Developing Carbon and Greenhouse Gas Assurance for Bioethanol Production in the UK

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Acknowledgements

With thanks to members of the Steering Committee: Friends of the Earth, The Worldwide Fund for Nature (WWF), English Nature, The Royal Society for the Protection of Birds (RSPB), National Farmers Union (NFU), The Home Grown Cereals Authority (HGCA), British Sugar plc, Green*ergy* International Ltd, Wessex Grain Ltd / Green Spirit Fuel Ltd, Bioethanol Ltd, Bronzeoak Ltd, Cmi plc and all participants who offered and comments on during the production of this report.

Executive Summary

This report sets out the findings of a study relating to the development of a Greenhouse Gas (GHG) assurance scheme for bioethanol, a renewable transport fuel with a substantial GHG saving potential. The study reviewed the current science of GHG life cycle analysis (LCA), as it applies to biofuels, and examined existing environmental assurance schemes for crops that may be used for biofuel production.

The main outputs of the study are:

1. A description of the main requirements for an environmental assurance scheme for biofuels that would enable the GHG benefits to be quantified.
2. A "Greenhouse Gas Calculator for Bioethanol" (and user guide) that illustrates how wheat production processes, bioethanol processing and transport options affect the full life cycle GHG intensity of bioethanol, compared to petrol.

Regulatory frameworks for assurance schemes were studied to determine how a scheme for bioethanol (and biofuels in general) could be developed. Whilst the focus of this project has been on bioethanol, the models underpinning the scheme design and calculation tools could be applied to biodiesel. It is envisaged that a full-scale trial of the scheme will take place in early 2006.

Concurrent with this study, the Government has been examining the feasibility of introducing a renewable transport fuels obligation (RTFO). One of the considerations within such a policy mechanism is the role of environmental and GHG assurance. At the time of writing, the role of assurance within the RTFO was regarded as an important component of its future development. However, during the first phase of implementation, it recommends carbon reporting, perhaps coupled to voluntary environmental and social assurance.

Initially, the scope of this assurance scheme concentrates on GHG certification, but with a very clear understanding that, as the assurance scheme develops, the incorporation of other sustainability measures would be addressed.

A feature of the scheme is that it will not be a single standard with a simple pass or fail, but a system which monitors and regularly audits performance on key criteria. This means that, at both the farm level and processing plant level, there would be regularly audited performance data collected which could be used to deliver continuous improvements. The GHG Calculator can be used to evaluate ways of improving GHG saving performance. This can have economic as well as an environmental benefits because it can be used to optimise farm inputs or factory configurations, which are the major factors contributing to GHG performance.

Main findings:

UK agriculture has the potential to produce 2-3 million tonnes of biofuel (bioethanol and biodiesel) without disruption of land use or existing habitats.

The most practical way to develop a GHG assurance scheme is to build upon and integrate with existing crop assurance schemes and established fuel industry systems.

GHG assurance can be based upon readily measured data, that can be verified and audited, with minor modifications to existing assurance schemes and systems. Much of the data required is already captured within these schemes and systems.

A biofuels assurance scheme should first establish procedures for GHG certification/declaration and then address issues of local environmental and social impacts.

Standardised approaches to the measurement of GHG impacts of biofuels are possible; indeed, the process of peer review showed that there is considerable support within the scientific life cycle assessment community, for the adoption of standardised methods, so long as these are transparently applied and supported with "best available evidence" as it becomes available.

The "Greenhouse Gas Calculator for Bioethanol" shows that there is a considerable range of GHG benefits from bioethanol from different sources. UK produced bioethanol will not necessarily be of lower carbon intensity[1] than imported bioethanol, since the GHG emissions associated with bulk sea transport are a relatively minor component of the GHG footprint.

The most effective ways of reducing the carbon intensity of bioethanol are as follows

- efficient use of fertilisers for feedstock production
- use of renewable/low carbon energy in feedstock processing (ideally use of co-products)
- use of co-products to generate heat or electricity that can be exported
- use of high efficiency processing technology (often associated with large scale plants)

The development of bioethanol certification sets the standard in the EU for a coherent and effective approach to GHG assurance and sustained GHG improvements, targeted at the agricultural and transport sectors.

[1] Carbon Intensity is the total amount of GHG produced per unit of fuel on a whole-of-life basis. This is normally expressed in kg CO_2e /tonne.

Abbreviations Used in Text

ACCS - Assured Combinable Crops
AFS - Assured Food Standard
BEST - Bioethanol for Sustainable Transport
CFC - Chlorofluorocarbon
CH_4 - methane
CHP - Combined Heat and Power
CO_2 - carbon dioxide
CSL - Central Science Laboratory
DDGS - Distillers Dried Grains and Solubles
ETBE - Ethyl Tertiary Butyl Ether
FFV - Flexi-fuel Vehicle
FSC - Forestry Stewardship Council
GHG - Greenhouse Gas
HGCA - Home Grown Cereals Authority
LCA - Life Cycle Analysis
LCVP - Low Carbon Vehicle Partnership
LPG - Liquified Petroleum Gas
N_2O - nitrous oxide
NFU - National Farmers Union
NGOs - Non-governmental Organisation
O_3 - ozone
RSPB - The Royal Society for the Protection of Birds
RTF - Renewable Transport Fuel
RTFO - Renewable Transport Fuel Obligation
UKAS - United Kingdom Accreditation Service
WWF - World Wildlife Fund for Nature

1 Background to the project

1.1 The Market Background

Climate change and concerns about energy security are driving the search for alternatives to petrol and diesel to power transport vehicles from resources that are more secure and significantly less polluting than traditional fossil fuels. This project was conceived to support the development of a UK based bioethanol industry, developed around conventional crops, particularly wheat, but including a variety of other co-products. Bioethanol, more conventionally known as ethyl alcohol and its derivative ethyl tertiary butyl ether (ETBE), is a practical replacement to gasoline in retail petrol formulations.

Currently bioethanol is the dominant global renewable transport fuel. This is due to a number of factors

- the dominance of gasoline as a road transport fuel
- the bioethanol programme in Brazil, which started over 30 years ago
- the increasing popularity of flexi-fuel cars in South America, the United States of America and latterly in Europe

Bioethanol offers Greenhouse Gas (GHG)[2] savings of up to 80% over conventional fossil fuels. The actual savings are highly dependent on the types of crops grown and the technology used to make bioethanol. Local air quality emissions are also lower, particularly when compared with diesel.

However, the key advantage of bioethanol is that it is a liquid fuel which can be distributed with minor modifications to the existing fuel supply infrastructure. It is biodegradable and easier to extinguish when burning than petrol or diesel. The global dominance and availability of bioethanol has interested the major car manufacturers, most of whom now offer options on their cars which can use high blends of bioethanol at up to 85% vol/vol. These cars are offered to consumers in a format called flexi-fuel vehicles. This means that the cars can run on the $85\%_{vol}$ bioethanol or up to $100\%_{vol}$ petrol when bioethanol is not available. Coupled with the low cost of this option, this flexi-fuel characteristic will enable the creation of market demand whilst a fuel supply infrastructure is being put in place. This avoids the classic dilemma of the “no market” therefore “no fuel” supply chain problem generally associated with bioenergy market creation.

[2] **GHGs** are gases in the earth’s atmosphere that absorb and re-emit infra-red radiation. These gases occur through both natural and human-influenced processes. The major GHG is water vapour. Other GHGs include carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), ozone (O_3) and CFCs.

We are aware that, at present, two major car manufacturers are considering launching flexi-fuel versions of their cars onto the UK car market. The additional price to consumers, of being offered a car of this configuration, has not been revealed but the cost to manufacturers is minimal.

1.2 The Argument For Certification of GHG Benefits of Fuel

Considerable interest in UK based ethanol production has already been stimulated by the Government's duty derogation on biofuels. However, recent academic work has conclusively demonstrated that the GHG savings, resulting from biofuel production, are highly sensitive to

- management practices throughout the production and supply pathway
- technology, again throughout the production and supply pathway
- site and scale
- immediate previous agricultural history

Through this UK and international work it has become clear that the use of generic carbon and energy input data for specific biofuel production pathways will not provide realistic life cycle GHG savings information. A transparent and universally applicable and accepted methodology is required, based on data for specific biofuel production pathways, in order to gain a sufficiently accurate estimate of GHG emissions.

Certification is a familiar concept in the agricultural and forestry industries but is less developed in other product areas. The primary driver for the development of this certification scheme has come from the wide range of stakeholders consulted during the preparatory process of the project. Interviews were conducted with consumers, farmers, processors, the oil industry and car manufacturers as well as the environmental NGOs. The broad consensus from all these interviews was a requirement to provide assurance on a number of key dimensions.

Discussions with consumers highlighted the need for information and general assurance about the environmental acceptability of new biofuels. A copy of the HGCA study “Consumer perceptions of biofuels” can be found in Appendix 6. There is considerable ignorance amongst consumers (based largely on unfamiliarity) regarding the broad issues of climate change, energy inputs, carbon savings and environmental impacts of biofuels. An analysis of current advertising and media coverage of these issues shows clearly that much of the current coverage is based on myth and misconception. Most consumers believe that LPG is a green fuel, whilst most media commentators extol the benefits of hydrogen as a saviour of the world's climate.

For the farming industry in the UK, certification has become an accepted and necessary way of doing business and most of the crops envisaged for bioethanol production are already covered by existing certification schemes such as the Assured Combinable Crops

Scheme. At the other end of the spectrum, both car manufacturers and oil companies expressed concerns about their brand integrity and required assurance on key issues such as environmental acceptability and carbon saving performance.

The issue of brand integrity was of most concern to those car manufacturers who had ambitions to create a new sector in the UK car market built around the values of climate change alleviation and general sustainability. Further discussions with these manufacturers revealed their recent successes in opening up this sector in other European markets. The concerns and motivations of the statutory bodies and environmental NGOs were based largely on the specific focus of their organisations. Climate change improvement and reduction of GHG emissions was a universally held objective, whilst others were also concerned about environmental impacts, such as harm to biodiversity, resulting from agricultural intensification and land use change.

In addition to these interviews, a preliminary examination of the underlying science was also undertaken and published in the HGCA funded report “Environmental Impact of cereal and oilseed cropping in the UK” (Turley et al, 2005). This study revealed that, under current production regimes and systems, there is a huge variance in environmental performance by fuels from different sources.

The HGCA report sets out to determine the environmental impact of using cereals and oilseed rape for biofuels in the UK. It benchmarks current production and shows that biofuels can make a real difference to both energy efficiency and GHG levels. It also addresses points in production where improvements can be made.

A major finding is that, compared to fossil-derived petrol, bioethanol from wheat has the potential to reduce energy inputs by 61% and total GHG emissions by 65%. Similarly, biodiesel from oilseed rape has the potential to reduce energy inputs by 66% and total GHG emissions by 53%.

The report evaluated cropping trends, inputs, environment and biodiversity. It concluded that there is little difference in the environmental impact of growing crops for food or biofuel use. There may be some scope to reduce environmental impact if biofuel buyers accept different quality and grain protein specifications. This could allow some inputs, such as nitrogen, fungicides and insecticides to be reduced. See Section 4 for more details.

