



Carbon benefits of Biofuels - A Greenergy perspective

There has been much discussion about the extent to which various biofuels provide genuine reductions in greenhouse gas emissions. This paper summarises Greenergy's views on this subject and is one of a series of Greenergy Perspectives on a variety of issues around biofuels.



Summary

Greenergy is a significant producer and supplier of petroleum and biofuels into the UK transport fuels market, supplying over 15% of the UK's overall petrol and diesel market and approximately one third of the biofuels market. Greenergy has extensive worldwide sourcing experience, with manufacturing operations in the UK and a blending facility in Rotterdam from which we supply customers across Europe.

In this Perspective, Greenergy reviews the range of carbon benefits from current biofuels production and looks at the reasons for the differences in the published figures.

Many biofuels have much lower carbon emissions than their fossil alternatives but the range of emissions savings varies widely and some biofuels have little carbon benefit. The science of determining the carbon benefits of biofuels is still developing and one of the reasons for the range quoted in different sections of the media is attributable to different ways of counting the carbon. When counting the carbon benefits of biofuels, emissions from changes in land use need to be considered. In some cases the emissions from land use changes such as peat burning or deforestation may outweigh the benefits of the carbon reduction from the use of the biofuel.

In general the carbon benefits of biofuels produced from efficient crop production in tropical countries with high yields and low fertiliser inputs are higher than those from crops produced in cooler regions with higher levels of inputs.

The carbon benefits of sustainably produced biofuels should be the basis on which government promotes their use. This kind of incentivisation will promote incremental improvements in existing biofuel production processes by rewarding those biofuels with higher carbon benefits over those with lower carbon benefits. This distinction needs to be based on sound science.

1 Overview of Carbon¹ Benefits from Biofuels

Perspective

Greenhouse Gas emissions associated with biofuel production vary considerably depending on the type of feedstock, the intensity of fertiliser use, the use of co-products (the parts of the plant not converted to biofuel), and the efficiency of the conversion process. While many biofuels have much lower emissions than their fossil alternatives, some biofuels have little carbon benefit.

Biofuels are made from plants that have taken up carbon from the atmosphere by the process of photosynthesis, when a biofuel is burned the carbon in the fuel returns to the atmosphere – completing a cycle. However, because some fossil fuels are used in the production of biofuels the process is not “carbon neutral”.

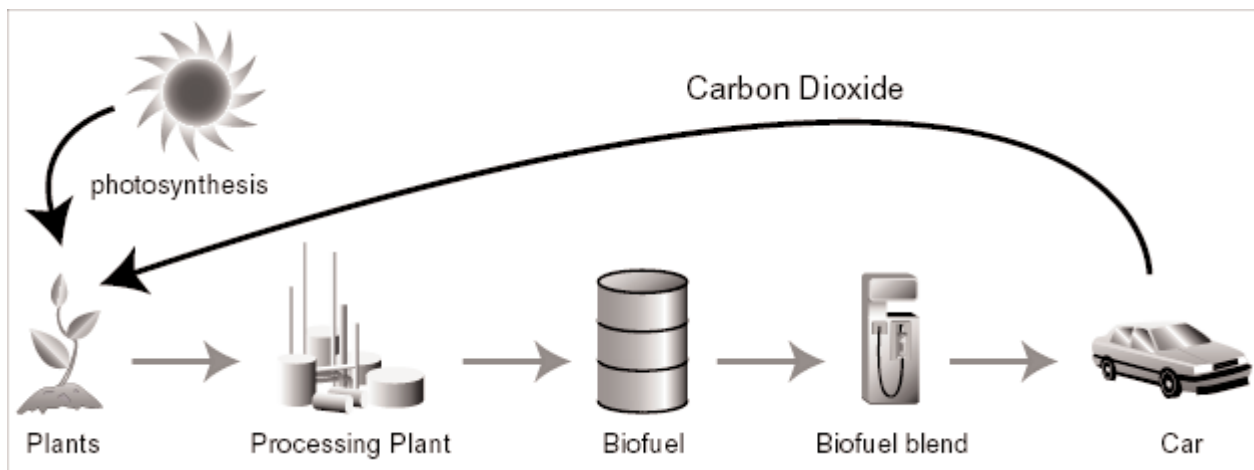


Figure 1. plant - fuel - car - atmosphere

The main sources of greenhouse gases from the production of biofuels are:

