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Biofuels: sorting the wheat from the chaff

Sam Cockerill on telling the good from the bad and the downright ugly

THERE has been much public debate about biofuels policy initiatives this year, leading to a recognition that not all biofuels are equal when it comes to carbon emissions, environmental sustainability and impact on global food supply. There is an emerging consensus, endorsed by the recent *Gallagher review*, that there should be a robust differentiation between 'good' and 'bad' biofuels. Good biofuels must meet four criteria:

- significant contribution to greenhouse gas reduction;
- neutral or positive impact on food supply;
- neutral or positive impact on major carbon stocks and sinks (such as rainforest or 'Cerrado' grassland); and
- value for money, offering significant greenhouse gas (GHG) savings per unit cost.

Only a few facilities tick all the boxes; the 'EU animal feed wheat refinery' concept adopted by Ensus is one of them.

greenhouse gas reduction

Using standard methodology defined in the UK's Road Transport Fuels Obligation (RTFO) legislation, bioethanol from the Ensus plant will initially generate around 70% GHG savings compared to mineral fuels. Many emissions studies of maize and feed wheat bioethanol indicate lower GHG savings due to the high energy inputs required in the process – first to cook the grains, then to dry the protein concentrate co-product. However, the Ensus plant will draw low carbon electricity and process heat from a gas turbine combined heat and power (CHP) unit on site. In addition, the plant uses heat that is recovered from the final drying step to heat the mash at the start of the process, significantly reducing the overall heat requirement. In future, Ensus aims to deliver additional GHG savings by a combination of product specification (selling un-dried feed where possible), process improvements (driving down the overall process energy requirements), and supply chain activities (helping growers to improve GHG emissions from agriculture).

food supply

Protein is in short supply worldwide, and especially so in Europe which produces less than 30% of the protein concentrates (protein-rich materials for animal feed) it needs. The EU is consequently the world's largest importer of protein concentrates and each year imports around 44m t to support the EU's meat, dairy and egg production. Soy meal, mainly from South America, is the mainstay of this global trade, and represents three quarters of EU protein concentrate imports.

Although Europe could grow more cereal crops such as animal feed wheat on its existing arable land, the protein level of feed wheat grown in Europe is typically just 10%, far below the 30–40% that would be needed to substitute for soy meal in the compound animal feed industry. It is possible and economic to refine EU-grown feed wheat to concentrate this plant protein up to the required levels, by converting excess starch to ethanol. In doing so, it allows the EU to use its surplus agricultural capacity to reduce dependence on imported protein, while producing ethanol biofuels at the same time.

land use change

When forest or grassland is cleared for agriculture, organic matter in the plants and soil is released as CO_2 'land use change' emissions. Academic papers by Searchinger and Fargione earlier this year highlighted the need to consider associated land use change emissions when evaluating the overall impact of biofuels, and for good reason: Land use change accounted for 18% of global man-made greenhouse gas emissions in 2000, more than the emissions from all forms of global transport combined. More startling is the fact that just three countries accounted for over 60% of these emissions: Brazil, Indonesia and Malaysia. These three countries are also the world's largest three exporters of biofuels or biofuel feedstocks.

However, the implied association between biofuels and land use change is misleading. Crops such as soy produce both soy meal for food and soy oil for fuel, and it is the demand for both food and fuel that has led to the rapid expansion of soy monoculture in South America, cutting into rainforests and other high carbon stock land to meet Europe's demand for protein and biodiesel feedstocks. Soy meal production for EU imports occupies around 19m hectares of land, and over 80% of this production is in South America.

Animal feed wheat refining in Europe is a far more effective use of land than soy production to help meet the world's rising food and fuel needs for two reasons. Firstly, feed wheat is a more efficient plant than soy. Per hectare, feed wheat produces almost as much protein as soy but converts twice the amount of incident sunlight to plant energy, storing much of the excess as starch, which can be readily converted to biofuel. Secondly, feed wheat is suited to temperate climates where there is a surplus of existing agricultural land, and so does not contribute to pressure on land use in the tropics where non-arable grassland and rainforest typically carries a much higher carbon stock.

By displacing demand for soy meal in Europe, animal feed wheat refining reduces the amount of land that is needed to produce soy in South America, and so reduces the associated carbon emissions from forest and grassland that would otherwise have been destroyed. For this reason, feed wheat bioethanol is one of the few biofuels for which these 'indirect' land use change effects are positive, contributing to additional GHG reduction

Ensus is building the UK's first animal feed wheat refinery on Teesside. The plant will soon be helping to reduce greenhouse gas emissions, improve food security in Europe and reduce European demand for soy imports that contribute to deforestation in South America. With total investment by Ensus and related parties of over £300m ($600m), this will be the largest production source of bioethanol and high protein animal feed in Europe when it comes on stream in 2009.

Ensus is a young company formed in 2006 by several ex-ICI managers. It has drawn on this rich process industry experience to conceive a plant design that is highly efficient, delivering industry-leading emissions savings – and operating economics – by focusing on energy recovery within the process, and integration with the Wilton industrial complex in which it is located.