1.3 The Need for a Progressive System

Whilst ethanol produced from conventional crops, using conventional fermentation technology, is likely to be the most accessible technology used during the initial development of the market, there is a widely recognised appreciation that two other key technologies will come into play at later stages in the development of the market. These emerging technologies can be classified under the general headings of

- lignocellulosic
- gasification and Fischer-Tropsch synthesis

Similarly, it is likely that the conventional fermentation technology pathway will also develop and improve its economic and environmental performance with substantial market deployment.

> ***It is imperative therefore, that any carbon certification scheme incorporates a level of progressive performance and recognises and reports continuous improvement.***

This is seen to be a vital component of a biofuel certification scheme. Experience with the Renewables Obligation for electricity has proved beyond doubt, that a non-progressive system locks in the current technology. Thus, in the electricity market, wind generation technology dominates because it was the converged technology at the point of introduction of the Obligation. Why should anyone invest in a newer, riskier technology which is probably more expensive? The fact is, that new technologies are currently excluded from the electricity market and Government is having to re-visit the Renewables Obligation, to identify means by which next generation technologies can be brought to market.

1.4 Original Intentions

The original, overall scope and objective of the project was to provide an assurance scheme to the agricultural industry and to the production and distribution chain for bioethanol, to ensure that GHG and environmental claims could be substantiated. These were initially identified as

- the quantification of the carbon savings achieved under different cropping and production regimes
- assurance on the wider environmental sustainability issues

In addition, consideration was also given to social issues. However, the scheme development has coincided with legislative changes in the UK, notably the Energy Act 2004. This has created a new context for the scheme, especially with regard to the role of assurance and certification in relation to the new legislation. It is appropriate therefore, to describe the new context and underlying policy and legal framework within which the scheme will have to sit.

1.5 The Legislative Context

The major legislative driver is the EU Biofuels Directive which has, as its primary objective, the reduction in GHG emissions in the transport sector. This European Directive (CEC 2003/30/EEC) on the promotion and use of biofuels and other forms of renewable transport fuels sets reference targets of 2% by 2005 and 5.75% on an energy basis, by 2010. The Directive also states, that the encouragement of the promotion of biofuels should be consistent with security of supply and environmental objectives, related policy objectives and measures within each member state. It continues that in the measures that they take, the Member States should consider the overall climate and environmental balance of the various types of biofuels and other renewable fuels and may give priority to the promotion of those fuels showing a very good cost-effective environmental balance, whilst taking into account competitiveness and security of supply.

The Directive also mandates the Commission to produce a bi-annual report for the European Parliament and Council on the progress made in the use of biofuels and other renewable fuels in the Member States. The report should include:

- The life cycle[3] perspective of biofuels with a view to indicating possible measures for the future promotion of these fuels that are climate and environmentally friendly and that have the potential of becoming competitive and cost efficient.
- The sustainability of crops used for the production of biofuels particularly land use, degree of intensity of cultivation, crop rotation and use of pesticides.
- The assessment of the use of biofuels with respect to their differentiating effects on climate change and their impact on carbon dioxide emissions reduction.

This would seem to indicate that the European Commission will be required to assess and report on Member States progress in achieving the targets set, as well as a more detailed analysis of the GHG savings achieved and some measures of the sustainability aspects of biofuel crop production.

The UK Energy Act 2004 gives the Secretary of State for Transport the power by order, to impose a renewable transport fuel obligation on each transport fuel supplier of a specified description. This order is referred to as an RTF order and places an obligation on the supplier to produce evidence which shows that during a specified period, the specified amount of transport fuel was supplied for delivery to places in the UK. The enabling act is a complex piece of legislation which also includes,

- Definitions of renewable transport fuels.
- Methods by which the amounts of renewable transport fuel are to be counted.
- Methods by which different renewable transport fuels can be aggregated.

This latter point refers to how supply companies who purchase a wide range of renewable transport fuels such as biofuels, biogas or renewable hydrogen, can calculate the actual quantities of these fuels required to fulfil their obligation.

It is evident from both the European Directive and the Energy Act 2004 that there will be a requirement for the monitoring of the GHG saving impacts of various renewable transport fuels. Furthermore, the European Directive identifies the sustainability of biofuel crop production as an issue, and the UK legislation also states that ‘provisions can

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[3] ‘Life Cycle’ is defined by the International Standards Organisation (ISO) as: ‘**Life Cycle** is consecutive and interlinked stages of a product system, from raw material acquisition or generation of natural resources to the final disposal (ISO 14040).’

also be made on the effects of the production, supply or use of a fuel on' and it lists amongst other issues

- agriculture
- sustainable development
- the environment generally

This would again seem to indicate a requirement to provide data on the various impacts of biofuel production, especially with regard to cropping. The UK Government's position and detailed requirements have yet to be revealed. The enabling legislation contained in the Energy Act 2004 is currently being further developed within Government and it is unclear at this time whether carbon certification or more general environmental assurance will be required as a measure of compliance with the Renewable Transport Fuels Obligation (RTFO). The Government has concluded a number of feasibility studies on both the functioning of the RTFO and the role that certification and assurance will or will not play (Bauen et al, 2005). One purpose of the current report is to provide instructive support for the assessments to be made over the coming months.

1.6 The Implications of the Changed Legislative Context

The development of the project has continued because the original aims and objectives stand with or without Government involvement. The possibility of the Government linking an Assurance Scheme to the RTFO has placed an added requirement for scientific rigour in the understanding of the environmental impacts and in the development of the carbon calculation models and in ensuring that the design of the scheme complies with the requirements of ISO 65 EN 45011.

The Steering Group sees the need for GHG accreditation and would like to see this used as a platform for wider environmental and social conditions with the target of full sustainability of biofuels use.

2 The Development Process

2.1 Aims and methodology

The overall aim of this project has been to produce an environmental certification system for bioethanol production from wheat. The underlying philosophy of the project methodology was to recruit the best available scientific input and involve a broad range of stakeholders in setting the context and underlying policies for the development of the certification scheme.

2.2 Recruiting the Steering Group

The scientific input was provided by a team from Imperial College London, under the direction of Dr Jeremy Woods and a team from the Edinburgh Centre for Carbon Management, under the direction of Dr Richard Tipper.

The Steering Group comprised a range of potential stakeholders in the proposed assurance scheme. It included the following organisations (see also Appendix 1):

- Friends of the Earth
- The Worldwide Fund for Nature (WWF)
- English Nature
- The Royal Society for the Protection of Birds (RSPB)
- National Farmers Union (NFU)
- The Home Grown Cereals Authority (HGCA)
- British Sugar plc
- Green*ergy* International Ltd
- Wessex Grain Ltd / GreenSpirit Fuel Ltd
- Bioethanol Ltd
- Bronzeoak Ltd
- Cmi plc

In addition the Ford Motor Company provided input and advice.

2.3 The Scoping Studies

The scoping studies comprised two major components. The first was a comprehensive study of the Environmental Footprint of Arable Cropping in the UK. This study, funded by HGCA, was undertaken by the Central Science Laboratory under the overall direction of Dr David Turley. The findings of this study have been separately reported and are summarised later in this report (Turley et al, 2005).

The second part of the scoping study looked at all relevant existing assurance schemes and held discussions with the originators and managers of those schemes, the certification companies currently engaged in agricultural assurance schemes, the Worldwide Fund for Nature (originators of the Forestry Stewardship Council, FSC), the Forestry Commission and some farmers and growers. The second part of the scoping study also examined the current regulations regarding environmental assurance and the processes required to enable a scheme to comply with National, European and International law. Particular emphasis was given to

- ways and means of encouraging participation
- lessons learned from other experience in scheme development and management
- Internationalisation

Regarding this latter point, the study perspective was from the point of view of products sold in the UK but sourced from overseas. For example, the study examined the systems and structures put in place by the British Retail Consortium to certify overseas production of fresh produce for sale in UK supermarkets.

Concurrent with the examination of existing assurance schemes, the study team developed protocols and rules for life cycle assessments by consulting the current globally respected experts. Advice was also obtained from the Ford Motor Company that particular note be taken of the Sustainable Mobility Project 2004 report, produced by the World Business Council for Sustainable Development (WBCSD, 2004).

Preliminary examination had shown a large number of production pathways for bioethanol and a database was developed of all current and prospective bioethanol production systems.

An essential requirement for the development of an environmental certification scheme is the determination of the boundaries of the evaluation and the unit of evaluation. This task was undertaken and the findings discussed and agreed by the Steering Group. Similarly, standard comparators were also agreed. The study also examined each individual stage of the production processes so that separate life cycle assessment modules could be produced.

Modules were produced for

- crop production harvesting and transport
- transport to the production facility
- the bio ethanol conversion systems
- blending in distribution to point-of-sale
- vehicle efficiencies

2.4 Discussion of key issues

The detail of the scoping studies is discussed further in the report. It is however, important to highlight a number of the key considerations emanating from this part of the study. Primary amongst these are three considerations

- to what extent should the certification scheme be based on a single standard with a simple compliant / noncompliant measure (called a critical failure point) or should the scheme report and certify actual carbon / GHG saving performance?
- to what extent should the scheme measure other environmental and social performance indicators and incorporate these in the overall scheme?
- what allocation system should be used when measuring the performance of derived co-products during the production process?

2.4.1 A Single Standard or Actual GHG Saving Performance?

During the scoping study and following an examination of existing certification systems within agriculture, it was revealed that the current on-farm data collection and certification measures in the UK were comprehensive and had very high participation rates (over 90%). It was also discovered that to a large extent, UK farmers held positive views about certification and assurance. This meant that data collection for measuring actual GHG savings and environmental performance on-farm in the UK, was not as difficult as previously envisaged. It was evident that most of the data was already recorded and could be readily accessed for the purposes of this scheme. Discussions with key authorities suggested that the data collected from overseas producers was less comprehensive although the institutional and organizational structures existed to collect the required data.

Furthermore, whilst assembling the database of production systems, a very large variance in carbon saving performance could be shown between different bioethanol production systems. Generally, the major factor that contributed to this variance was the production system itself (see section 4). On balance therefore, consideration of the very wide variance on carbon saving performance meant that a single standard would have to be set at quite a low level if it was to comply with international trade regulations. Furthermore, the Steering Group included representation from an experienced international developer, currently developing a bioethanol plant in Southeast Asia. Their advice confirmed, together with input received from the British Retail Consortium, that undertaking actual GHG saving performance certification was practical and could be provided cost effectively. It was therefore determined that a progressive system, measuring actual carbon saving performance, should be adopted.

2.4.2 Other Environmental and Social Performance Indicators.

It was generally agreed by the Steering Group that the primary focus of the initial stage of this project should remain on GHG performance. Designing and developing a GHG assurance scheme provides a means of quantifying GHG savings through applied Life Cycle Assessment. A measurable assessment of inputs and outputs from growing a crop to the tail-end emissions is a key point in the development of an overall assurance scheme and the Steering Group agreed that the scheme should be developed along these lines.

