growing wheat. The total amount of set-aside in the Region is 55,338 ha and temporary grassland 52,370 ha. The land currently given over to other cereals is likely to be suitable for growing wheat. If all of this land (98,240 ha) was solely used to produce wheat then another 785,920 t/a wheat grain would be produced in the Region.

Adding together all three areas together (set-aside, temporary grass and extra cereal land) gives 1,647,584 t/a. Growing wheat on all of this land would nearly double production from 1,893,192 t/a to 3,540,776 t/a. This is simply a hypothetical scenario to give some idea of the upper boundary of possible production on these lands Even with these extreme assumptions all the additional wheat would be required to provide a 50% input to the proposed plant.

In practice not all this land would be suitable for growing wheat, and in any case this would not be desirable with biodiversity interests and would potentially compete with use of the land for other energy crops. If we assume that about 50,000 ha would be suitable and available, then about 400,000tpa extra wheat could be produced. Together with the assumed 200,000 tpa surplus in the Region 600,000tpa would be available for biofuels without impacting on the food market. If 50% of the wheat is imported this would support about a 340,000 tpa bioethanol capacity in the Region; equivalent to about 2 of the proposed plant. If wheat were also sourced from the adjacent East Midlands Region with similar assumptions, then up to 5 plant might be supported. More than this would require increasing dependency on imported wheat.

Ideally, farmers would commit to producing wheat for alcohol/bioethanol production because the type of wheat that gives the greatest yields of bioethanol (soft-wheat varieties with high starch levels and low protein levels) is different to the wheat that is preferred for food production (wheat varieties with high protein levels).

In Yorkshire and the Humber, wheat is transported by lorry from each farm; there are no co-operative arrangements in the Region for centralising wheat collection and transporting by rail. There are no rail-connected farms in the Region.

Glencore has an exclusive contract to supply all the wheat to the proposed Ensus plant at Wilton in the North East Region. Glencore states that while farmers in the North East would be well-placed to supply the plant with wheat, Glencore would not be limited to sourcing UK wheat if it was more economical to import supplies.

Oil seed rape

The amount of OSR sourced by Greenergy through its contracts (250,000 t in 2007) is greater than the amount produced in the Region (210,000 t in 2005). Good agricultural husbandry requires that OSR is grown on a one in five year rotation, and the amount of OSR grown in the Region suggests that maximum use is already being made of OSR as a break crop for cereals. More OSR could be grown as a break crop as part of a rotation for additional wheat, or on other set aside land. Assuming it was grown on all set aside land once in 5 years then an additional 11,000 ha/y could be grown, amounting to a yield of about 30,000 tpa. 2.7t rapeseed is required to produce 1t biodiesel, so that the additional amount will only support production of about 11,000 tpa biodiesel. This suggests that any further biodiesel plant in the Region would be heavily reliant on imported oils. An alternative would be to source OSR from adjacent East Midlands, in this case another large scale biodiesel plant could be supported in the Region.

Another consideration with OSR is the crushing facilities in the Region. There are currently three plants in operation in the UK, two operated by Cargill, in Hull and Liverpool, and one by ADM. The Hull plant has capacity to process 240,000 tonnes of oilseed per year, sourced from Yorkshire and Humber and surrounding Regions. The plant has the ability to crush more seed if required, but believe that there will be a shortfall of OSR available. DRAX are also considering investing in an OSR crushing plant.

Sugar Beet
British Sugar is the UK's sole sugar beet processor. The plant proposed at Wissington will be integrated with the sugar production operations, and such integrated production is likely to be most cost effective. There are no plans to use sugar beet as a feedstock, for current or proposed plants in the Region.

There may also be competition between growing biomass for electricity/heat and crops for biofuels, both on set-aside and non set-aside. Care must be taken not to 'double count' the land available for energy crops. This can be avoided by developing the strategies for biofuels and biomass for heat and electricity together. There is also an opportunity to explore the synergies between biofuels and electricity/heat production.

Even after extraction of added value chemicals from rape meal there will be a solid residue which will be suitable for use as a fuel. Likewise, after processing of lignocellulosics for bioethanol, the remaining lignin will still be available for use as a fuel. There is therefore an opportunity to work 'smarter', and extract added value from biomass feedstocks, but still have a significant residue available as fuel.

Imported feedstocks
All the proposed biofuels plant in the Region intend to import a substantial proportion of their feedstock. This is one of the primary reasons for wishing to locate at the Humber docks.

Wheat, OSR, palm oil and soya oil are all internationally traded commodities. Although the proposed plant all intend to use home produced feedstocks, it is possible that they will switch to higher proportions of imported feedstocks if these are substantially cheaper.

At the moment palm and soya oil are cheaper than rapeseed oil, although they produce lower quality biodiesel.

Wheat prices are quite volatile. Generally, with the national surplus, UK wheat prices are lower than for imported wheat by around £7-10/tonne. The HGCA believes that increasing consumption of wheat for bioethanol plants would move the UK wheat price towards import parity.

4.1.2 Crops for second generation biofuels plant

Wood feedstocks, agricultural residues and in some cases MSW are considered possible feedstocks for second generation biofuels. The suitability of a particular feedstock will depend on the particular technology used. The production of second generation biofuels does not therefore depend on use of food crops, and this is considered one of its advantages. However, the range of feedstocks is similar to that required for production of heat and electricity from biomass.

Potential quantities of biomass feedstocks in the Yorkshire and Humber areas are estimated in the Carbon Vision report [12] and are summarised in the table below.

Table 12 - Potential quantities of biomass feedstocks in the Yorkshire and Humber areas

Biomass Fuel	Resource available (odt/y)* –	Comments
Forestry arisings and residues	55,000-120,000	
Arboricultural arisings	294,000	Widely dispersed resource
Saw mill co-product	6000	Saw mills take in 100,000 t/y. It is likely more waste wood is available from then, but is currently sold to alternative markets.
Energy Crops	1,000,000-3,000,000	This combines SRC and miscanthus and assumes planting on 10% of arable land and yield of 9odt/ha
Straw	1,016,000-2,400,000	This does not take alternative markets for straw into account. In reality probably no more than a third of this is available.
Wood waste	690,000	The use of this fuel will depend on the need to comply with the Waste Incineration Directive.
Total	**3,061,000-6,510,000**	

The figure for energy crops is equivalent to assuming all set aside and temporary grassland in the Region is used for energy crops. The actual planting in the Region is currently about 2,000 ha for SRC and 7,000 ha for miscanthus. BICAL have just announced a further 14,000 ha of miscanthus to be planted in the Region on set aside land to supply DRAX. With existing plantings this will bring the supply to DRAX to 300,000 odt/a by 2009.