- Energy used in the manufacture of fertilisers for growing crops
- Nitrous oxide (a powerful GHG) released from soils in warm, wet conditions as a result of bacterial action on soil nitrogen
- Energy used in the processing of crops to biofuels

Minor sources of greenhouse gases from the production of biofuels are:

- Fuel used by farm equipment (tractors & harvesters)
- Fuel used to transport crops to processing facilities
- Fuel used to transport finished fuels

¹ In this perspective sheet we use the term “Carbon” to denote emissions of CO₂ and other greenhouse gases from human activities including methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride.



Figure 2. Greenhouse gas emissions from the production of bioethanol from wheat grown in Europe and are in **kgCO2e/tonne ethanol**. Derived from RTFO Default Values (2009)².

² RTFO Technical Guidance – Default Values and Fuel Chains. Version 2 March 2009
http://www.renewablefuelsagency.org/_db/_documents/Carbon_and_Sustainability_Guidance_Part_Two.pdf

2 The Range of Carbon Benefits from Biofuels

Perspective

In general, the carbon benefits of biofuels produced from crops with high yields and low fertiliser and other inputs in tropical countries are greater than those from crops produced in cooler regions with higher levels of inputs.

Typical Ranges of Lifecycle Greenhouse Gas Emissions per km for Conventional Fuels and Biofuels