The Steering Group also discussed the importance of wider-reaching environmental and social considerations in the development of a biofuels industry. It was agreed that serious consideration should also be given to the development of other environmental and social performance indicators. The primary driver for this view came from the RSPB and English Nature which feel that there is a real opportunity to incorporate measures to address issues of biodiversity within the development of an assurance scheme. Further discussions with oil and motor companies, particularly Shell and Ford, also reinforced the requirement for at least a default value for environmental and social performance. The reasons for this view stem largely from the need to maintain brand integrity and to avoid a consumer backlash effects if bioethanol from dubious sources were to find its way onto UK forecourts.

Time constraints have meant that this matter is still under discussion and consideration by the Steering Group. At the time of writing, the Steering Group had agreed that this very important subject would be pursued further in the next phase of the project, once the Assurance Scheme Steering Board has been established.

2.4.3 Which Allocation Measure should be used?

Allocation is a key concept in life cycle analysis and is a matter of much controversy and debate. In any life cycle analysis, inputs used in production on the farm, such as fertiliser, pesticides and fossil energy are set against outputs at the end of the production system, such as bioethanol and the co-products, such as dried brewers grains (DDGS). These factors are used to derive an overall balance of the fossil energy in and renewable energy out of the total chain and to determine the overall GHG losses and gains.

Of course, any production and supply chain is not simple. In the case of wheat to ethanol for example, all the fertiliser, pesticide and fossil energy inputs that go into crop production must be inventoried and set against the impacts bioethanol use e.g. as a substitute for petrol, thus arriving at a net savings or emissions figure. However, the situation is more complex than that because any chain has co-products such as straw, or manufacturing process by-products such as DDGS. Multiple uses of co-products further complicates these calculations, for example, the straw could be used for animal bedding, electricity generation or used to make more bioethanol using an enzymatic-hydrolysis technology. Furthermore, the DDGS could be used as an animal feed thereby displacing another crop and its associated inputs, or used to generate electricity. Careful analysis is required to arrive at a defensible, transparent and therefore credible calculation as discussed in sections 3.3 and 4.

2.4.4 The Scheme Structure and Documentation

This stage will involve production of three key documents

- A simple overview of the scheme to inform Government, the marketing community and investors, of the nature of the scheme and advise on the issues and methods necessary to make valid and supported GHG savings claims.
- A full scheme specification describing all aspects of the scheme, the underlying science, protocols and procedures for each of the life cycle assessment modules based on ISO 14040, methods of aggregation and reporting methods together with a full reference section describing all of the supply chain options.
- The scheme management plan comprising the composition of the scheme board and the accreditation processes and protocols.

2.4.5 Field Trials Proposal

Having designed the scheme, calculation tools and the supporting documentation, it will be necessary to undertake field trials to ensure practical implementation and identify problems and corrective measures. It is envisaged that an on-farm system for data collection would follow the format of existing documents, such as the Assessment Checklist used for the Assured Combinable Crops Scheme (Appendix 5).

The field trials are expected to test and demonstrate the scheme design and protocols, and trials of the management system. At the time of writing, it had been provisionally agreed that the scheme trials would be incorporated in the EU-funded BEST (BioEthanol for Sustainable Transport) project. The BEST project is designed to kick-start the market for ethanol fuelled vehicles in Europe, primarily by establishing 8 large scale demonstrations in the EU but also a Chinese and Brazilian demonstration too. Each demonstration will establish the supply chains and refuelling infrastructure to support around 300 flex-fuel vehicles (FFVs) and in some regions urban bus routes as well. Imperial College is responsible for coordinating the evaluation and monitoring of all the demonstrations. In the UK, BEST includes a market trial of E85 vehicles in Somerset, led by Somerset County Council, with the E85 fuel supplies being provided by Green Spirit Fuels and sold through five public access garage forecourts. The project starts in January 2006 (BEST, 2005).

3 The Evidence Base

This section describes the underlying science for the calculation model, based on published research, consensus-building activities of the UK Low Carbon Vehicle Partnership (LCVP, 2004) and the Environmental Footprint study (Turley et al, 2005). Overviews of the published research can be found in Appendix 2, the Environmental Footprint study in Appendix 3, and the GHG Calculator in Appendix 4.

3.1 Source Data for the Calculation of Greenhouse Gas Emissions

Bioethanol is a petroleum substitute that has been used in Brazil as a motor vehicle fuel for over 3 decades, but has only recently grown in market share in Western countries. Bioethanol, produced from renewable resources, is deemed to be more environmentally friendly than fossil fuels, but the environmental impact of bioethanol differs according to feedstock choice, transportation distances and fuel production methods.

The main reason for the initial use of biofuels was for energy security. Where countries have the resources to grow the crops and no access to indigenous fossil fuel reserves or adequate foreign currency reserves, then biofuels are an attractive alternative. Latterly, biofuels have also been seen as a way to reduce GHG emissions that are responsible for human induced climate change.

GHG emissions are a relatively straightforward environmental impact that can be measured from the different life cycle stages of bioethanol production. The measure of GHG emissions can be used to compare one aspect of the environmental impact of bioethanol derived from different sources.

However, in order to achieve comparable and defensible results from the life cycle assessment as established by the ISO 14040 series, care needs to be taken to

- define the boundaries of the analysis and the reference system(s)
- carry out a comprehensive inventory of all the relevant inputs and outputs
- establish a viable unit for the measurements ‘functional unit’ e.g. kgCO_2 equivalent per GJ ethanol

It is also important to realise that the systems being evaluated are dynamic. Therefore many of the ‘default’ values will vary over time as technologies, management practices and scientific understanding develop. Assurance systems based on periodic monitoring through certification, as proposed here, are an innovative and far reaching solution to this dynamism.

3.1.1 Studies reviewed

Authors	Year	Description
dos Santos	1997	Energy and CO_2 analysis of crops used for ethanol production
Macedo Macedo et al	1998 2004	GHG and energy balance analysis of bioethanol production from sugar cane in Brazil Assessment of GHG emissions in the production and use of fuel ethanol in Brazil
DTI	2003	Review of technology and carbon abatement potential of renewable transport fuels in the UK
LCVP	2004	Well to Wheel evaluation of ethanol production from wheat
Mortimer et al	2004	Whole of life study for UK-based bioethanol supply chains
IFEU	2004	Summary of studies in carbon analysis of biofuels

3.2 Methodology Selection

The methodology used in all studies mentioned is based on life cycle analysis, but most differ in their detail. There is currently no universally agreed, consistent standard method of analysis of well-to-wheel GHG emissions from biofuels, and certain issues, such as the allocation of emissions to process co-products, remains disputed between interested parties.

The best available evidence for well-to-wheel life cycle analyses must include the following elements as a minimum

- Boundaries
    - The boundaries are transparent and justified and cover at least feedstock input production, feedstock production, feedstock transport, but not the construction of machinery, plant or other equipment
- Functional unit
    - A clearly stated universal unit of measurement for use throughout the analysis and in cross-comparison with other relevant studies
- Reference systems
    - Clearly defined system prior to intervention i.e. ‘what replaces what.’

- Sources
    - The sources used for background data must be stated and be relevant and recent
- Allocation
    - Allocation to co-products is transparent, justified and is suitable for the co-products in question
- Uncertainty
    - Uncertainty has been considered and is described in a transparent manner.

In order to select best available evidence, the methodology of selected studies must include the points described above, and also show the detail of the emissions for each life cycle step included inside the boundary.

3.3 Allocation issues

Allocation procedures partition all resource inputs and environmental outputs between the different co-products arising from a production process. Different bioethanol feedstocks lead to a number of different co-products, by-products and wastes when processed to bioethanol, and a standard allocation process which can be applied to all bioethanol technologies does not exist. The reason allocation is a key issue in determining emissions associated with a particular biofuel, is that co-products and by-products can replace other materials and energy sources, and their associated processes.

The principles used in lifecycle analysis to account fairly for this complexity are called 'allocation' and there are four main systems (Table 3-1) as follows

- Substitution e.g. crediting the dried brewers grains used in coal fired power stations with the emissions from the displaced coal
- Market price - this measure is based on the current market value of the different co-products. Allocation is done according to the proportion of total value of the processed outputs
- Energy content – if the co-products could be used for energy production, this measures the energy in the co-product and accounts for its energy potential. This method is increasingly being regarded as unsatisfactory
- Mass Balance – this measures the physical properties of the co-product and is the most straightforward method. As with the 'energy content' methodology, using the mass balance to allocate between co-products is not recommended

Table 3-1: The Four Allocation Methodologies

Allocation method	Comment	Benefits	Drawbacks	Level of complexity
Substitution	Preferred method by academic studies, based on applying input and output credits for by-products based on LCA results of their main production process, e.g. crediting glycerol from biodiesel production with the emissions from industrial glycerol production displaced	Reasonable reflection of reality; when applied consistently gives good transparency; can be applied to varied by-products	Time-consuming; relies on other LCA studies; cannot be applied when product is always a by-product; difficult to understand	High
Energy content	Based on allocation according to the energy content of by-products, allocation is done based on physical properties	Can be used for varied by-products as most have potential to be used in energy production; straightforward method	Technically all energetic uses are not equivalent and therefore this method does not reflect fully the GHG impact of by-products; not applicable to non-energy providing by-products	Low recruit the best available scientific input and
Mass balance	Based on the proportion of total mass of outputs, allocation is done according to physical properties	Can be used for varied by-products; straightforward method	Does not reflect the value or GHG impact of a by-product	Low
Market price	Based on the current market value of the different by-products, allocation is done according to the proportion of the total value of process outputs each by-product has	Relatively straightforward although requires access to specific markets; can be used for varied by-products	Not based on constant values and therefore unreliable in the medium to long term; does not reflect physical properties of the by-products	Medium

Each of these different allocation systems vary in complexity, with some requiring quite complex monitoring. Using market price (or substitution) for example, requires access to market data on a continuous basis and would produce changing results, according to changes in markets. The principle methods used for this study were substitution. However, the underlying understanding of allocation is continually changing and the scheme structure design should take account of this in order to ensure that the correct allocation procedure is used.

3.4 Data selection process for measuring greenhouse gases

For each life cycle stage included, the availability of the following potential evidence types is assessed

- direct instrumental measurements of GHG emissions, or calculations based on instrumental measured of mass balances
- estimates based on direct measurements quantities of fuels or electricity consumed
- estimates based on 3rd party or supplier approximations of fuels or electricity consumed
- published literature based source of data or evidence

The sources of this evidence (3rd party, operator, supplier or study) shall also be considered, taking into account the potential for bias and operator error. Then, taking into account the factors listed in the table below, the evidence is rated. If two or more sources of evidence have the same rating then the most direct evidence type shall be preferred.