The large-scale users of biomass in the Region are currently the power stations at DRAX and Ferrybridge, using the biomass for co-firing.

Plant and status	Fuel	Capacity	Comments
Drax – co-firing at present	~ 1.5 million tonnes/annum by 2009	3% of power station output rising to 10% by 2009	Are interested in using energy crops and trying to establish supply base.
Ferrybridge – co-firing at present	Co-fires at least 500,000 t/year at present. Includes PKE, olive stones		

DRAX is the main customer for energy crops, taking both SRC and miscanthus.

It is estimated [13] that demand for a single second generation biofuels production plant would be of the order of 1.5 million odt/a biomass. This is of the same order as that required by DRAX by 2009.

If all this biomass were to be sourced in the Region these two schemes alone would require the whole (optimistic) resource estimate for the Region. There is, however, the opportunity to use the resource more effectively by processing for biofuels first, and then using the residue as a fuel for co-firing.

Even using the feedstocks in the most efficient manner, it is clear that a substantial proportion of the biomass required will need to be imported.

4.2 Further development of current biofuels technologies in Yorkshire and Humber

4.2.1 Advantages of Yorkshire and Humber for further developments

There is currently unprecedented interest in development of biofuels production plant on the South Humber bank, with five companies seeking to locate their biofuels plant there. There is currently one plant under construction and four in planning.

Yorkshire Forward's Biofuels Programme identifies the following advantages for companies to invest in Yorkshire and Humberside:

The existing refining and chemical industrial base, with the associated skilled labour force. We provide 27% of the UK's refinery output, with major petrochemical companies having sites already in this Region; for example BP in Hull and ConocoPhillips and Total south of the Humber. There are already significant major capital intensive chemical production facilities on the Humber and both large scale and individual CHP energy generation capacity. Alongside this is the substantial infrastructure of chemical construction and maintenance contracting expertise;
The geographic location; particularly on the Humber for refinery pipelines, sea, road and rail access and logistics;
Also of significance is the West Yorkshire cluster of relevant speciality chemicals and South Yorkshire's engineering capability to provide factory equipment;
A strong and relevant research community with world recognised capability.

The South Humber Bank appears particularly attractive for the above reasons and additionally:

- The ports are considered to have adequate capacity with the ability to cope with additional imports of biofuel feedstock.
- Crop feedstocks grown in the area.
- Simon Storage's existing tank and pipeline infrastructure, and their willingness to co-invest in new pipelines etc with the new companies as demand arises.
- There is suitable land available for biofuel production plants, for example in NE Lincolnshire near the ports. For several years 1,000 acres of zoned industrial land has been available. There are also suitable sites available in North Lincolnshire, including a 2,000 acre greenfield with direct access to the Humber, designated for chemical and/or port related use.
- ConocoPhillips' Combined Heat and Power (CHP) plant provides steam heat and electricity to its own refinery and steam heat to the Total refinery. It has approval to expand the capacity of the CHP plant from 730 to 1,180 MW. The expanded plant will be able to supply heat and power to a wide range of local industrial customers.

Extract from Yorkshire Forward's Chemical Industries Fact Sheet:

The South Humber Bank is Europe's last remaining sizeable area of greenfield land located near to a major port and suitable for chemical companies.

The area available on the South Humber Bank is approximately 800 hectares. The vision for the land is for it to become a fully integrated economic zone providing competitive services to any company that takes the opportunity and locates here.

The land benefits from sympathetic planning policy, which will allow for heavy chemical sites to be built and has been awarded European Objective 2 status, which gives access to European funding; in addition the site is in a Regional Selective Assistance area, which gives access to further government grants.

This land is adjacent to the two oil refineries of TotalFinaElf and ConocoPhillips. In addition

ConocoPhillips are building a CHP generator on the land next to the site and have offered very competitive rates for any company that makes use of the extra power they generate.

However, it should be recognised that the Humber Flats, Bank and Coast is an internationally important wildlife area [29] and has been designated a Special Protection Area (SPA). The current RSS identified the need to ensure its protection and enhancement alongside economic development. This means that further development around the South Bank will require an Appropriate Assessment to determine its cumulative impact on the integrity of the SPA. Currently each development is submitting an individual assessment, and this will mean that future applicants will struggle to prove that their development will not create a cumulative negative impact.

Our analysis suggests that the area around the Humber ports is the most attractive location for large-scale biofuels plant. We have therefore concentrated on the opportunities in this area. However currently there is no agreed strategic way forward to take account of both economic and environmental considerations described above. To take advantage of the economic opportunity it is vital for all interested parties to draw up collaboratively a way forward which takes account of both economic and environmental considerations and will facilitate acceptable development in the area.

Each of the advantages of location on the Humber Bank is discussed in more detail below.

Presence of oil companies

Two of the UK's nine major oil refineries are located in the Region, within a few miles of the Port of Immingham: Total (Lindsey Oil Refinery) and ConocoPhillips. These two facilities refine approximately 27% of the UK's petroleum fuels. Their annual production of diesel and petrol is shown in Table 13 below.

Table 13: Production of diesel and petrol at regional oil refineries

	ConocoPhillips	Total
Refining capacity	11.5 million t/a	10 million t/a
Diesel production	5 million t/a	3 million t/a
Petrol production	3.7 million t/a	2.5 million t/a

Both facilities despatch refined petroleum products including diesel and petrol by pipeline, rail, road and sea. Approximately half of Total's product is transported via its 'Fina-line' pipeline from the plant in Killingholme to Hemel Hempstead, with a capacity of 6 million litres per day.

Some biodiesel from the Greenergy Immingham plant is already transported to the refineries to be blended with mineral diesel at 5%, for retail sales. Abengoa also proposes this for bioethanol.

The imminent introduction of RTFO targets provides a driver for all oil companies in the UK to source biofuels at up to a 5% share (and in the future at higher shares), for blending to comply with the RTFO. Whether they chose to source these locally or to import biofuel from other places in the UK or overseas will depend on the price – it is likely to be cheaper to source from the existing and proposed biofuels plants very close to the refineries, with lower transport costs.

If all proposed bioethanol plants on the South Humber Bank were approved and producing at planned capacity, they would produce 1,220,000 t/a, or around 20% of the annual petrol production of the Total and ConocoPhillips refineries. The expanded Greenergy plant and proposed Helius plant if approved would produce 300,000 t/a, or around 4% of the annual diesel production of the Total and ConocoPhillips refineries.

ConocoPhillips may be in a position to accept more bioethanol and/or to expand capacity at the Humber refinery; it is planning to invest a further £700 million in the refinery in the period up to 2010 to "maintain its place at the forefront of the industry". We are unaware of future plans for the Total refinery.