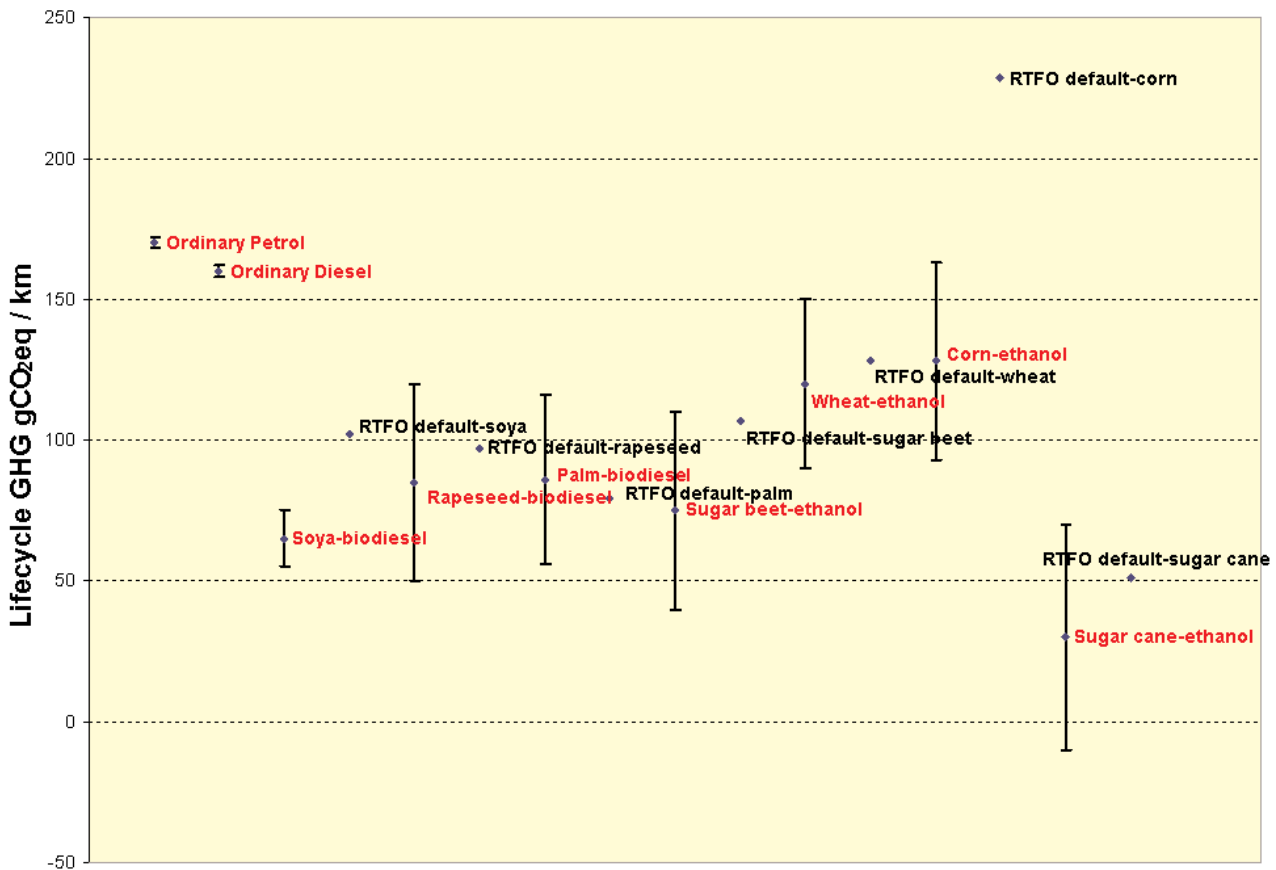


Figure 3. Reported ranges of lifecycle greenhouse gas emissions per km for conventional fuels and biofuels. Derived from Larson (2005)³ and RTFO Default Factors (2008)⁴.

³ Eric D. Larson. 2005. 'A Review of LCA Studies on Liquid Biofuel Systems for the Transport Sector. Energy for Sustainable Development.

⁴ For E4Tech: Ausilio Bauen, Philip Watson and Jo Howes, for Ecofys: Bart Dehue, Carlo Hamelinck, Richard Archer, Esther Garcia, Gemma Reece, Eric van den Heuvel. 2007. Carbon and Sustainability Reporting within the Renewable Transport Fuel Obligation: RTFO Default Values

Soya biodiesel:

The carbon benefits of biodiesel made from soya oil depend significantly on the amount of agricultural greenhouse gas emissions that are assigned to the soy meal which is the major product by mass and value.

Rapeseed biodiesel:

The carbon benefits of rapeseed biodiesel depend upon the amount of greenhouse gas emissions associated with rape meal, which is a significant co-product and also to the estimated emissions of Nitrous oxide (produced in warm wet soil conditions).

Palm biodiesel:

There is little published information on the lifecycle of biodiesel from palm. However the carbon benefits will depend to a large extent on how mill effluent is treated and whether palm husks and other biomass are used to power the processing plant.

Sugar Beet bioethanol:

The carbon benefits of ethanol from sugar beet depend to a large extent on the quantity of fertiliser applied and the efficiency of processing.

Bioethanol from Wheat and Corn:

The carbon benefits of bioethanol produced from wheat and corn depend to a large extent upon the fuel used for processing and the efficiency of processing plant. High processing GHG emissions in some plants in the US are the result of coal-fired processing plants.

Bioethanol from Sugarcane:

Bioethanol from sugarcane grown on extensive scale in Brazil has a high carbon benefit because of the high productivity of sugar cane in the tropics and the highly efficient plants using cane biomass to supply process energy. Some processing plants export electricity as well as biofuel.

RTFO default factors:

The Renewable Transport Fuel Obligation (RTFO) default factors were based on inputs from an expert group convened by the Low Carbon Vehicle Partnership (LowCVP, 2007) to provide “conservative”, rather than best estimates of carbon benefits of various biofuels. Use of conservative values throughout a lifecycle study will tend to underestimate the actual benefits of biofuels.

Data compiled from the UK's Renewable Transport Fuels Obligation⁵ (RTFO) expert group convened by the LowCVP show how ethanol produced from sugarcane in the tropics requires less fertiliser and less land per unit output than temperate corn or wheat.