Table 3-2: Factors to consider when rating the quality of evidence for GHG emissions

Evidence Type	Factors to consider
Direct instrumental measurements of gaseous emissions, or calculations based on instrumental measurements of mass-balances	• Type and make of instrument used. • Expected level of precision and accuracy. • Reliability of stochiometric assumptions, given knowledge of operational conditions. • Appropriately qualified staff. • Reliability of record keeping. • Reliability of calibration and verification procedures. • Consistency of data record. • Processes for error-correction.
Estimates based on direct measurements quantities of fuels or electricity consumed	• Reliability of data source for conversion factors. • Reliability of source of data for quantity of energy consumed. • Reliability of verification or checking procedures used.
Estimates based on approximations of fuels or electricity consumed	• Reliability of data source for activity levels and conversion factors. • Validity of assumptions on which approximation is based. • Reliability of any verification or checking procedures used.
Published literature based source of data or evidence	• Quality of evidence used in the study. • Geographic and temporal relevance. • Major assumptions or qualifications used in the study. • Type of literature and potential for bias or error: - "grey" industry literature, - peer reviewed journal, - Governmental report, - statistic provided by a national, or international agency, - other published document.
Other unpublished information within suppliers management system	• Reliability of data source for conversion factors. • Validity of assumptions on which approximation is based. • Reliability of any verification or checking procedures used.

3.5 Data reviewed for bioethanol tool

3.5.1 Selection of background data

The GHG Calculator currently evaluates the impacts of changing management practices and technologies on the GHG emissions arising from a stipulated UK based wheat-to-ethanol chain. According to the criteria as described above, the following sources were selected to provide the data for use in the Calculator to assess the emissions impact of feedstock production or for cross-comparison with alternative (non-wheat) ethanol production chains.

<u>Wheat</u>

LCVP (2004) by Rickeard et al – this study reported the consensus of a number of leading life cycle experts from Europe, representing industrial and academic interests and a peer review process through the stakeholder representation of the Fuels Working Group of the Low Carbon Vehicle Partnership. Its outcomes were concluded to supersede other wheat-to-ethanol LCA studies.

Mortimer et al (2004) – this study presents the most comprehensive emissions assessment of feedstock to bioethanol pathways, including source data assessment and discussion on allocation. It is relevant to the UK, and the most recent in a series of bioethanol studies.

<u>Sugar beet</u>

Mortimer et al (2004) – as above.

<u>Sugar cane</u>

Macedo et al (2004) – this study is the most recent in a series of energy and GHG balance studies done in Brazil, updating previous work with the latest assumptions. Sugar cane to bioethanol pathway studies are rarely included in European studies, so this piece of work presents the most transparent, recent and geographically relevant source of background data.

3.5.2 Selected allocation methodologies

As a result of the diversity in allocation methodology and the lack of an accepted standard method, no single method was adopted for the feedstock pathways summarised below. The lack of standardisation of the allocation methodology may be seen as a limitation to comparability between life cycle pathways, and is therefore an area requiring further work.

Wheat

GHG emissions are allocated where appropriate using the substitution methodology as selected by the Low Carbon Vehicles Partnership Fuels Working Group (LCVP, 2004). In summary, for electricity usage, it has been assumed that any electricity exported substitutes electricity from the UK mix, thus avoiding power generation elsewhere in the UK. Distillers' Dark Grains and Solubles (DDGS) can be used for energy in Combined Heat and Power (CHP) applications, but its most common use is currently as animal feed. This use is adopted in the current calculation, substituting for soya and maize-derived animal feed imported from the US. However, using DDGS for electricity and heat generation can also be evaluated.

Alternative allocation methodologies have been developed and may prove more effective in the longer term than substitution. For example, the market price emissions allocation methodology as adopted by Mortimer et. al. (2004) could be modified and incorporated at a later stage as it can dynamically reflect the current use of the co-products, and is a quantitative method.

Sugar beet

Allocation follows a market price methodology as deemed most appropriate by Mortimer et al (2004) in their comprehensive study on the energy and GHG balances of a range of biofuels options for the UK. The current market price of co- and by-products is used for proportional allocation of life cycle emissions at various stages of production and processing. Allocation occurs at all life cycle stages.

Sugar cane

Allocation follows a substitution methodology as defined by Macedo et al (2004) considering alternative uses for bagasse. Other co-products of the sugar cane to ethanol pathway could also be diverted into alternative uses but the methodology only considers current practices. Bagasse is widely used to fuel boilers to raise steam to provide process energy. The steam may first be used to generate electricity, which means that most mills are self-sufficient in energy, and therefore the greatest emission credit in the sugar cane pathway comes from the displacement of fuel oil and electricity. More efficient sugar mills can produce surplus electricity from the bagasse which can be exported to the grid or nearby markets. Allocation occurs only in the processing life cycle stages.

4 The Bioethanol Greenhouse Gas Calculator

The GHG Calculator is designed to allow the full life cycle GHG emissions arising from the production of bioethanol from wheat to be calculated using a credible and transparent methodology. The Calculator is a spreadsheet based tool that also allows selected variables, for example fertiliser inputs, to be altered so as to be representative of a chosen production and supply chain. In its current form, it enables many of the central issues concerned with the development of an applied biofuel GHG assurance/certification scheme to be explored. However, it is not a certification tool. A brief overview of the GHG Calculator and its role and limitations is provided below. Further details are provided in Appendix 4.

4.1 Summary

The GHG Calculator, reported in Appendix 4, has been designed to address some of the concerns voiced over the complexity and efficacy of biofuel production. It could also form the basis for GHG certification with further development. As a first step, the Calculator provides a transparent basis for calculating the GHG emissions arising from a batch of UK-derived bioethanol using specified agricultural and conversion processes. The calculations and underlying 'default factors' are based on the full life cycle assessment methodology and emission factors agreed through an expert stakeholder-led process carried out by the Low Carbon Vehicle Partnership (LCVP, 2004).

This recent life cycle evaluation by Rickeard et al for the Low Carbon Vehicle Partnership, has shown that a conservative range in net GHG emissions from wheat-based fuel ethanol production in the UK would be between 7% and 77% lower than the emissions from petrol. Importantly, the emissions are highly sensitive to how and where the ethanol is produced and the default factors assumed. This range in emissions resulted entirely from changes in the configuration of energy supply technologies within the conversion facility, with only a single emission factor (agricultural scenario) being considered for feedstock (wheat grain and straw) supply.

In practice, the potential emissions range is significantly greater than stated above; see for example, Bauen et al. (2005) or Woods and Bauen (2003). The broader range arises from the very large array of technological, energy input and management options available at almost every stage in the feedstock production and conversion sectors, location of production (local or international) and the importance of integrated transport logistics. Recent developments in high starch wheat R&D (HGCA project no: 2979) show how inputs can be reduced, particularly nitrogen, depending on the quality requirements of the ensuing processing plant. Turley et al (2005), have also demonstrated the sustained reduction in inputs being achieved by British agriculture through efficiency gains and emerging management techniques, such as precision farming.

Despite these improvements, feedstock production (farming) remains one of the principle sources of the GHG emissions resulting from ethanol production, as demonstrated in Table 4-1. In addition, Table 4-1 highlights the importance of nitrogen fertiliser, diesel and field-level nitrous oxide emissions in the full chain emissions. Therefore, agriculture will have a major role to play in reducing the GHG emissions of biofuel production and will require clear signals and practical guidance on how best to achieve emissions reductions. A major role for the Calculator is as a planning tool to help sensitise farmers to these new challenges.

Table 4-1: Farming share of energy and GHG emissions for ethanol production

	Energy Inputs		GHG Emissions	
	GJp/ha	% of total chain	Kg CO_2eq/ha	% of total chain
Diesel	4.7	7.0%	356.6	5.8%
K fertiliser	0.4	0.6%	21.0	0.3%
P fertiliser	0.7	1.0%	29.1	0.5%
N fertiliser	7.5	11.1%	1238.0	20.2%
Pesticides	0.6	0.8%	10.8	0.2%
Seed Material	2.5	3.7%	160.4	2.6%
N_2O emissions			1290.6	21.0%
Total Farm	**16**	**24.2%**	**3106**	**50.6%**
Rest of Chain	51.1	75.8%	3037.2	

Notes: based on average UK wheat production factors and a Natural Gas-Gas Turbine Boiler + fired Steam recovery conversion plant (LCVP, 2004; Model B22). This model assumes a wheat grain yield of 8 t/ha.yr and that straw is ploughed back in.

4.2 The Calculator

In order to assist farmers with evaluating how their choice of management, technologies and inputs would affect the overall GHG emissions of the resulting ethanol production, the Calculator has been designed to allow a selected range of the key variables to be altered by the user. For example, producing low protein wheat for ethanol production should allow reduced nitrogen fertiliser applications. In the Calculator, the default value for N-fertiliser applications can be changed and the resulting reduction in GHG emissions calculated. Appendix 4 provides a 'user's guide' explaining which factors can be altered and summarises the scientific basis for the calculation of potential GHG emissions using the Calculator.

For ease-of-use, the Calculator divides up the ethanol production and supply chain into the following sub-sectors

- farming inputs and yields
- pre-processing
- feedstock transport
- processing/conversion
- transport to end-use, duty or blending points

The GHG emissions arising from each of these sub-sectors is displayed in numerical and graphical form for each calculation (Figure 4-1). In addition, a choice of reporting units is provided in order to facilitate cross-comparison with alternative LCA studies.

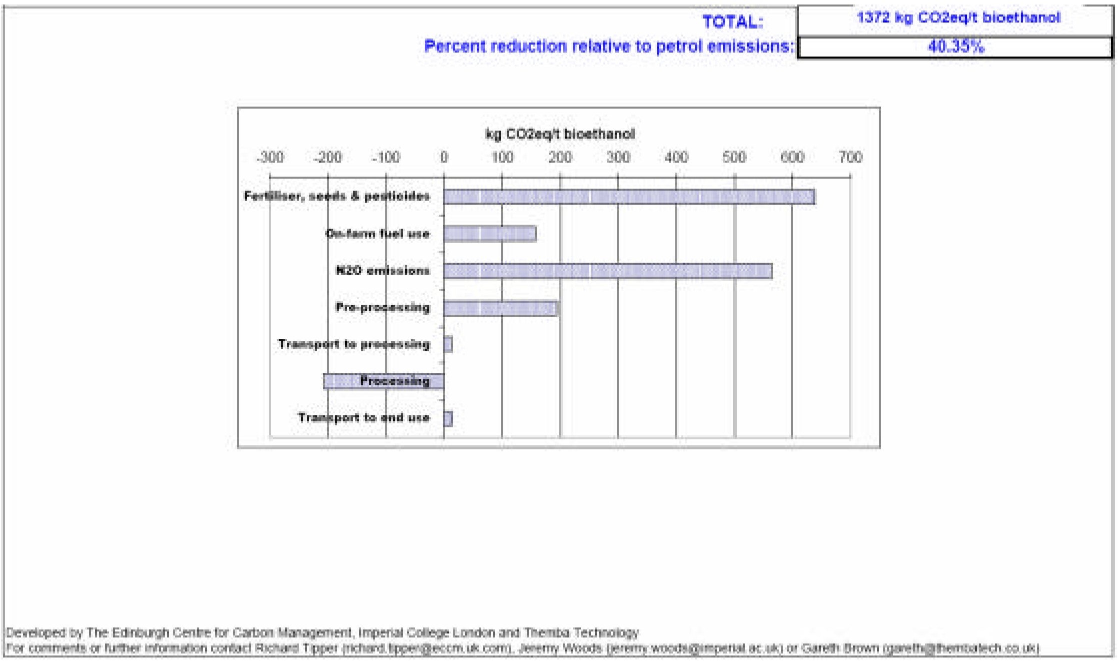

Figure 4-1: example GHG emissions arising from ethanol production by sub-sector

4.3 Uncertainty

Despite the growing consensus that biofuels can play a substantive role in reducing GHG emissions from the transport sector, there remains a significant degree of uncertainty, associated with estimating the GHG emissions resulting from individual biofuel production chains. Empirically, land use change, field-level nitrous oxide emissions and dynamic reference (baseline) values, pose the most serious challenges to providing a high degree of confidence in the calculated emissions. These are all areas of rapidly developing understanding and future versions of the Calculator will need to incorporate any new findings, once verified. Such a continuing verification process would require the establishment of an institutional unit tasked with updating the associated 'default values' as proposed in Bauen et al (2005).