Transport infrastructure

This section briefly describes the Region's transport infrastructure and investigates whether the transport infrastructure could support the development of more biofuels plants in the Region. Particular focus is given to the South Humber Bank.

Yorkshire and Humber's *Freight and Logistics Intelligence for the Regional Transport Strategy* (2005) identifies that Region has good transport infrastructure with high rates of use of waterways, rail and ports, but there are locally-specific capacity constraints.

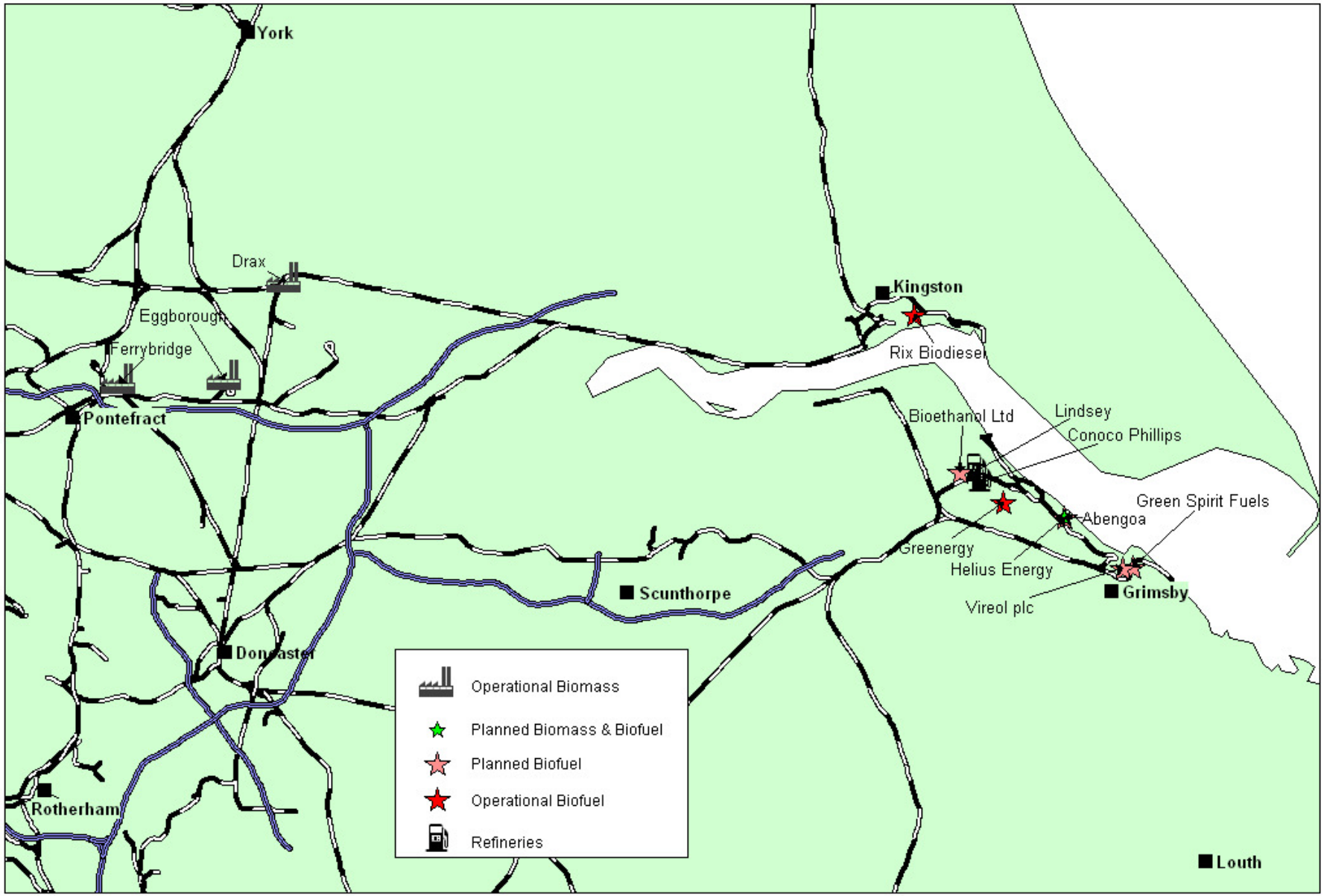
The following map shows the locations of the existing and proposed biofuels and electricity production plants in the Yorkshire and Humber area. It also shows that there are good motorway and rail links to the Region.

Ports: There are four ports in the Region: Immingham (the UK's largest single port), Grimsby, Hull and Goole. The Port of Immingham handles around 20 million tonnes per annum of petroleum products. Consultations with the YH Assembly and NE Lincolnshire Council, as well as previous consultations undertaken within the *Vision for Coal* project suggest that due to recent expansions, the port facilities are considered more than adequate at present and would be able to cope with increased imports of biofuel feedstocks.

Roads: The M1/A1 is the major north-south road transport artery running through the centre of the Region. A major east-west link is provided in the centre of the Region by the M62 which links Hull with Manchester.

Rail: There is a single freight rail line, Grimsby Light Railway, between Immingham Dock and Grimsby Dock, which Abengoa is planning to use. The rail freight facility in the ports area links to the UK main lines. There is a current push to encourage greater use of freight rail both in the Region and nationally. To this end, Network Rail recently announced a £600 million package of works to improve operations in Humber, Teeside and Merseyside. This will address inter-regional east-west (Trans-Pennine) constraints as well as those in the Yorkshire and Humber Region. For example the number of train passes into the Port of Hull will be increased from 10 to 22 per day. Rail capacity into the Port of Immingham will also be improved. Amongst other measures, Network Rail is bringing back into use an almost disused line, which will create a diversionary route in the event of an incident and thus reduce the system's vulnerability.

Pipelines: There is a network of private pipelines in and around the Immingham and Grimsby docks, which is used to transport chemicals and petroleum products. The network is mainly owned and operated by the company Simon Storage. Simon Storage has demonstrated its willingness to co-invest in new storage and pipeline infrastructure with new chemical companies as demand arises. They provided the storage and pipelines for the Greenergy site. In addition, the Total oil refinery operates its own pipeline from the plant in Killingholme to Hemel Hempstead, with a capacity of 6 million litres per day. It is difficult to find details about the private pipeline network.


York
Drax
Eggborough
Ferrybridge
Pontefract
Kingston
Rix Biodiesel
Bioethanol Ltd
Lindsey
Conoco Phillips
Green Spirit Fuels
Abengoa
Greenergy
Helius Energy
Vireol plc
Grimsby
Scunthorpe
Doncaster
Rotherham
Louth
Operational Biomass
Planned Biomass & Biofuel
Planned Biofuel
Operational Biofuel
Refineries

Located in cereal growing area
Availability of crop feedstocks was discussed in the previous section.
The proposed plant plan to use a proportion of locally grown wheat and oil seed rape in their plant.
There are currently no plants existing or proposed to use **sugar beet** as a feedstock.