The plant will use over 1m t/y of animal feed wheat, drawing on surpluses and spare agricultural capacity in the UK and Europe. Although feed wheat is the feedstock of choice, the refinery can also use other grains such as maize and barley, as well as sugar beet juice and molasses. In turn, the plant will produce four co-product streams:

- wheat protein concentrate for animal feed, displacing imported soy bean meal (primarily from Brazil);
- bioethanol for petrol substitution/addition;
- carbon dioxide, which is captured for use in the food, beverage, horticultural and industrial markets; and
- 25 MW of surplus electrical power for export as a consequence of the high level of energy integration.

Similar approaches are being adopted in France, Germany, Spain, Austria and the Netherlands. In future, as this European feed wheat refining industry goes along the learning curve and stimulates process technology development, there will be many opportunities to improve the carbon footprint and economics of the process further still.

per litre. Ensus biofuel GHG savings with respect to petrol are boosted to well over 100% when this is taken into account.

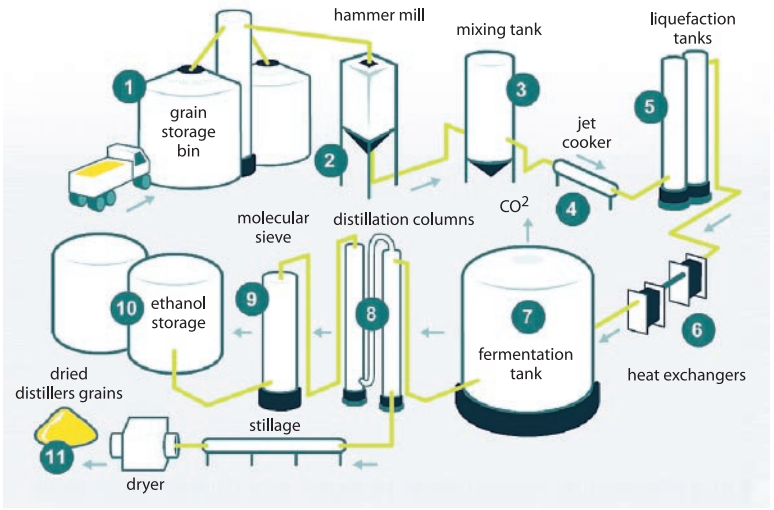
cost of CO_2 savings

As a result of land use change benefits, the effective GHG savings of animal feed wheat ethanol are higher than other biofuel options including Brazilian sugar cane ethanol. Feed wheat ethanol is also the lowest-cost biofuel in the EU, and although it remains more expensive than sugar cane ethanol, the higher GHG savings mean that feed wheat refining is the most cost effective biofuel route to cutting CO_2 emissions in the EU today. In fact, with oil above $100 per barrel, feed wheat ethanol can help cut CO_2 emissions less expensively than many power generation alternatives, including biomass energy crops.

This conclusion is in stark contrast to ostensibly 'green' initiatives to grow miscanthus and short rotation coppice willow (SRC) energy crops on prime agricultural land in the UK to enable us to co-fire coal power stations such as Drax with biomass. Whilst this offers undeniable GHG savings, it takes land away from crops such as wheat that produce both food and fuel and which, by displacing imported soy meal, offset an even larger quantity of GHG emissions by reducing global land use change.

Globally, as in Europe, decisions that direct the deployment of land and other finite resources today will determine our capacity to meet our food, fuel and environmental needs in future. There is a growing realisation that meeting just one of these needs is not enough – we must find new, integrated approaches that help us meet all of these needs together, and in the most efficient way possible.

Animal feed wheat refining in Europe is one such approach, and Ensus will play a leading role in the establishment, development and continuous improvement of this new industry. tce



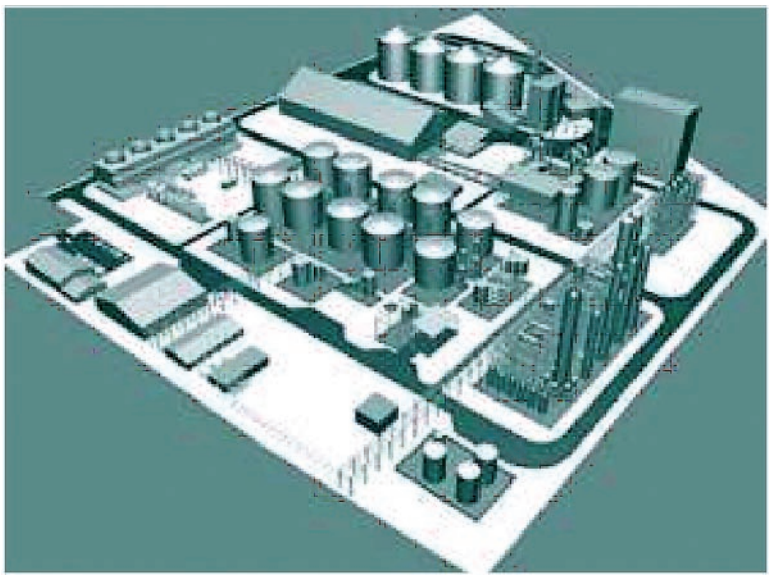


Figure 1a (top) and 1b: Ensus' animal feed wheat refinery concept

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further reading

1. Timothy Searchinger *et al*, "Use of US croplands for biofuels increases greenhouse gases through emissions from land use change", *Science Express*, 7 Feb 2008

2. Joseph Fargione *et al*, "Land clearing and biofuel carbon debt", *Science Express*, 7 Feb 2008