Department for Transport

# Carbon and Sustainability Reporting Within the Renewable Transport Fuel Obligation

# Requirements and Guidance

## Government Recommendation to the Office of the Renewable Fuels Agency

January 2008

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# 1. Executive Summary

## The Renewable Transport Fuel Obligation

The Renewable Transport Fuel Obligation (RTFO) is one of the Government's main policies for reducing greenhouse gas emissions from road transport. The RTFO will commence on 15 April 2008 under the Renewable Transport Fuel Obligations Order 2007 (2007 no 3072) ("the RTFO Order") and is intended to deliver reductions in carbon dioxide emissions from the road transport sector of 2.6 - 3.0 million tonnes per annum (equivalent to carbon savings of 700,000 - 800,000 tonnes) by 2010, by encouraging the supply of renewable fuels.

The greenhouse gas (GHG) and sustainability impacts of different biofuels vary significantly. The GHG benefits of biofuels depend, among other things, on the system of cultivation, processing and transportation of feedstock. The introduction of biofuels can also lead to unintended negative environmental and social impacts. Maintaining public confidence in biofuels requires Government and the biofuels industry to find effective ways to manage the potential negative impacts of their increased demand.

## The Reporting framework

To encourage suppliers to source sustainable biofuels the Government proposes that the Office of the Renewable Fuels Agency (RFA) should require biofuel suppliers to submit reports on both the net GHG saving and the sustainability of the biofuels they supply, in order to receive Renewable Transport Fuel Certificates (RTFCs). The Government recommends that these reports should address the *direct* impacts arising from biofuel cultivation that are potentially within the influence of companies sourcing or producing biofuels through effective supply chain management. The Government will ask the RFA to report to the Secretary of State on any potential *indirect* impacts of biofuel production, such as indirect land-use change or changes to food and other commodity prices that are beyond the control of individual suppliers, of which it becomes aware.

The Government believes that a reporting framework will encourage the supply of those biofuels which deliver a high level of greenhouse gas savings in a sustainable way. The Government also sees the reporting framework as an essential 'stepping-stone' towards a mandatory assurance scheme. The Government announced on 21 June 2007 that it:

i. aims to reward biofuels under the RTFO **in accordance with the carbon savings that they offer from April 2010**, provided that this is compatible with World Trade Organisation rules and EU Technical Standards requirements, and is consistent with the policy framework being developed by the European Commission as part of the review of the Biofuels Directive, and subject to consultation on its environmental and economic impacts

ii. aims to reward biofuels under the RTFO **only if the feedstocks from which they are produced meet appropriate sustainability standards from April**

**2011**, subject to the same provisos and consultation as above and subject to the development of such standards for the relevant feedstocks.

This first step is necessary due to the currently limited availability of data and the need to test the robustness of the criteria and methodology in the absence of comprehensive internationally agreed standards. There are also concerns that the unilateral adoption by the UK of a mandatory assurance scheme at this early stage could be challenged under World Trade Organisation rules.

The Government recommends that the RFA should allow transport fuel suppliers, at least initially, to report that they do not have information on the sustainability or otherwise of their biofuel. This is in recognition of the fact that it may be difficult to provide information for some fuels – particularly those purchased on the spot market. The Government recommends, however, that the RFA should keep this matter under review as supply chains mature.

The Government recommends that the RFA should require annual, independently verified reports of overall supplier performance from suppliers applying for certificates. These reports will demonstrate suppliers' performance in sourcing sustainable biofuels with good GHG savings[1].

## Targets

The Government has set targets for three key aspects of the reporting scheme. The targets will not be mandatory but will illustrate the level of performance which the Government expects from fuel suppliers. The Government expects suppliers to strive to meet these targets but there will be no penalties for failing to meet them.

| **Annual supplier target** | **2008-2009** | **2009-2010** | **2010-2011** |
|---|---|---|---|
| Percentage of feedstock meeting a Qualifying Environmental Standard | 30% | 50% | 80% |
| Annual GHG saving of fuel supplied | 40% | 45% | 50% |
| Data reporting of renewable fuel characteristics | 50% | 70% | 90% |

The Government will keep these targets under review in the light of suppliers' performance

[1] It is recommended that suppliers claiming fewer than 450,000 RTFCs in an obligation period will not need to submit an annual report.

in meeting them and other developments. The Government will give notice of any modifications.