Methodologically, the allocation of emissions to co- and by-products remains unresolved, although a range of credible methodologies have been developed and the substitution methodology adopted here is broadly accepted. The uncertainty resulting from this methodological dilemma is most keenly felt when trying to compare the benefits of bioelectricity versus biofuel production. Biofuel production chains being almost entirely 'poly-generational' (i.e. they produce more than one energy output simultaneously e.g. liquid transport fuel and electricity), therefore remain difficult to compare with mono-generation chains e.g. biomass-to-heat or biomass-to-electricity.

4.4 Conclusions

The tool, its underlying methodology and default factors, are based on the current state-of-the-art scientific understanding on the life cycle impacts of biofuel production in the UK and Europe.

In developing the GHG Calculator three major roles are envisaged, as follows

- demonstrate that calculating LCA GHG emissions arising from bioethanol production from wheat in the UK can be credible, transparent and defensible
- provide an educational and practical help tool for farmers (and ethanol producers) to quantify how changes in management and technologies could be optimised to reduce GHG emissions
- provide the basis for developing a cost effective and credible GHG certification system; initially for bioethanol and then for other biofuels

If the Calculator is to be developed as a tool for GHG certification of biofuels, it will have to be sufficiently flexible to incorporate

- new technologies, management practices and inputs, at all stages in the production and conversion chain
- New understanding that affects
    i. the Life Cycle Assessment calculation methodology e.g. in co-product allocation
    ii. changes in the baseline / reference data e.g. GHG emissions per kWh UK grid-mix, land use and fossil fuel emission factors

In the short term, the only proven viable alternative to petrol and diesel are biofuels (bioethanol and biodiesel). It is therefore, critical that biofuel production (and use) is optimised to maximise the GHG benefits that can arise from substituting the relevant fossil fuels. Should Government take its role in incentivising energy use on the basis of GHG emissions seriously, producers and suppliers risk having locked themselves into inefficient supply pathways (including sunk investments in infrastructure) and thus becoming uncompetitive, unless they maximize GHG performance at an early stage in planning. The GHG Calculator described here, and in more detail in Appendix 4, is designed to demonstrate how such calculations could be derived and to ensure that they take place using an agreed and transparent evidence base.

5 Assurance, Accreditation and Certification Schemes

The development of assurance schemes which gain public acceptance is dependent on the quality and transparency of the underlying standards, certification and accreditation systems and the operators. This section explains the roles of each of these three components and the actions required to develop a Biofuels Assurance Scheme in the UK.

5.1 Definitions

Before discussing assurance, accreditation and certification, it is important to set out some definitions. In most instances, the consumers' first contact point with such schemes is at the level of the Assurance Scheme. In marketing jargon, an assurance scheme manifests itself at the point of sale, as a "marque" or logo on the product. Thus food sold in supermarkets which carries the Red Tractor logo conforms to the requirements of the British Food Standards. This is a widely recognised mark and is perceived by consumers as a brand name or marque.

An Assurance Scheme is designed to provide reassurance about a product or service, based upon a set of criteria, which are deemed relevant to the marketing or consumer acceptability of that product or service i.e. it assures that a product or service is produced to meet a set of specified standards.

Certification is a process of ensuring that the organisations or individuals who are providing the goods or services properly fulfil the criteria of the assurance scheme.

Accreditation works at a level above certification and assurance and is designed to ensure that those bodies undertaking certification and assurance, work to internationally agreed standards and protocols. For example, an organisation can only provide certification if it is accredited by the Assurance Scheme.

To demonstrate the structure of UK assurance and to provide examples of the type of issues covered by assurance, Appendix 5 shows how one of the main Certification Companies, Cmi plc, operates. Similar procedures are followed by other certifying bodies, such as PAI & EFSIS.

5.2 A Structure for an Assurance Scheme and Compliance with European and international standards for accreditation.

The primary source document for guidance for compliance, with the relevant European and international standards, is the European Corporation for Accreditation guidance EA 7/02. This guidance is complex and comprehensive. A review of the key principles and requirements is outlined below.

The key principles and requirements are

- non-discriminatory
- legal and regulatory compliance
- impartiality
    - structure
    - balance of interests
- practical requirements
    - legal entity
    - distinctive name
    - separation of policy and commercial management
    - financial stability
    - transparent complaints procedure

Each of the principles and requirements is discussed in detail in the following sections.

5.2.1 Non-discriminatory

This means that the assurance scheme body (see Figure 6-1) has to put in procedures which allow universal access to the scheme. That is, anyone can apply the certification once accredited. In addition, these processes must ensure the elimination of any form of discrimination, for example, the delaying or speeding up of applications. The non-discriminatory principle has to be underpinned by a very tightly defined scope of the accreditation offered.

5.2.2 Legal and Regulatory Compliance

This principle is enshrined in the standard and requires the assurance body to modify accreditation procedures in response to legal and regulatory change. This requirement has a profound effect on the structure and scope of the assurance scheme. The structure of the scheme and the organisational model will therefore require the setting up of the mechanism to capture existing legislation and to provide for changes in prospect.

5.2.3 Impartiality

It is required that impartiality be safeguarded throughout the development of a structure which must be designed to enable the participation of all parties significantly concerned in the development of policies and principles regarding the content and functioning of the certification system. For assuring the production of bioethanol to minimum GHG standards, this has been interpreted to mean that the Assurance Scheme Body must include all stakeholders who are involved in the development of this new industry and those organisations which have a view about how this new industry should behave in the marketplace. Furthermore, the structural model must ensure that the scheme body is clearly separated from the entity that runs the commercial side of the scheme, to safeguard against conflicts of interest.

It is also required that within the overall scheme structure, the committee or body responsible for policies and principles should be at the highest level and must have built into its terms of reference, a requirement to ensure that all significantly concerned parties have an opportunity to participate.

5.2.3.1 Balance of Interests

It is also deemed essential that, a balance of interests defined as ‘where no one organisation or industry sector predominates’ is built into the overall structure of the committee responsible for policies and principles. This balance of interests can be chosen from Government, industry, consumers and NGOs. The rules clearly state that representation should be equal and balanced between all participating organisations. In practice, this means equivalence of representation by each sector of the industry and stakeholders. Where more than one sector provides more than one participant to represent separate aspects of the sector's interests, the fact that they come from one sector is deemed to constitute a single interest. This can be interpreted to mean, for example, that the environmental interests can be represented by two bodies each reflecting different aspects of the environmental requirements.

5.2.4 Practical Requirements

5.2.4.1 Legal Entity

Accreditation of the scheme body will only be granted to a legal entity which must have declared scope activities and geographic location. In the UK, this can be achieved through the formation of a company limited by guarantee, where the scope and activities can be clearly defined in the articles of association. Difficulties may arise if the scheme body is part of a larger organisation, particularly with regard to conflict of interest.

5.2.4.2 Distinctive Name

The legal entity must have a distinctive name and this name should appear on the accreditation certificate.

5.2.4.3 Separation of Policy and Commercial Management

The guidance specifically defines the relationships between the policy committee and the commercial management of the scheme. Simply stated, ultimate power lies with the policy committee who have the responsibility for ensuring the proper, impartial running of the scheme. If the advice of the policy committee is ignored by the commercial management committee, the policy committee shall take appropriate measures which may include informing the accreditation body i.e. UKAS. This is an essential requirement for accreditation of the assurance scheme.

5.2.4.4 Financial Stability

There is also a requirement for financial stability which requires the scheme body to demonstrate that it can run the scheme and fulfil its contractual obligations. In practice, this means the submitting of management reports, annual reports, financial reports and financial plans, to the accreditation body. These reporting procedure and paper trail requirements also apply to safeguarding the impartiality of the scheme and demonstrating an absence of conflict of interest.

5.2.4.5 Transparent Complaints Procedure

There is also a requirement for establishing a transparent complaints procedure.

5.3 The Structure of Assurance in the UK

The United Kingdom Accreditation Service (UKAS) is the sole national accreditation body recognised by Government to assess against internationally agreed standards, organisations that provide certification, testing, inspection and calibration services. Accreditation by UKAS demonstrates the competence, impartiality and performance capability of these certification bodies. It should be noted that UKAS has organised similar accreditation processes for verifiers within the UK Emissions Trading Scheme (UK-ETS) and the European Emissions Trading Scheme (EU-ETS). Furthermore, the information and data requirements from biofuel processing plants and logistical operations are virtually identical to the requirements of the verification of the UK-ETS, the Climate Change Agreement Scheme and the EU-ETS.

Accreditation is used worldwide. In most developed economies there is a parallel body to UKAS. UKAS is the UK's signatory to European and International agreements to facilitate the breaking down of technical barriers to trade. It is recognised internationally through European and world multilateral recognition agreements. This recognition enables Government to use accredited bodies to meet obligations under world trading agreements for example, compliance with EU directives and the World Trade Organisation Technical Barriers to Trade Agreement. UKAS represents the United Kingdom on three European and International bodies; namely the European Co-operation for Accreditation, the International Laboratory Accreditation Corporation and the International Accreditation Forum.

Below UKAS we have three accredited certification bodies. These are CMi plc, PAI and EFSIS. These are the only three certification bodies accredited by UKAS for work on assurance schemes in British agriculture. All these organisations have extensive international operations as they are required by the British Retail Consortium to provide certification and assurance services for agricultural products grown overseas and sold in the UK.

These three organisations provide certification for a host of assurance schemes designed to provide consumer reassurance about the quality of products, the production system, the environmental regime, or the general sustainability of a host of agricultural products. For example, the familiar lion mark on eggs is an assurance scheme designed to provide assurance about the safety of eggs.

These assurance schemes aim to help to distinguish products at point-of-sale so that the product can be positioned as having added value and therefore carry a price premium.