We estimate that 2 each of large scale bioethanol and biodiesel plant could be supported in the Region using about 50% local feedstocks and without impacting on food use of the crops. Further plant could be supported by using crops from adjacent East Midlands or by utilising a greater proportion of the wheat for biofuels, or by importing a higher proportion of feedstocks.

Wheat supply is likely to be by road from individual farms. Grain supply companies are already active in offering contracts for wheat supply to biofuels plant in the area.

The Region has a local OSR crushing plant in Hull. It has capacity to process 240,000 tonnes of oilseed per year, sourced from Yorkshire and Humber and surrounding Regions. Cargill stated that it would be able to increase production if more OSR was grown, however they expressed the view that within the next few years there would be a shortage of OSR in the UK.

Skilled workforce
The Humber Estuary is also home to many related chemical industries and industrial towns such as Hull and Scunthorpe, with infrastructure as well as skills and expertise relevant to the production of biofuels. There are also trade associations such as Humber Chemical Focus that can offer support.

Utilisation of by-products/wastes
By-products of the bioethanol production process are dried distillers' grains with solubles (DDGS) and carbon dioxide in roughly equal amounts by weight. The distillers grains produced in the bioethanol process are similar in composition and feed value to grains currently produced by the brewing industry, creating a valuable alternative to imported soya and maize protein. This cheaper source of animal feed could significantly help the livestock industry in the Region.

The Abengoa Planning Statement proposes that Dried Distillers Grain Solubles (DDGS) generated from the fermentation process would be sold as an animal feed or as a biomass fuel in coal-fired power stations. They are also investigating selling the CO_2 by-product to the brewery industry.

By-products of the biodiesel production process are rapeseed meal, used an animal feed or a biomass fuel, and glycerine. The glycerine is available as a feedstock to the chemical industry for other chemical processes.

The GHG savings from biofuel production could be improved by using the by-products / waste products as biomass fuels in the production process, instead of gas or electricity. The proposed Helius plant would use biofuels waste products in the biomass power plant.

Other sites for biofuels production plant
The other opportunities identified are for small-scale biodiesel production from RVO near centres of population, and co-location of a medium scale biodiesel plant with an electricity production plant.

4.2.2 Possible constraints on development

Possible constraints fall into two main categories:

Issues for the biofuels industry across the UK
- Recent drop in investment enthusiasm, drop in crude oil price, increase in wheat price.
- Will firms want to expand biofuels production beyond the level needed to meet RTFO?
- Feedstock availability for first generation biofuels. If introduced by the Government, binding sustainability requirements may effect the operation of biofuels plants dependent on imports.

Regional issues

- Competition from other UK Regions for inward investment. Teesside, Firth of Forth, and Merseyside are all similar port locations with existing oil industry. Teesside and the broader NE Region is benefiting from the support offered by the Northeast Biofuels consortium.
- specific constraints in the Humber Region are electricity availability / upgrades to substations etc,
  transport including;
    - southern road access for wheat transport
    - road junction upgrades in the Region
    - ecologically sensitive areas in the Humber estuary
    - flood risk.

Transport

Initial indications are that transport infrastructure is not likely to significantly impede the development of biofuels plants, particularly for biofuel plants located close to the port

Yorkshire and Humber's *Freight and Logistics Intelligence for the Regional Transport Strategy* (YHA, 2005) identified road constraints in the Region, as well as specific constraints to port operations as the last link road and rail access to the ports were deemed to be poor. Most of these are now being addressed, but until these issues are resolved road capacity to the South of the Humber remains low and this is affecting current planning applications.

Heat and Electricity

Further away from the ports area, NE Lincolnshire Council has suggested that electricity supply may be an issue; new plants may need extra grid capacity or substations. Alternatively, some of the heat and power demands could be met by biofuel plants themselves, using the biomass generated to produce process heat. If approved the Helius plant could supply electricity to the proposed adjacent Abengoa bioethanol plant.

Economics of biofuels production

The price of feedstocks increases with increasing demand, thereby increasing the cost of biofuels production. However there is also a positive effect, being increased income for feedstock producers. This will have a positive influence on the security of UK wheat prices and growers' incomes for years to come. Keith Davies, the Managing Director of Glencore Grain UK stated "For the first time the value of wheat is going to be linked to the value of oil, and long term there's only one way the cost of energy is likely to continue to go" [30].

The prices of wheat and oilseed rape being grown for food are not necessarily higher than for biofuels, depending on the contract. The proposed bioethanol plants are all trying to secure wheat and offering contracts to farmers; in January 2007 Centaur Grain/Bioethanol Ltd were offering farmers an extra £3/t above the base price as well as a bioethanol premium (extra £4.50/t if the bioethanol sales targets were exceeded by 10%). It is likely that wheat and oil seed rape will be imported if the cost is lower than home produced feedstocks.

Biofuels compete with mineral fuels. The price of mineral fuels, i.e. crude oil, has recently been relatively low which makes biofuels comparatively less attractive.

Security of Government Support

The level of duty incentive for biofuels at 20 pence per litre is guaranteed until 2010-2011, but is expected to reduce in the longer term as the RTFO buy out price increases. This will impact on small producers who do not wish to register for the RTFO. Industry representatives are lobbying for a doubling of the 15p-a-litre duty on oil company sales under the Renewable Fuels Transport Obligation (RFTO). The representatives will argue that it will be cheaper for oil companies to pay the duty once it comes into force next April compared to buying biofuels and the duty should be increased to 30p. The level of buy out in the RTFO is expected to increase over time, and the RTFO is expected to be a long term mechanism The level of the obligation is also expected to rise to at least 10% once existing difficulties with vehicle warranties are resolved. Carbon accounting and sustainability requirements are expected to become more stringent after 2010. One possibility is that there will be a higher level of support for biofuels that can demonstrate a higher level of GHG savings. This should make the economics of second generation biofuels more attractive.

Planning
The South Humber Bank area has been earmarked for industrial development. However, it is also an internationally important wildlife area and habitats for wildlife and wetlands in the Region must be protected in the course of these developments, particularly where flood defences and drainage are part of the development plans.