The Government recommends that the RFA should publish reports of individual supplier performance on GHG savings and sustainability on an annual basis and possibly more frequently. The RFA may also wish to make available other information on the environmental impact of the RTFO including information from annual and monthly carbon and sustainability (C&S) reports that identifies individual suppliers. The Government recommends that, in a manner which is consistent with the requirements of the Freedom of Information Act 2000 and Environmental Information Regulations 2004, the RFA should make information available in a way that is accessible to consumers and which could inform their purchasing decisions. The Government recommends, however, that in compiling this information the RFA should recognise the commercial sensitivity of information such as individual suppliers' sales volumes or information from which individual suppliers' market shares can be deduced.

## Reporting Requirements

The Government recommends that the RFA should require obligated suppliers who wish to claim RTFCs to submit monthly and (if they apply for 450,000 or more certificates in an obligation period) annual C&S reports. The Government recommends that the RFA should require monthly reports to be submitted by the 15th day of the month following the month in which the fuel was supplied. This would mean that, for example, reports for the period 15 June 2008 to 14 July 2008 (inclusive) would be due by 15 August 2008. The Government recommends that the RFA should require non-obligated suppliers to report whenever they wish to claim RTFCs.

Under the RTFO Order each obligation period is one year ending on the 14 April, with the first ending on 14 April 2009. The Government recommends that the RFA should require annual reports by the 28 September following the end of the relevant obligation period and that these should be accompanied by an independent verifier's statement. The annual report, unlike monthly reports, will not be linked to the issuing of certificates, but failure to submit an annual report may result in the imposition of a civil penalty under the RTFO Order.

## Monthly reports

As explained above, the Government recommends that the RFA should require obligated suppliers to report monthly on the fuels they have supplied, and non-obligated suppliers to report whenever they wish to receive RTFCs for the fuel they supply. The term "monthly reporting" is used throughout this document to differentiate these reports from annual reports.

The Government recommends that monthly reports should list the "administrative batches" of feedstock or fuel. An "administrative batch" is one with homogenous sustainability characteristics. For example, three tanker movements of fuel with identical sustainability characteristics (e.g. palm oil from Malaysia meeting the requirements of the Round Table on Sustainable Palm Oil (RSPO)) could be reported as a single batch. But a separate

tanker movement of palm oil from Malaysia without any form of assurance would have to be reported as a different batch to the ones above, as its sustainability characteristics would be different. The Government recommends that the RFA should require transport fuel suppliers to use a monthly reporting data sheet along the lines of the one in Table A. It is not recommended that there is a comments section in the monthly reports but suppliers should have the opportunity to provide comments in their annual reports. It is recommended that the scope and format of monthly reports are kept under review.

## Annual Reports

The Government recommends that the deadline for submitting annual reports should be 28 September to better fit with article 23 (5) of the RTFO Order (which sets a deadline for the correction of data found to be inaccurate after it is reported to the RFA). It is recommended that the RFA should keep the format and scope of annual reports under review. It is also recommended that the RFA consider the need for training in order to assist suppliers in completing these reports. In addition the Government recommends the RFA should require annual reports to contain aggregate monthly information and details of the following:

- Actions that have been taken to increase the sourcing of sustainable biofuels and biofuels with a lower carbon intensity, including actions to promote production on idle land
- Environmental management system certificates
- Existing verified environmental / corporate responsibility reporting
- Steps taken by suppliers to obtain more detailed information for reports

## Scope and Principles for RTFO C&S Reporting

### Greenhouse Gas Calculation Methodology

The methodology recommended by the Government is based on a well-to-wheel calculation that includes all significant sources of GHG emissions. This enables direct comparison of fuel chain GHG saving on a like for like basis. Detailed calculations have been made for the principal feedstocks expected to supply biofuel to the UK at the start of the RTFO scheme:

- Ethanol from: sugar cane, sugar beet, molasses, wheat and corn
- Ethanol converted to ETBE
- FAME biodiesel from: tallow, used cooking oil, palm oil, soy and rapeseed
- Biomethane from anaerobic digestion of MSW and manure.

Detailed calculations have also been made for hydrogenated vegetable oil biodiesel from palm oil, soy and rapeseed, although this fuel is not eligible for RTF certificates under the RTFO order as it stands.