Examples of such schemes are LEAF or Tesco's 'Natures Choice'. These provide the consumer with the assurance that the produce carrying this mark has been produced to high environmental standards and command a premium in the marketplace, some of which is passed back to the producer to cover the additional costs of compliance and certification. The supermarket Waitrose for example, pays the farmer a premium for fresh produce grown under the LEAF Marque scheme.

5.3.1 Examples of Assurance Schemes

5.3.1.1 The British Food Standard

The red tractor is a logo which denotes compliance with the British Food Standard. This is an assurance scheme which covers six sectors of agricultural production

- beef and lamb
- pork
- poultry
- dairy products
- the vegetables
- cereals and oilseeds
- sugar

The main criteria and measures which are covered within the British Food Standard include

- pesticide handling and application
- fertiliser storage and application, including the use of organic fertilisers such as sewage sludge
- grain storage
- hygiene
- haulage of grain from the farm
- the assurance that the product is free from genetically modified crops

The scheme body Assured Food Standards (AFS) is an independent organisation set up to manage the red tractor logo. AFS is run by an independent Chairman and Board of Directors, which includes all the major stakeholders of relevance to this sector. The stakeholders include

- the retail and food processing sectors
- academia
- consumer bodies
- environmental NGOs

It is a requirement that any scheme recognised by Assured Food Standards must operate to the international standard by ISO Guide 65 EN 45011.

For cereals or oilseeds and pulses, the assurance scheme uses the Assured Combinable Crops Standards (ACCS).

The cost of the scheme is borne entirely by the farmers whose costs for participation in the scheme range from £120 to £170 per annum.

The literature reports that the participation by arable farmers in this scheme is over 80%. However, recent discussions with the scheme operators suggest that participation is now almost universal.

5.3.1.2 The Soil Association

The Soil Association symbol can be found on over 70% of the organic produce sold in British shops and is the most widely recognised organic standard logo.

The presence of the logo on an organic product is perceived by British consumers as a guarantee that the product has been grown to the highest standards of organic integrity.

Whilst the Soil Association is the scheme body, Soil Association Certification Ltd enforces these standards through certification and regular inspections of producers, processors and suppliers.

The scheme itself covers the following key areas

- farming and growing
- fertiliser production
- agricultural production methods and systems
- on-farm packaging and processing
- food processing and manufacturing
- abattoirs
- food processors including overseas
- restaurant and caterers
- retailers

In addition, this scheme covers education and training courses, health and beauty care, textiles and wood and paper products.

Farmers and growers apply to become Soil Association Certified and carry the cost of certification. Certification includes annual inspections to ensure that the organic standards are being met.

All these assurance schemes work with UKAS accredited certification bodies such as Cmi plc, PAI or EFSIS, who are themselves accredited certification contractors.

The importance of UKAS, is that as the accreditation body at the peak of this pyramid, it ensures full European and International compatibility. This means that very many of these assurance schemes apply to both UK and overseas production systems. It should also be recognised that owing to the structure of the UK food industry, with its high levels of international trade, the certification bodies have had of necessity to develop an international capability. Whether beans are grown in Zambia or Kent, the same assurance system applies and often the same certification companies undertake the inspections. However, this generally applies to fresh produce at this stage and not crops suitable for bioethanol production, such as grains and sugar cane. Discussions with the certification bodies confirm that the current systems could accommodate these crops.

Another analogous system of assurance has been developed for forestry products although the developments within this sector have often been undertaken without direct reference or the involvement of UKAS. This has resulted in the situation whereby an assurance scheme and its operator can often be the accreditation body also. This potential conflict of interests is now being corrected.

6 Conclusions

6.1 An Assurance Scheme Board – Engaging with Stake Holders

The design of the proposal scheme has leant very heavily on the advice contained in the EN 7/02. The design of the scheme, as set out below, is believed to be compliant with this guidance.

The Assurance Scheme Body will be represented by the scheme board, comprising a broad representation of the key stakeholders (Figure 6-1). Initially, the board will comprise two members from each of the following stakeholder sectors

- environmental NGOs
- representative of the 'expert panel' (Figure 6-1)
- farmers and growers
- bioethanol producers
- oil companies and fuel suppliers
- car manufacturers who have an interest in marketing flexi-fuel cars

Consideration should be given to whether statutory or regulatory bodies, Government and consumer groups should also be included. At the time of writing, the Government's position was still undecided, with regard to the role of assurance within the RTFO and it was agreed that Government representation within the scheme board would be acceptable. Further advice is being sought as to the inclusion of statutory bodies.

The guidance allows for more members to be included within each sector, provided that the overall balance of interests is maintained.

It is envisaged that the areas to be supervised by a Carbon Accreditation Scheme would be agreed by the Board and then applied via the existing UK Assurance Certification procedures.

6.2 Recommendations for a proposed Scheme Structure for GHG Accreditation and Assurance

Based upon the published guidance and discussion with a Steering Group of this assurance scheme, the proposed scheme structure is set out in Figure 6-1.

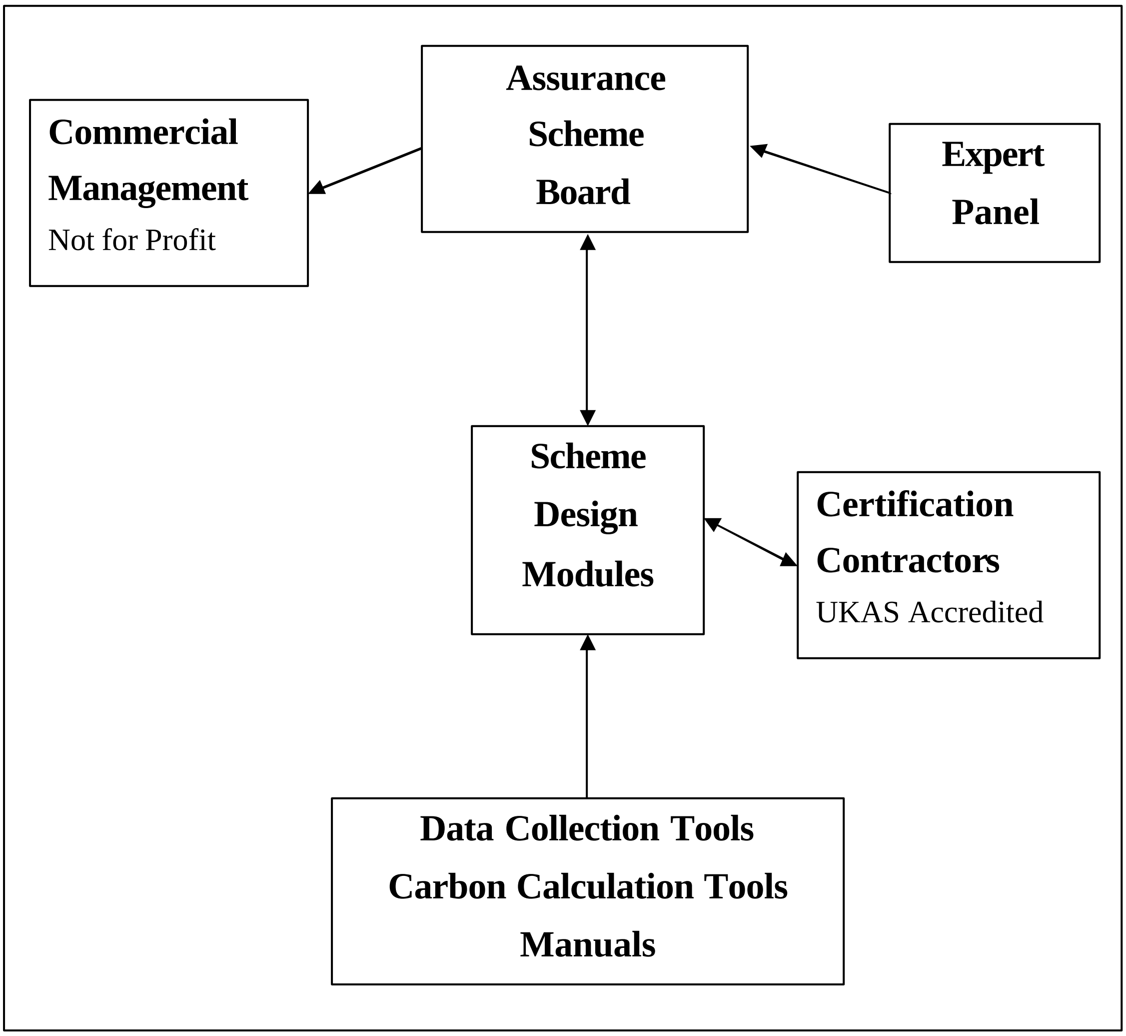

Figure 6-1: Assurance Scheme Structure

6.2.1 The Expert Panel

The science underpinning GHG certification is in continuous development and it is essential that the scheme board be advised about the latest developments and other scientific matters pertaining to their activities. With this in mind, it is proposed to set up a scientific panel of 'experts' to provide up-to-date and impartial advice to the scheme board, regarding the issues and developments in carbon certification and environmental and social assurance.

6.2.2 Commercial Management

A not-for-profit commercial entity will be set up alongside the scheme board to organise and run the scheme under its guidance. This not-for-profit organisation will be responsible for commissioning, organising and supervising the relationships between the Assurance Scheme Body and certification contractors.

6.2.3 The Certification Contractors

The certification contractors will be responsible for data collection and auditing of farms and processing plants. The choice of contractor will be based on the principle of the best practitioner. All contractors will need to be UKAS accredited. Issues such as current market coverage, international expertise and overall competence will determine the choice of contractor. The research to date suggests that two contractors will be required, one with expertise in farm auditing, both in the UK and internationally and a second which will have to demonstrate expertise and competence in the auditing of processing plants.

6.2.4 Scheme Design Modules

A range of scheme design modules have been developed, including data collection sheets and a GHG calculation tool.

6.2.5 The Scope of the Scheme

The determination of the scope of the scheme is at the discretion of the assurance scheme board. It is the primary function of this board, to define the scope and boundaries of the scheme. Much preliminary work has been undertaken, legal advice obtained and discussions within the Steering Group regarding the scope of the scheme. The project ended primarily focusing on GHG certification because this data was relatively easy to collect, analyse and develop into a model during the short timescale for the project. However, on advice from stakeholders, particularly the environmental bodies, other measures of sustainability have been proposed. The matter of the incorporation of other sustainability measures has been complicated by the current questions surrounding the assurance requirements in the RTFO. Notwithstanding this, it was agreed that the scheme board would take as one of its first tasks, the need to discuss how to progress work on incorporating environmental sustainability standards.

It is important to recognise that this scheme is designed to measure environmental performance, particularly with regard to GHG performance and is not an absolute standard. Whilst it is considered that there should be a base level of compliance, the assurance scheme is designed to encourage progressive improvement throughout the production chain. By measuring and reporting back it is envisaged that agronomic and production plant performance will be encouraged to improve over time. It is vital for the development of the industry that this principle is enshrined in the scope of the scheme.

It must be recognised that, in the case of bioethanol, its presentation to the consumer, particularly with regard to E85, will be on the basis of GHG performance and environmental and social sustainability.