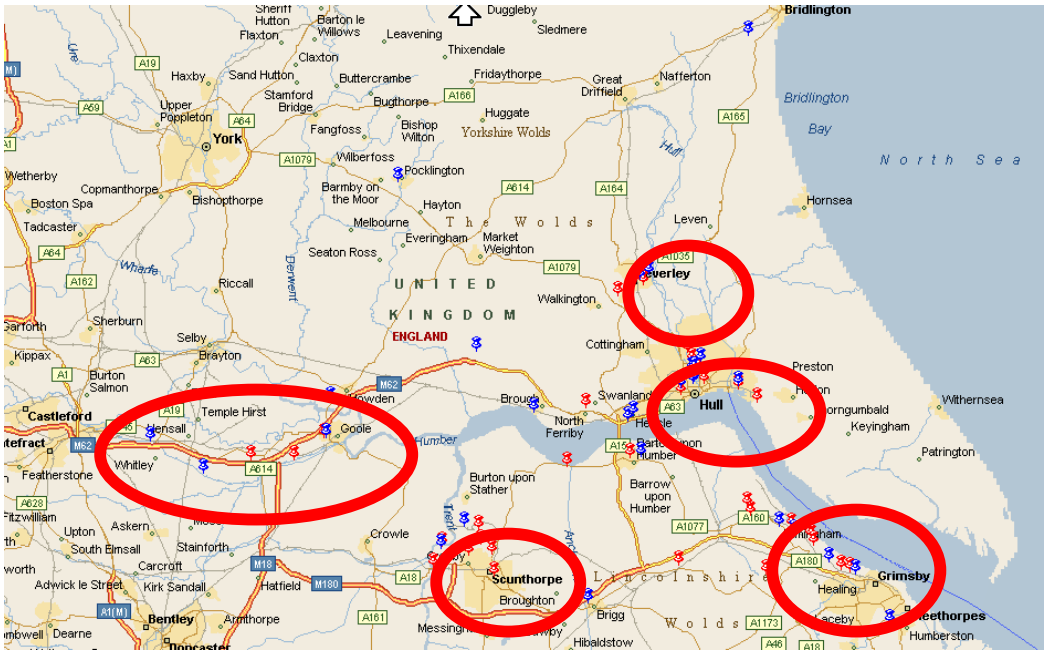
We recommend that a strategic way forward should be developed collaboratively between all interested parties to take account of both environmental and economic considerations. We believe this will facilitate appropriate development in the area.

Summary
There are good opportunities for up to two each of large-scale biodiesel and bioethanol plants in the Humber area. There are no 'show stoppers' to these developments. The main constraints on additional developments are the local feedstock availability and planning issues on the South Humber Bank.

4.3 Opportunities for the chemicals industry

There are more than 500 chemical enterprises in the Region. The Humber Region Chemical Industry Cluster Mapping Study (2006) identified the main chemicals plants in the Region, which are located in five main areas as shown in Figure 6. The most common chemicals plants are those that manufacture organic base chemicals (11 sites) and paint, varnish and coatings (10 sites), while the largest site manufactures iron and steel.

Figure 6: Chemical clusters in the Yorkshire and Humber area.



There are both immediate and longer-term opportunities for the chemicals industry from biofuels production in the area.

Immediate Opportunities

- To sell surplus heat and electricity to the biofuels plants.
- To obtain by-products from the biofuels production process either for use as renewable fuels or for feedstocks for bio-based chemical products

Solvay will build a new epichlorohydrin plant on its industrial site of Tavaux, France, implementing a novel process with greatly enhanced environmental performance. The process, called Epicerol™, was successfully developed by Solvay's R&D and is based on the transformation of glycerine, a by-product of the biodiesel industry. The new plant, which is scheduled to be operational by the first half of 2007, will be fed with glycerine derived from rapeseed oil and fits perfectly with the development of the Biodiesel industry actively supported by the French government. The development of the glycerine-based process for the production of epichlorohydrin is covered by eleven patent applications issued by Solvay.
The steadily increasing demand for epichlorohydrin – whose main applications include the production of epoxy resins, paper reinforcement and water purification – is expected to exceed the existing global production capacity by 2010. Solvay has secured a long-term contract for the supply of glycerine with French company Diester Industrie, capitalizing on the fast growth of the biofuels industry and the large quantities of glycerine available at an appropriate price. The new plant will have an initial production capacity of 10 kilotons per annum and could be quickly duplicated to respond to the rapid market growth.
In the Epicerol™ process, glycerine – a renewable material – is substituted for propylene, a hydrocarbon. Other environmental benefits include reduction of chlorinated by-products and sharp reduction of water consumption.

These opportunities are linked to the development of the Biorefinery concept. The co-location of the existing chemical plant and the first generation biofuels plants gives rise to opportunities to make best use of the by-products from all operations, working towards a type 2 biorefinery.

Humber Chemical Focus are already working along these lines in the Yorkshire and Humber Region, and have been raising awareness of opportunities for the chemical industry amongst their members. They are now working with Yorkshire Chemical Focus to set up a biofuels network, which is intended to encompass all members of the existing supply chain. We believe this is a useful initiative that should be encouraged and supported. A similar model has been successful in Teeside.

Northeast Biofuels' support for the biofuels industry in the North East Region / Teesside

NorthEast Biofuels (NEB) is a group of private and public sector organisations committed to the development of a sustainable transport biofuels business in the North East of England.

NEB's aims are to:
facilitate the development of liquid biofuel supply chains in the Region;
influence local, regional and national Government policy on biofuels;
promote community awareness of the benefits of the biofuel industry;
identify new business and research opportunities;
support active companies in this emerging sector.

The group constitutes a 'vertical cluster' covering the entire supply chain. Members include:
farming businesses, including Farmway, GrainCo, Agrovista, Monsanto and Terra;
biofuel producers and distributors in the Region: Biofuels Corporation, D1 Oils and Petroplus;
engineering, utilities, bulk storage and logistics: K Home International, SembCorp, Simon Storage and Vopak;
the public sector:One NorthEast, and various independent bodies, such as Renew Tees Valley, North East Process Industries Cluster (NEPIC) and North East Community Forests.

NEB is supported by member organisations in cash and in kind and with matched funding from One NorthEast.

NEB has recently facilitated the development of a proposed OSR crushing plant in the Region. NEB identified a gap in the supply chain, with only three OSR crushing plants in the UK, all outside the NE Region. Following two years of feasibility studies initiated by NEB, Tees Valley Biofuels Ltd was formed in 2005 with seed funding mainly from the NEB group. Its proposed crushing plant at Teesside has planning permission and would start production in late 2008, processing 500,000 t/a of oilseeds mainly from OSR grown in the NE Region.

NEB is also providing support for the biofuels industry in the Region through:
ONE Green Route - establishing a regional network of independent fuel stations supplying BioPlus biodiesel
Conferences - attracting a major European conference, the Fifth Motor Biofuel Conference, to the Region
Oilseed development - conducting oilseed rape crop trials to establish best practice, and supporting the development of new varieties
By-product opportunities - identifying novel income stream potential from rape meal and glycerine.
Small scale producers - providing advice to farmers and entrepreneurs on producing and marketing biodiesel and other vegetable oil-based fuels.