Ethanol Production and Nitrogen Fertiliser Inputs for Different Ethanol Biofuel Crops and Countries

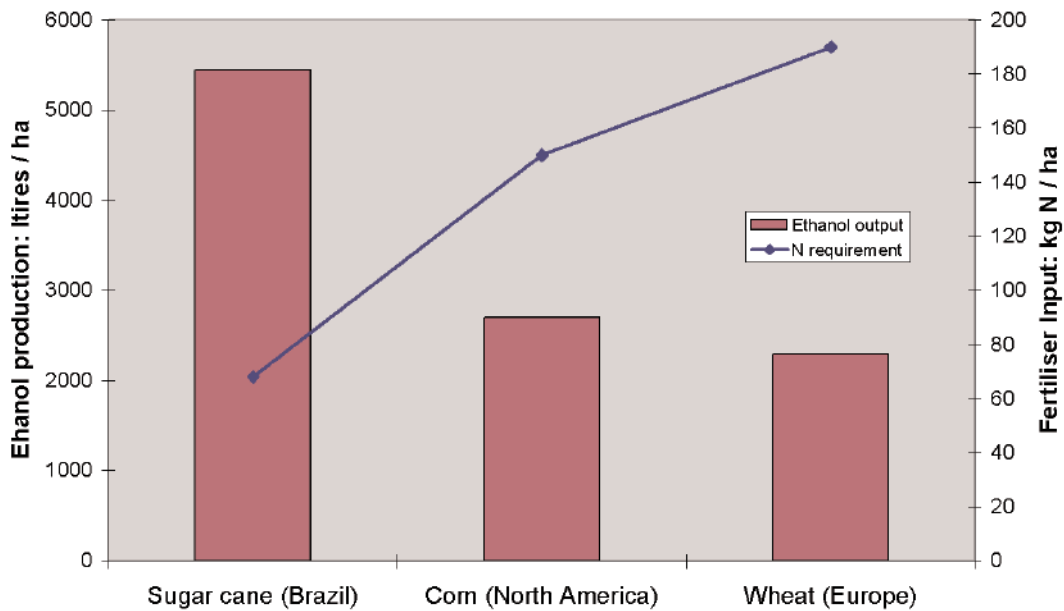


Figure 4. Ethanol production and nitrogen fertiliser inputs for different ethanol biofuel crops and countries. Taken from RTFO Default Factors (2008)⁶.

⁵ The Renewable Transport Fuel Obligation Expert Group is convened by the Low Carbon Vehicle Partnership (www.lowcvc.org)

⁶ For E4Tech: Ausilio Bauen, Philip Watson and Jo Howes, for Ecofys: Bart Dehue, Carlo Hamelinck, Richard Archer, Esther Garcia, Gemma Reece, Eric van den Heuvel. 2007. Carbon and Sustainability Reporting within the Renewable Transport Fuel Obligation: Second Draft Technical Guidance for Pilot Companies.

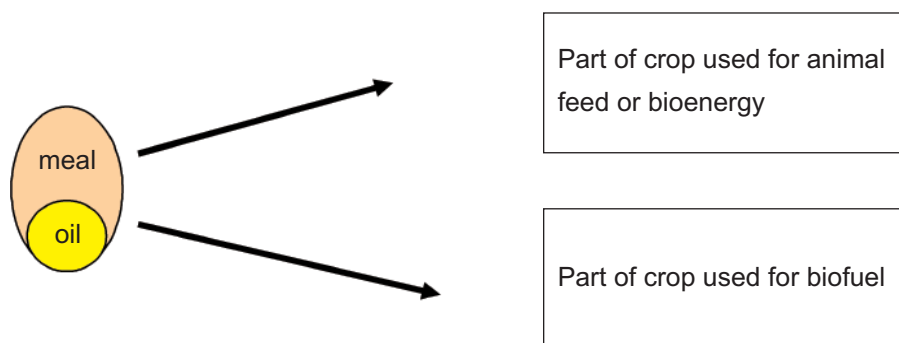
3 Standard Figures for the Carbon Benefit of Biofuels