6.2.6 Future priorities

A consideration of the environmental and social measures in detail requires the following issues to be evaluated more fully (see also Appendix 4, section 5.2).

6.2.6.1 Land Use Change

It is recognised that land use change has two major impacts, firstly with regard to GHG performance, particularly where formerly uncultivated land is converted to arable or plantation cropping. This can result in large emissions of GHGs into the atmosphere, which can greatly outweigh the carbon emissions saved by using the biofuels produced. It is vital that the scheme captures land use change as an essential input into the GHG performance measuring tools.

Land use change can also have a severe and detrimental effect on biodiversity, particularly in tropical countries where plantation agriculture is expanding into areas of pristine natural habitat. In the UK, it is unlikely that land use change with regard to bioethanol feedstocks growing, will be a significant feature for some years to come. This is because it is envisaged that the market will rely on the current export surplus of grain as its primary raw material during the market development phase (Turley et al, 2005).

6.2.6.2 The Optimisation of Inputs and Management Practices

The GHG performance measurement tool as currently configured, captures fertiliser, pesticide and diesel usage. The tool provides diagnostic information to the farmer, regarding the usage of these inputs and the detrimental effect they have on the agronomic GHG performance. By configuring the scheme on GHG measurement principles (not on an absolute standard), a grower can improve his performance by optimising inputs, particularly fertiliser applications, which are a strong influence on the overall GHG balance. As well as optimising GHG performance, the reduction of inputs has an immediate economic benefit to the farmer. Thus, by providing suitably audited annual measurements of performance, the market is encouraging improved environmental performance through better targeting of agrochemical inputs.

However, it may not be possible to assure optimisation of inputs and management practices through GHG indicators alone, and it may also be necessary for an environmental standard to incorporate additional safeguards, for example by requiring farmers to produce nutrients, soil and crop protection management plans. Some of these are already required under existing assurance schemes, such as the ACCS.

6.2.6.3 Wildlife Enhancement

The issue of the encouragement of wildlife enhancement methods and practices, such as conservation headlands, over-winter stubbles, skylark plots or buffer strips requires careful consideration.

At this stage in the development of the assurance scheme, the Scheme Board will have to consider the role and purpose of wildlife enhancement measures. On land that is currently used for cereal production, it would be difficult to adopt wildlife enhancement measures as an environmental baseline, although they could be included as a higher standard in 'premium' biofuel products if this market develops. Where land use change has taken place, such as the planting of cereals on un-cropped set-aside, then there could be an argument for their inclusion as a baseline standard, to mitigate against the environmental impacts of crop production on this land. There are likely to be similar issues associated with crop production in other parts of the world and attention will need to be paid to developing a standard that can be applied internationally.

Suffice to say at this stage, wildlife enhancement and the encouragement of biodiversity could become an important differentiator in the marketplace. In the context of 5% blends, not identified at point of sale, it is difficult to see discussion of wildlife enhancement as an important issue. However, in the context and the mindset of a purchaser of a flexi-fuel car who is keen to see maximum environmental performance from the fuel used, wildlife enhancement could be an important issue.

6.2.6.4 Social Issues

As part of the development of an assurance scheme, social issues have also been discussed by the Steering Group. This is a challenge for international trade to meet accreditation ratings. Social issues such as child labour, Health & Safety and pollution are key concerns for the consumer but are less easily quantifiable.

6.2.7 Conclusion

UK agriculture has the potential to produce 2 to 3 million tonnes of biofuel (bioethanol and biodiesel) without disruption of land use or existing habitats.

Food Assurance Schemes will permit easy transition to Carbon Accreditation Schemes to validate claims.

The first priority is to start GHG accredited assurance and certification, then to address GHG ratings, environmental issues and social issues.

The development of bioethanol certification sets the standard in the EU for a coherent and effective approach to GHG accreditation and to ensure future GHG improvements.

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Appendix 1. Carbon Accreditation Steering Group Members

Bioethanol Ltd	Mike Eyre, Andrew Morris
Cmi plc	Paul Calver
Wessex Grain Ltd / Green Spirit Fuels Ltd	Malcolm Shepherd, Carol Bowman
Bronzeoak Ltd	Jessica Chalmers
British Sugar plc	Clare Wenner, Anthony Sidwell
Green*ergy* International Ltd	Donna Clarke
HGCA	Alastair Dickie, Rebecca Geraghty, Dr Mairi Black
English Nature	Anna Hope
Imperial College	Dr Jeremy Woods
WWF	Andrea Kaszewski
Friends of the Earth	Katie Elliot
NFU	Matthew Ware
RSPB	Lucy Bjork, Richard Oxley
British Biogen	Peter Billins
Edinburgh Centre for Carbon Management	Dr Richard Tipper, Aino Innkinen

Appendix 2. Overview of Published Research

Dos Santos (1997) Energy Analysis of Crops Used for Producing Ethanol and CO_2 Emissions

Description

This study is an assessment of the energy balance and greenhouse gas emissions of bioethanol production from different feedstocks, including: sweet sorghum, corn, sugar beet, wheat and sugar cane. It is a fairly brief desk-based study, which is based entirely on existing literature, and applies to the situation in the early to mid-nineties depending on the studies used.

Methodology

The methodology used is not defined, but appears to be based on the methodology used in the sources of data used. Life cycle stages included are agricultural production and processing, fuel production, and in some cases, transport and fuel use. Allocation is not discussed but is accepted directly from studies where it is applied.

Overall, the report is a summary of a few studies, with little discussion of methodology or source selection.

Summary of Results

Ethanol from sorghum

- 1.1024 tC/ha

Ethanol from corn

- 135.18 tC/ha

Ethanol from sugar beet

- 1.335 tC/ha

Ethanol from wheat

- 1.96 tC/ha

Ethanol from sugar cane

- 0.377 tC/ha (from Macedo 1991, 1996)
- 0.422 tC/ha (own study)

Macedo (1998) Greenhouse Gas Emissions and Energy Balances in Bioethanol Production and Utilization in Brazil; IFEU (2003)

Description

This study is a review of an energy balance and emissions assessment of Brazilian sugar cane ethanol undertaken in 1992. This study updates the original figures with additional emission sources and more current technology, as well as more recent yield figures for sugar cane harvest and ethanol production.

Methodology

The methodology for calculating energy balance and emissions is not clear from this study but refers to previous work by the same authors. It is deemed acceptable by IFEU (2003) in its study of biofuels and meets its criteria of: covering standard life cycle stages; presenting primary data; being the most recent work by the author on the topic; is not purely based on other authors' work; is up to date.

Credit is given to bagasse substituting for fossil fuel, but no other allocation is made. Certain life cycle stages are incomplete, and therefore IFEU (2003) have added the impact of fertiliser production to Macedo's results.

Summary of Results

For ethanol from sugar cane:

- Emissions are given for the whole life cycle for the total bioethanol from sugar cane produced in Brazil in 1996. This includes credit for the use of the co-product bagasse, and tailpipe emissions. For 13.7 million m^3 of bioethanol, the life cycle emission is calculated as -46.7 million tonnes of CO_2. This translates as -3.41 million tonnes CO_2 per m^3 of bioethanol.
- The production stage covers fuel use on plantations, which is 33.08 $kgCO_2e/t$ bioethanol delivered, and fertiliser production and use as 150.57 $kgCO_2e/t$ bioethanol delivered.
- Full life cycle energy balances are given, updated for 1996. From this, emissions for other cultivation stages are extrapolated using information in IFEU (2003) and MCT Brazil (2002) to give 26.67$kgCO_2e/t$ bioethanol delivered.

Macedo et al (2004) Assessment of Greenhouse Gas Emissions in the Production and Use of Fuel Ethanol in Brazil

Description

This study is a follow-up from previous energy and greenhouse gas balance studies of the sugar cane to ethanol biofuel pathway in Brazil. This report is part of an initiative to develop a country-wide database of all bioethanol-related activities and to assess the benefits of the bioethanol industry in energy and greenhouse gas emission terms. The study presents the life cycle analysis of GHG emissions in the production and use of ethanol under the typical conditions found in Brazilian sugar industry and ethanol mills today. The data used in this update were collected in 2002, using older data where still relevant.

Methodology

Two scenarios are considered in the analysis: Scenario 1 reflects current typical practice; Scenario 2 reflects best available values. (Scenario 1 is considered here). The energy flow assessment is split into three boundary levels, to determine where the greatest energy use and greenhouse gas emissions arise. The life cycle stages are split into four groups:

- Group 1: carbon flows associated with the uptake of atmospheric carbon by photosynthesis and its gradual release by oxidation (the flows in and out of this 'group' are declared neutral)
- Group 2: carbon flows associated with the use of fossil fuels in the production of all chemicals and inputs used in the agricultural sector and industrial sectors for the production of sugar cane and ethanol, as well as in the manufacture of equipment, construction of buildings and their maintenance (the latter are discounted in our current study as these are outside required boundaries)
- Group 3: those GHG flows not associated with the use of fossil fuels e.g. N2O emissions from the soil
- Group 4: 'virtual' flows of GHG emissions, i.e. what would take place without ethanol and bagasse. This is the baseline case, but for the purposes of determining well-to-tank emissions, only the bagasse credit has been included in the bioethanol processing phase

The data used is the most recent available from national agricultural statistics, the sugar industry and ethanol industry to give a representative view of the current situation in Brazil. The analysis and results are presented in a transparent way with main workings and assumptions set out in appendices.

Allocation is depicted using diagrams and explained further in appendices with details of substituted products. However, topics such as uncertainty are skirted. Nonetheless, this study provides the most up to date and comprehensive review of the energy and greenhouse gas balances in the sugar cane to bioethanol pathway.

Summary of Results

For ethanol from sugar cane:

- Fossil fuels (scenario 1) 19.2kg CO2e/tonne cane
- Methane and N2O from trash burning (scenario 1) 9kgCO2e/tonne cane
- Soil N2O (scenario 1) 6.3 kgCO2e/tonne cane
- Total emissions (scenario 1) 34.5 kgCO2e/tonne cane, translates to roughly 505.25 kgCO2e/tonne bioethanol delivered (excluding credits from surplus bagasse use)
- Disaggregating the feedstock production component from these data results in a total of 369.05 kgCO2e/tonne bioethanol

DTI (2003) Technology Status Review and Carbon Abatement Potential of Renewable Transport Fuels in the UK

Description

A review of technology status for the production of renewable transport fuels (RTFs) in the UK. The paper discusses the possible progression in technologies required for the production of increasing quantities and different types of RTFs, and analysing the costs of the different RTF options and their potential contribution to reducing GHG emissions from the UK transport sector. It is a desk-based review and compilation of renewable transport fuel studies up to the year 2002, drawing heavily on the biofuels report done by General Motors et al in 2002.

Methodology

The DTI study reviews existing Renewal Transport Fuel Chains on a Well to Tank basis (WTT) and includes the following life cycle steps for each fuel:

- feedstock production
- feedstock transport
- fuel production
- fuel distribution

Status and impacts of transport fuels are determined from existing studies, where the selected studies represent best available evidence.