Longer-term opportunities

- To produce bio-methanol for biodiesel production
- To become involved in second generation biofuels developments, and development of biorefineries where there are both multiple feedstocks and a wider range of bio-based products.

UK Research into the production of added value chemicals from biomass is currently being undertaken in the Green Chemistry Centre of Excellence at the University of York, Institute of Grassland and Environmental Research (IGER) and the Satake Centre for Grain Process Engineering at Manchester Metropolitan University. No large industrial/commercial-scale work has been identified in the UK. Opportunities for renewable materials as commodity chemicals have been studied by several bodies. The most comprehensive reports on the subject are the U.S. Department of Energy (DOE) report, 'Value added chemicals from biomass' [10] and the UK Business Resource Efficiency and Waste Programme (BREW) report, 'The biotechnological production of bulk chemicals from renewable resources' [11]. The DOE report looked at over 300 potential building-block chemicals and classified them according to screening criteria i.e., processing costs, estimated selling price, technical complexity of the process and market potential. The authors listed fifteen "top value-added chemicals". A detailed review was then carried out on the potential uses and market size for each chemical and the technology barriers preventing uptake. The BREW report itself takes a wider view, looking at energy savings, reduction in greenhouse gas emissions, and requirements for market penetration of renewable feedstocks with likely timeframes for product breakouts. As the criteria for chemical selection was different in each report (BREW focuses on bulk chemicals whereas the DOE report looks at "value-added" chemicals) the two studies identify different chemicals as potential renewable feedstocks.

However, there are considerable overlaps between the two reports, with seven of the DOE's top value-added chemicals appearing on the BREW list. A summary is shown in table 14 below.

Table 14 Potential chemical co-products from biorefineries

"Top value added chemicals from Biomass" DOE Report		Bulk Chemicals selected in the BREW Project
C2		ethanol, acetic acid
C3	glycerol, 3-hydroxypropionic acid	lactic Acid, glycerol, 3-hydroxypropionic acid, 1,3-propanediol, acrylic acid
C4	succinic acid, fumaric acid, malic acid, aspartic acid, 3-hydroxybutyrolactone	succinic acid, fumaric acid, aspartic acid, 1-butanol, 1,4-butanediol
C5	glutamic acid, itaconic acid, levulinic acid, xylitol, xylonic acid	xylose, arabinose, xylitol, arabinitol, levulinic acid, furfural
C6	2,5 furan dicarboxylic acid, glucaric acid, sorbitol	sucrose, glucose, sorbitol, 5-hydroxymethylfurfural, adipic acid

Summary
There are both immediate and longer-term opportunities for the chemical industry in the Region from biofuels developments. In the short term there is the opportunity to produce value added products from biofuels by-products. In the longer term there is the opportunity to become involved in production of a wider range of bio-based products, which may include second generation biofuels.

4.4 Development of Second Generation Biofuels

There have been several enquiries from companies interested in setting up second generation plants in the Region. The Abengoa planning proposal leaves half of the site available for further development, which may not use grain as a feedstock and could be second generation. Attractions of the area for second generation plant are similar to those for first generation plant. In particular, the economics of second generation means that large scale plant will be required, which in turn will require a high volume of feedstock; a substantial proportion of this will need to be imported as explained in the feedstock section. The port location is therefore an advantage for these technologies.

The Region also has the advantage that fuel supply chains for lignocellulosic crops are currently being developed for heat and electricity generation applications. There may ultimately be competition for resources between these industries, but the diversity of markets will be advantages to the rural community, and there is the opportunity to develop synergies such that value added products are extracted from the biomass and the residue is still available as a fuel.

Companies who are also looking to develop second generation biofuels plants give the opportunity for further future inward investment in the area. They also offer longer-term presence of a biofuels industry in the area.

Currently, however, the UK is behind in development of second generation technologies. The current situation is that pilot and first commercial plant are being developed in the USA, Germany and France, where there has been a track record of R&D in these technologies. If this course continues, in time second generation production plant may be built in the Region, but the benefits of R&D and building of skills will not come to the area.

The U.S. Department of Energy (DOE) has awarded Abengoa Bioenergy a financial assistance grant up to $76 million to design, construct, and operate a first of a kind commercial facility to produce ethanol from lignocellulosic biomass. Abengoa Bioenergy, a global producer and technology company, is one of the largest producers of ethanol in the world, with production facilities in the United States and Europe. The award is part of the DOE program to promote the demonstration and commercial deployment of lignocellulosic conversion technology for ethanol production

When completed, the facility will produce 15 Mgal from lignocellulosic biomass and 85 Mgal from starch. The energy for the process will be obtained via biomass gasification, improving the life cycle of the ethanol produced. This plant will place Abengoa Bioenergy in a unique position to advance the commercial deployment of its enzymatic and thermochemical conversion technology for fuels and energy production. Abengoa Bioenergy plans to build a hybrid plant capable of processing biomass and starch that will lower the investment risk and accelerate the commercial deployment of the enzymatic hydrolysis technology. The hybrid plant is scheduled to operate towards the end of 2010 with a total estimated cost of more than 300 million dollars.

There is an opportunity to pro-actively build a case for the siting of a UK R&D effort and pilot scheme for second generation biofuels in the Region. The feasibility of such a project is currently under investigation by NNFCC, who will shortly be publishing major studies concerning the development of BTL and biorefineries in the UK. If this opportunity is not taken, second generation biofuels plant may still come to the Region for the same reasons that attracted first generation plant, but the skills building opportunity will be lost.

4.5 Research and development opportunities

Yorkshire and the Humber has the largest concentration of universities in the UK with the Universities of Leeds, Bradford, Sheffield, Hull, York. Central Science Labs and the National Non-Food Crop Centre are also located in the area.

The Region already has substantial expertise in the bioenergy area. Central Science Labs are involved in projects on the valorisation of rape meal for the DTI. National Non-Food Crop Centre assists in administration of a Defra R&D Programme: Non-Food uses of crops - supply chain assessment and development. Biofuels and biorefineries are priority areas within this programme. The Centre for Novel Agricultural Products and the Green Chemistry are located at York. Leeds and Sheffield Universities are members of the EPSRC SUPERGEN consortium and Sheffield Hallam have been involved in estimation of GHG emissions from biofuels.

Yorkshire Forward's Biofuels Programme recognises the advantages to the Region of a strong and relevant research community with world recognised expertise. It believes the area of the use of sustainable resources will attract research investment and underpin the Region's ability to retain quality jobs and new graduates. They are currently working on a proposed plan for academic/business collaboration which includes:

- Review of expertise and capability; technologies, people, facilities, collaborations in existence
- Identification of what is special (international recognition) in this Region
- Investigation of collaboration mechanisms and funding models
- Stimulation of our world class academics and key businesses to develop second and third generation technologies for further economic growth of the Region.