Perspective

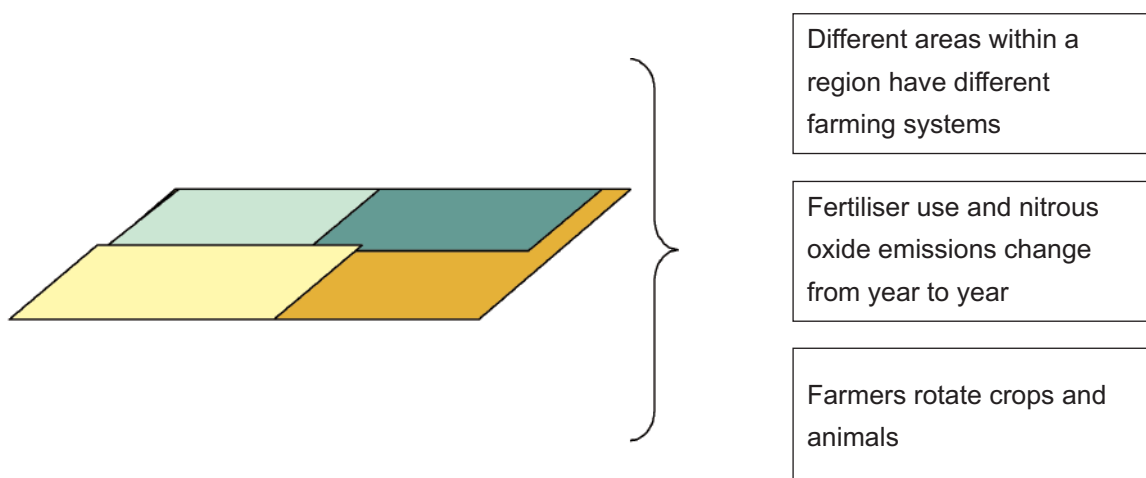
The science of determining the carbon benefits of biofuels is still developing. One reason for the range of benefits found in different sections of the media is that researchers have used different approaches to quantifying these effects.

Key issues to be resolved by scientists and policy makers include:

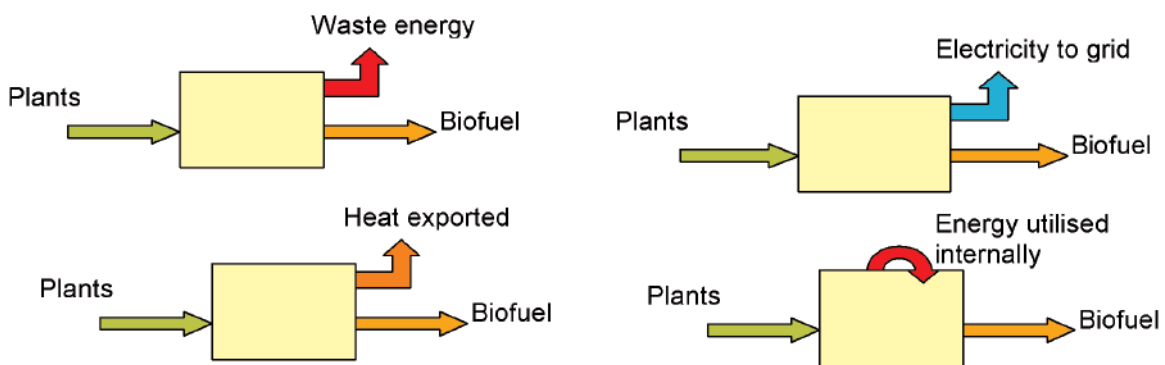
A) Allocation: How to divide environmental impact between co-products?



B) Changes in place and time of Crop Production: the numbers depend on scale and timeframe



C) Wide Variety of Feedstock Processing Plants: the technology of fuel processing plants is constantly changing. The diagrams below show the multiple ways in which co-products can be used for energy within processing plants. Each variant will have a different carbon benefit.



4 Changes in Land Use and the Carbon Benefit of Biofuels

Perspective

When counting carbon to determine the benefits of biofuels, emissions from changes in land use need to be included. If deforestation or peat burning occurs the carbon emissions are likely to outweigh any benefits from the use of the biofuel.



Figure 5. Illustration of deforestation in Amazonia.