Allocation to co-products is discussed, but co-products are considered more in terms of their potential value and potential for use, and as they are treated in the selected studies.

Uncertainty is not dealt with as the study does not use primary data, and relies on the methodology of the studies reviewed.

Summary of Results

For ethanol from sugar beet:

- Emissions for the life cycle stages are given as high, medium or low figures, according to the data available from selected studies. For the feedstock production stage, including transport to the processing facility, these are as follows: 24 kgCO2e/GJ EtOH (low), 25 kgCO2e/GJEtOH(medium), 33 kgCO2e/GJEtOH(high);
- One of the studies used for these figures does not extract production figures alone and therefore each production figure includes transport;
- Emissions are not disaggregated between stages in production;
- Allocation is not consistent throughout selected studies.

For ethanol from wheat:

- Emissions for the life cycle stages are given as high or low, according to studies selected. For the feedstock production stage (excluding transport) the values are as follows: 8 kgCO2e/GJEtOH (low), 15 kgCO2e/GJEtOH (high);
- Transport emissions are: 1.2 kgCO2e/GJEtOH (low), 1.6 kgCO2e/GJEtOH (high);
- Emissions are not disaggregated between stages in production;
- There is no allocation to co-products.

IFEU (2004) – CO_2 Mitigation through Biofuels in the Transport Sector

Description

This study analyses and compares all international, publicly accessible publications about all road transport biofuels currently in use. Through a rigorous selection process 63 of over 800 studies are identified as useful and appropriate for the work, and from these 106 energy and CO_2 balances are extrapolated and described.

Methodology

Studies with information relating to energy, greenhouse gas and other life cycle impacts of biofuels were identified for review. Publications were excluded on the following basis:

- no primary data were presented in the publication, all findings are based on a detailed study that itself is considered in the investigation;
- more recent publications by the same authors are available;
- the publication considers exclusively data from other authors, rather than primary data;
- the publication is no longer up to date;
- relevance.

The life cycle stages considered cover agriculture (feedstock production), transport of agricultural products, conversion to biofuels, biofuels distribution, fuel use. These can vary slightly depending on the studies chosen for analysis.

Credit is given to co-products through substitution but the allocation calculation process is not shown.

The IFEU study also aims to make energy and greenhouse gas emissions analyses comparable between fuels and studies, and therefore sometimes add to studies or adjust them where detail is lacking. These additions can take the form of new calculations, adjustments based on information given, or new estimates where findings are incomplete or unrepresentative.

Summary of Results

Greenhouse gas savings are given as a range to reflect different studies and production methods, for the full biofuel life cycle. Some disaggregation is shown in the German language appendices, but only in graphical form.

Ethanol from sugar cane

- 100 – 160 tCO_2e/ha saved (i.e. a negative emission number is given)

Ethanol from sugar beet

- 35 – 110 tCO_2e/ha saved

Ethanol from wheat

- 10 – 40 tCO_2e/ha saved

Mortimer et al (2004) Energy and Greenhouse Gas Emissions for Bioethanol Production from Wheat Grain and Sugar Beet

Description

The study is a greenhouse gas emission and energy balance assessment for the production of bioethanol in the UK from various readily available feedstocks using different production methods. These energy and greenhouse figures are compared with equivalent fossil figures to determine the potential environmental benefits available from the use of biofuels.

Methodology

The study compiles information from reviewed sources into disaggregated cradle-to-grave profiles of the selected feedstock to biofuel pathways. The following life cycle stages are included: cultivation and harvesting (including inputs to this stage); transport and storage of feedstock (if required); pre-processing; conversion to biofuel and distribution to end use.

Data sources are thoroughly reviewed to include only "best available evidence", and all calculations, sources and assumptions are clearly stated. All process co-products are accounted for, and allocation is extensively discussed and where used, justified and transparent.

Summary of Results

All results from greenhouse gas emission assessments are disaggregated, making life cycle stages between biofuel processes readily comparable.

Ethanol from wheat (UK) - standard agricultural practice

- fertiliser 0.00464 kgCO_2e/MJ bioethanol; fuel use on farm 0.00232 kgCO_2e/MJ bioethanol; other cultivation 0.00232 kgCO_2e/MJ bioethanol; pre-processing 0.0058 kgCO_2e/MJ bioethanol

Ethanol from sugar beet (UK) - standard agricultural practice

- fertiliser 0.0076 kgCO_2e/MJ bioethanol; fuel use on farm 0.0012 kgCO_2e/MJ bioethanol; other cultivation 0.0008 kgCO_2e/MJ bioethanol; pre-processing 0.0004 kgCO_2e/MJ bioethanol OR 0.0028 kgCO_2e/MJ bioethanol (including diffusion)

LCVP (2004) WTW Evaluation for Production of Ethanol from Wheat

Description

The LCVP report was prepared by a combined industry and academic group with an interest in bioethanol. It is a study aiming to create a new well to wheel evaluation of bioethanol production from wheat, with a specific focus on the potential for producing bioethanol in the UK.

Methodology

The LCVP work is based on existing studies, but also incorporates some additional input from current experts in biofuel life cycle analysis. A number of processing pathways are considered in the context of possible UK bioethanol production capacity development, based on three basic models:

- model a uses a natural gas-fired boiler and grid electricity
- model b includes the addition of CHP capability to the energy balance
- model c includes CHP capacity using straw from the wheat cultivation

The outputs of the models are also affected by the treatment of distillers' dark grains with solubles (DDGS) which can be treated as waste, a source of energy or an animal fodder.

The standard life cycle steps are considered in line with the background literature that much of the study is based upon. This literature is the most recent in the field of life cycle emissions assessments of bioethanol pathways, and any additions to this literature base is transparent and referenced.

All workings and assumptions are clearly set out and the problem of allocating emissions to by- and co-products thoroughly reviewed. The working group's selection of substitution methodology is in line with current academic thinking on preferred allocation methodology. The different model scenarios use different pathways for the use of straw, where the allocation is internalised in the life cycle assessment. All scenario results are also shown without any allocation, and with DDGS in different end uses.

Summary of Results

Wheat is the only bioethanol feedstock considered in this study. These data show the well to tank analysis results of the basic model a scenario without allocation to by- and co-products (allocation for DDGS use is only done in the manufacture stage).

- Without credit for by- and co-product: farming (CO2) 795 kgCO_2e/t EtOH; farming (N2O) 564 kgCO_2e/t EtOH; transport and drying 208 kgCO_2e/t EtOH

Appendix 3. Overview of Environmental Impact of Cereal and Oilseed Cropping in the UK

Home Grown Cereals Authority (HGCA) / Central Sciences Laboratory (CSL) – Environmental Impacts of Cereal and Oilseed Rape Cropping in the UK and Assessment of the Potential Impacts Arising from Cultivation for Liquid Biofuel Production. Authors: Turley, McKay and Boatman (2005)

The Environmental Footprint Study was commissioned by the HGCA and carried out by CSL. It is a desk based study which reviews current literature in the context of the environmental effects of existing on-farm practices for the production of cereals and oilseed rape for food and feed uses. The study proposes potential land change and production scenarios for growing cereals and oilseed rape for biofuels.

Methodology

The report reviews the main environmental impacts of cereal and oilseed rape cropping from current growing practices

- pesticide use
- fertilizer use
- soil impacts
- air impacts
- water impacts
- biodiversity impacts

The report then reviews the following potential scenarios for land use for the growing of cereals and oilseeds for biofuels

- production of biofuels crops takes place on arable land replacing the same, or other crops grown for food use
- production of biofuel crops takes place on set-aside, utilising landed deemed 'surplus to current requirements'

Five case studies have been assessed for their potential environmental impact

- Case 1 – Oilseed rape for biodiesel replaces conventional oilseed rape crop
- Case 2 – Wheat for bioethanol replaces conventional wheat crop

- Case 3 – Replacement of natural regeneration set-aside with oilseed rape
- Case 4 – Replacement of natural regeneration set aside with wheat
- Case 5 – Replacement of break crops by oilseed rape

Summary

The report sets out to determine the environmental impact of using cereals and oilseed rape for biofuels in the UK. It benchmarks current production and shows that biofuels can make a real difference to both energy efficiency and carbon levels. It also looks at where more improvements can be made.

The report shows that compared to fossil-derived petrol, bioethanol from wheat has the potential to reduce energy inputs by 61% and total greenhouse gas emissions by 65% for each megajoule of energy created. Similarly, biodiesel from oilseed rape has the potential to reduce energy inputs by 66% and total greenhouse gas emissions by 53%.

The report looks at cropping trends, inputs, environment and biodiversity. It concludes that there is little difference in the environmental impact of growing crops for food or biofuel use. There may be some scope to reduce environmental impact if biofuel buyers accept different quality and grain protein specifications. This could allow, some inputs, such as nitrogen, fungicides and insecticides to be reduced.

The study has also concluded that significant land use changes in the UK as a result of growing crops for the biofuels industry are not anticipated in the short to medium term owing to the current wheat export surplus of between 3-4 million tonnes annually. This is sufficient to produce 1 million tonnes of bioethanol or 10 production plants of 100,000 tonnes annual output.

Appendix 4 The Bioethanol Greenhouse Gas Calculator

Please refer to the PDF file “Bioethanol Greenhouse Gas Calculator” on ***www.hgca.com***

Appendix 5 Sample of UK Food Assurance Checklist

Please refer to the PDF file "CMi Assessment Checklist" on ***www.hgca.com***

Appendix 6. Consumer Perceptions of Biofuels: Omnibus Survey

HGCA undertook quantitative research with car drivers on the subject of biofuel in order to help the industry focus future marketing efforts.

The research was specifically aimed at:-

- Evaluating consumer understanding of the term biofuel
- Identifying the strongest communication messages
- Establishing propensity to purchase biofuel and at what price

The research comprised five questions in the weekly TNS Omnibus survey, with fieldwork taking place between 3rd and 7th September 2004.

From the original sample of 1,100 adults, there were 682 car drivers who took part in the survey.

Results

- Nearly half the sample (46%) had not heard of biofuel or could not define it – suggesting there is a low level of awareness for it amongst drivers
- There are signs of some polarisation between those who are aware of biofuel – males/ older/ ABC1's; and those that aren't aware – females/ middle age/ C2DE's. There are also some signs that the younger age groups are perhaps the most sceptical – they are least likely to buy and if they do, they want to pay less
- Nearly one in four respondents (37%) felt that the 'safer for the environment' message would be the strongest for communication, but not from Government! Scientists are perceived as the most trustworthy source of information followed by existing fuel companies and then independent sources and pressure groups. Government comes fifth on the list
- While 74% of respondents would be likely to change garage for Biofuel if it were at an 'acceptable' price to them, when it comes to the price they would be prepared to pay, 59% would only pay the same or less than the price of unleaded. Nearly one in five (18%) said they would be prepared to pay more. Given that nobody likes to pay more for anything, one in five would seem a healthy base to launch any potential Biofuel campaign.