This work should provide material to build a strong case for R&D on biofuels to be located in Yorkshire and the Humber.

Specific funding opportunities at the moment are

BBSRC: Capacity Building in Bioenergy research
Expressions of interest have been requested by 31 May 07 to establish the following activities intended to develop UK research capacity and promote high quality end-user relevant research in the area of bioenergy: flagship multidisciplinary centre for bioenergy research, programme grants with industrial collaboration and Research Networks. The emphasis will be on high quality fundamental biological research aimed at bioenergy development.

DTI: Emerging Energy Technologies Programme
Biorefineries are currently a priority area.

SUPERGEN Bioenergy
The next phase has been approved, and includes development of the biorefinery concept. Leeds and Sheffield Universities are already members of the consortium

Two other grants available for R&D in the Region are:

SME Grant for Research and Development
The DTI's Grant for Research and Development helps businesses carry out research and development work that will lead to technologically innovative products or processes. It is aimed at individuals planning to start up businesses in England and at businesses with fewer than 250 employees already operating in England. There are currently examples of SMEs working in the innovative areas of the development of micro-organisms to improve the fermentation economics of biofuels.

Industrial Research and Development Award for Large Companies
The Yorkshire Forward Industrial Research and Development Award for Large Companies is a new award scheme approved by the European Union that will lead to £18.5 million being invested directly into research and development projects. The award will run until 31 March 2008. An application could be made for a biofuels project.

None of these schemes will provide the level of funding required to set up a second generation biofuels plant. The best approach to involvement in such a project is closer involvement with ongoing EU R&D effort and lobbying Government on the strategic importance of such a project.

Research Institutes in the Region are already engaged in the major UK bioenergy research programmes. Although to date these programmes have concentrated on bioenergy for electricity and heat production there is now increasing emphasis on biofuels. There are niche opportunities for modest research projects. There is also a call from BBSRC for EOI in setting up a major centre for bioscience research relating to bioenergy.

Yorkshire and the Humber would be a good location for development of second generation biofuels in the UK. However, the UK is currently behind in second generation biofuels R&D and there are not currently funds available in the UK for major advances in second generation biofuels technologies or building of a pilot plant. The best opportunity for involvement in such projects is currently through closer interaction with EU projects.

5 Conclusions

Biofuels can contribute to the following policy objectives in the Yorkshire and Humber Region

- Climate change mitigation.
- Inward investment and job creation.
- Skills development.
- Rural development.

Yorkshire and the Humber has a number of attributes that make it attractive to potential biofuels developers and for biorefineries

- Local feedstock supplies- grain and OSR, also experience of perennial energy crops.
- Humber ports- experience of handling biomass, grain, oils- capacity to expand biofuels imports.
- Land available around the ports at reasonable cost, with transport connections.
- Two local oil refineries- already interested in purchasing biofuels and taking output from operating plant.
- Local chemical industry interested in opportunities from biofuels.
- Skilled workforce available in area.

There is already biodiesel production in the Region at all scales

At the large scale the Greenergy plant at Immingham docks has a capacity of 100,000tpa, and uses UK grown and imported vegetable oils as feedstock. At the medium scale the RIX Biodiesel plant in Hull has a capacity of 50,000tpa and uses Recovered Vegetable Oil (RVO) as a feedstock. At the small scale the Region has a number of schemes producing 10-1000tpa Biodiesel from RVO.

Another large scale Biodiesel plant and more small scale Biodiesel plants would be feasible for the Region

Two large scale bioethanol plant could be developed in the South Humber area using readily available local feedstocks

There is no current bioethanol production in the Region. Five large scale plant are currently proposed, all in the South Humber bank area. All these plant intend to use locally produced wheat but also intend to import a substantial proportion of their wheat feedstock. Our analysis suggests that the port location is the best location for these plant, and that two plant could be supported using 50% wheat feedstock readily available from the local area. Further plants would be possible, but would rely more heavily on imported feedstocks.

The Humber area would be a good location for development of a second generation biofuels plant

Second generation plant will require the same infrastructure and markets as first generation plant, and so will be attracted to the area. In addition second generation technology has more synergies with the chemical industry, and in particular companies developing other bio-based products. Second generation plant will also require large quantities of wood, perennial energy crops and crop residues as feedstocks. A supply chain for these is already developing in the area at the large scale due to the use biomass for co-firing.

Possible constraints on additional bioenergy production might be

- Amount of land available for crop production - careful to develop energy crops for both biofuels and electricity and heat production.
- The need to consider biodiversity and landscape issues both in feedstock production and in project development around the Humber Estuary.
- Road transport in the rural areas of the Region.
- Regional funding available to support biofuels projects.

Threats to development of the bioenergy industry are thought to be

- Sustainability of biofuels production - first generation biofuels may be less attractive if imports of palm and soya oils are constrained.
- Second generation technologies continue to be developed in USA/other EU countries and not attracted to Humber Region.
- Cheaper imports mean local suppliers do not gain benefits.

- UK Competitors offer better location packages and projects are not attracted to the Humber area.
- Planning approval is slow/onerous so projects are lost.

There are benefits for a number of related industries in the area if biofuels are developed

- Farmers and the rural community. Increased demand for wheat and oil seed crops, leading to better prices and secure long term market. Another market for perennial energy crops developing as second generation biofuels come on line.
- Oil companies can obtain the biofuels they require to meet RTFO from local source.
- Chemical companies have immediate opportunity to process biofuels by-products into value added chemicals. In the longer term chemical companies can take a pro-active role in biorefineries to produce a wider range of bio-based products.
- Added trade at Humber ports leading to opportunities to further develop the facilities and strategic importance of the ports.

Other benefits to the Region are

- Opportunity to attract more R&D on biofuels to the Region, and to establish a centre of excellence. This could be based on existing expertise in the Region.
- Inward investment from establishment of up to four large scale plant and associated services.