The relative carbon losses and gains relating to land use change associated with deforestation can be calculated as follows:

- Deforestation of 1 hectare of tropical forest may cause emission of 900 tonnes CO₂ (IPCC, 1996)⁷
- Emission reduction per year of biofuel production from 1 hectare of palm oil = approx 6 tonnes CO₂ (ECCM calculation based on RTFO Default Factors (2008)⁸)
- Years of biofuel production to compensate for deforestation = $900/6 = 130$ years

Where lower biomass forests such as Miombo woodland in Africa or Cerrado in South America are cleared for agriculture or plantations there may be lower net carbon losses. However, wherever native ecosystems are changed to agricultural production there may be losses in biodiversity.

⁷ Intergovernmental Panel on Climate Change. 2001. Good Practice Guidance for Land Use, Land Use Change and Forestry. Cambridge University Press, Cambridge.

⁸ For E4Tech: Ausilio Bauen, Philip Watson and Jo Howes, for Ecofys: Bart Dehue, Carlo Hamelinck, Richard Archer, Esther Garcia, Gemma Reece, Eric van den Heuvel. 2007. Carbon and Sustainability Reporting within the Renewable Transport Fuel Obligation: Second Draft Technical Guidance for Pilot Companies.

5 Accounting for the indirect carbon effects of biofuels

Perspective

It is difficult to accurately measure the indirect carbon emissions of biofuels because there are too many variables created by the differences between biofuel crops. These differences include country of origin and production inputs such as the amount of fertiliser required which can create uncertainty in any statistical analysis.

There is a school of lifecycle assessment academics, led most famously by Searchinger, who advocate "system expansion" to try to take in all significant effects throughout the market, including indirect effects. This "indirect land use change" effect is contested within the lifecycle assessment scientific community and is not consistent with the methodology used in the Renewable Transport Fuel Obligation.

The approach advocated by Searchinger et al is to try to account for the market shifting effect that may occur as a result of increasing the total demand for a given type of crop. The indirect land use change effect is estimated using economic models that predict the effects of supply and demand changes on farm land use decisions.

The data to support quantitative analysis such as this are rudimentary and the methodologies for calculating such effects rely heavily on subjective assumptions about the behaviour of commodity markets as well as policy decisions and regulations concerning land use in the producing countries worldwide⁹.

The methodology used by the UK Government for its RTFO, on the other hand, looks at direct inputs to production, so each crop is responsible for its own emissions. Under this methodology the loss of carbon stocks from direct land use change (areas converted from a previous use or vegetation type to biofuel production) must be included in the carbon intensity of the fuel, but no indirect land use change is assumed.

⁹ Open letter to the Council, Parliament and Commission of the European Communities from the Embassies of Argentina, Brazil, Columbia, Republic of Indonesia, Republic of Malawi, Malaysia, Mozambique and Sierra Leone, 6 November 2008

6 Maximising the Carbon Benefits of Biofuels

Perspective

The carbon benefits of sustainably produced biofuels should be the basis on which government promotes their use. This kind of incentivisation will promote incremental improvements in existing biofuel production processes by rewarding those biofuels with higher carbon benefits over those with lower carbon benefits. This distinction needs to be based on sound science.

The following table shows how significant increases in carbon benefits can be obtained from existing biofuels through incremental improvements to production processes. The next generation of biofuel technologies will be encouraged by stable policies that reward lower carbon fuels.

Improvement	Lifecycle Carbon Intensity of fuel (kgCO ₂ /litre)	
	Before Improvement	After Improvement
<i>Biodiesel from OSR:</i> Increase of yield of Oilseed Rape from 3 t/ha to 4 t/ha without additional fertiliser	1.74	1.34 (- 23%)
<i>Bioethanol from Corn:</i> Use natural gas instead of coal for ethanol production process	2.29	1.52 (- 34%)
<i>Biodiesel from Palm:</i> Treat Palm Oil mill effluent to avoid methane emissions	1.42	0.98 (- 31%)

Source: ECCM calculations based on RTFO Default Factors (2008)¹⁰.

¹⁰ For E4Tech: Ausilio Bauen, Philip Watson and Jo Howes, for Ecofys: Bart Dehue, Carlo Hamelinck, Richard Archer, Esther Garcia, Gemma Reece, Eric van den Heuvel. 2007. Carbon and Sustainability Reporting within the Renewable Transport Fuel Obligation: Second Draft Technical Guidance for Pilot Companies.