Specific actions that could be taken to develop biofuels in the area

- Increase RVO collection and utilisation at the local level, especially around large centres of population. Identification of total resource and further processors could be undertaken most effectively by NISP, who are already active in this area.
- Encourage use of biofuels in local Government transport fleets. This could be by an information campaign to ensure that Local Authorities have up to date and reliable information on the costs, availability, suitability and environmental benefits of biofuels.
- Encourage all farmers growing crops for biofuels to enter Environmental Stewardship schemes and to follow Best Practice Guidelines for production of energy crops.
- Support supply chains to supply local wheat and OSR to energy projects.
- Continue to develop supply chains for perennial energy crops for supply to both power plant and second generation biofuels plant/ biorefineries. Develop strategies for biomass and biofuels together to ensure adequate resources are available for both and that potential synergies are exploited. In particular encourage the transformation from fragmented biomass suppliers to a large scale consolidated and reliable supply chain for biomass.
- Foster a partnership approach to agree a strategic way forward to develop the South Humber Bank to take into account both environmental and economic objectives, in line with the RSS. This could be taken forward by the Yorkshire Forward-led group currently working on Sustainable Fuels and Feedstocks Development in Yorkshire and Humberside.
- Establish up to 2 each large scale bioethanol and biodiesel plant around the Humber estuary. Enhance economic viability of these plant by best use of by-products for both heat and power generation and for extraction of value added products.
- Engage the chemical industry in the immediate opportunity of utilising by-products from 1st generation biofuels processes e.g. converting glycerol into higher value products. Encourage Humber Chemical Focus and Yorkshire Chemical Focus to continue work in this area and to continue raising awareness of other opportunities for the chemicals industry.
- Take forward the biorefinery concept. Extend current biofuels interest group to include oil, chemical, power generation industry and research institutes in the area, to discuss best use and development opportunities for all possible products from bioenergy plant.
- Attract R&D activities in biofuels to the YH area. Universities and Institutes in the Region are already active in the bioenergy field. Apply to DTI ETI and BBSRC and EU for involvement and funding for second generation biofuels projects, with a view to establishing a centre of excellence in the area.
- Act to encourage siting of pilot plant for second generation biofuels in the YH Region.

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7 Glossary of acronyms and terms

AD	Anaerobic digestion. Microbial decomposition of organic material. Produces a methane rich biogas which can be upgraded to produce transport quality gas.
ARA	Amsterdam-Rotterdam-Antwerp
Biofuel	A liquid or gas transportation fuel derived from biomass
Biodiesel	Biodiesel is produced from oils or fats using trans-esterification and is a liquid similar in composition to mineral diesel. Current diesel car warranties allow up to 5% inclusion of biodiesel in the diesel blend.
Bioethanol	Bioethanol is produced by fermentation of sugars derived from biomass feedstocks. It is an alcohol fuel which can be used in petrol engines. Current petrol car warranties allow up to 5% bioethanol blend in petrol.
Biogas	A methane rich gas produced from biological feedstocks from on purpose AD or from biological material in landfill sites.
Biomass	Biomass is material derived from recently living organisms. It includes plants, animals and their by-products.
Biorefinery	A concept of a processing plant where a range of biomass feedstocks are converted and extracted into a spectrum of valuable products.
BREW	Business Resource Efficiency and Waste Programme
BTL	Biomass-to-liquids. Denotes processes to convert biomass to synthetic liquid fuels, primarily diesel fuels
CAP	Common Agricultural policy.
DDGS	Dried distillers grains with solubles
DME	Di-Methyl –Ether is a colorless gaseous ether. It can be used as an alternative to liquified petroleum gas or liquified natural gas in suitably modified diesel or petrol engines. Bio- DME is produced from biomass.
CNG	Compressed natural gas.
ECA	Enhanced Capital Allowance
EET Programme	DTI Emerging Energy Technologies Programme.
ERA-NET	A network of government agencies responsible for co-ordinating and funding national research efforts.
IGER	Institute of Grassland and Environmental Research
FAME	Fatty Acid Methyl Ester. Scientific name for Biodiesel made from vegetable oil and methanol
Fermentation	The production of bio-alcohols from sugars using yeasts or microbes.
First Generation Biofuels	Biofuels produced using commercially available technology, and usually using sugar, starch or oil feedstocks.
FT	Fischer Tropsch. The process named after its inventors that converts syngas to hydrocarbon chains.
GHG	Green House Gases. Total GHG emissions are expressed in tCO_2eq. Carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4) emissions are taken into account. Their emissions are estimated and the CO_2eq calculated using the appropriate IPCC weighting factors of $1tCO_2eq/t$ for CO_2, $23tCO_2eq/t$ for methane and $296tCO_2eq/t$ for nitrous oxide.
HGCA	Home-Grown Cereals Authority
Hydrolysis	The breakdown of starch into sugar molecules by the action of water.
Landfill Gas	A methane rich biogas produced under anaerobic conditions from biological material in landfill sites.
Lignocellulosic biomass	The 'woody' part of biomass including wood, crop straws, grasses. It comprises cellulose and hemicellulose, which have the potential to release sugars for fermentation and lignin which is resistant to decomposition but can be burnt, gasified or pyrolysed.

Miscanthus	Miscanthus is a tall grass-like fibre crop indigenous to Africa and Asia. It is a perennial crop with a useful life of 15-20 years and a yield of 10-12odt/ha under UK conditions.
MSW	Municipal solid waste
NISP	National Industrial Symbiosis Programme
NNFCC	National Non Food Crops Centre
Odtpa	Oven dry tonnes per annum.
OSR	Oil seed rape. A crop grown in Europe which produces rapeseed oil which can be used to produce Biodiesel.
RDP	Rural Development Programme
REIS	Regional Energy Infrastructure Strategy
RES	Regional Economic Strategy
RHS	Regional Housing Strategy
RME	Rapeseed Methyl Ester. Biodiesel derived from rapeseed oil
RSPO	Roundtable on sustainable palm oil
RTFO	Renewable Transport Fuel Obligation. The RTFO will place a legal requirement on transport fuel suppliers to ensure that a specified percentage of their overall fuel sales is from a renewable source.
RTS	Regional Transport Strategy
RVO	Recovered vegetable oil. Used vegetable oil which can be processed into Biodiesel.
RWS	Regional Waste Strategy
SFI	Selective Finance for Investment
Second generation biofuels	Biofuels produced using processes that have significant advantages over first generation processes in terms of some or all of products performance, economic or environmental performance. Usually utilise lignocellulosic biomass feedstocks. These processes are not yet commercially proven.
SPA	Special Protection Area
SRC	Short rotation coppice. A perennial energy crop, usually of willow or poplar, which are well suited to UK conditions. Has a useful life of about 20 years, and is normally harvested on a 3 year rotation. UK yields are typically 8odt/ha/y.
Syngas	A mixture of CO and hydrogen produced by gasification or steam reforming of various feedstocks and used for the manufacture of synthetic fuels and hydrogen
Trans-esterification	A mature technology for converting oils and fats into a diesel substitute. Oils are mixed with sodium hydroxide and methanol and the chemical reaction produces biodiesel and glycerol.
Tpa	Tonnes per annum
YPO	Yorkshire Purchasing Organisation

Appendices

Appendix 1: References

Appendix 1

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