The document contains the Government's recommendation to the RFA on the reporting requirements it should put in place for all biofuels currently covered by the scheme and the main feedstocks for their production. The Government is likely to extend the RTFO order to

other renewable transport fuels if they are introduced into the UK market on a significant scale. It is also possible that new feedstocks or production pathways become available for existing renewable transport fuels covered by the scheme. In these circumstances, the Government recommends that the RFA should develop new default values for these fuels.

The recommended calculation methodology uses default values that provide estimates of the carbon intensity of different fuel chains. This should enable suppliers with specific information about their supply chain to supply additional qualitative or quantitative data to improve the accuracy of the calculation. The Government recommends that the RFA should encourage better reporting of data by applying more conservative GHG savings to high level default values (where little is known about the origin of the supply chain); but typical default factors where the calculation includes more detailed information. This is illustrated in Figure A. This flexible calculation method should provide a practical, cost-effective and credible reporting system. The Government recommends that suppliers should also be required to report on the type of information used in their calculations through reporting the levels 0-5 illustrated in Figure A.

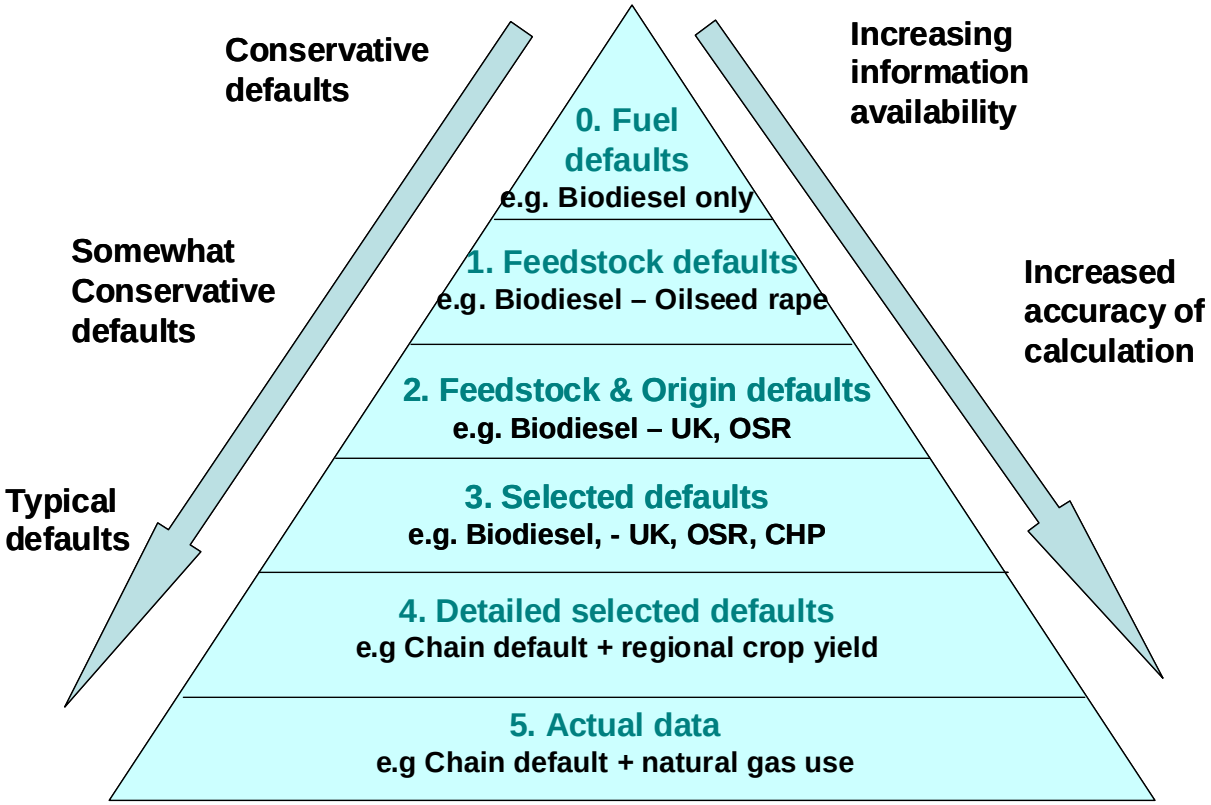
The Government recommends that the RFA should review all default values annually.

**Table A: Monthly reporting summary format – example data**

| General Information | | | | | | Sustainability Information | | | | Carbon Information | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Batch number** | **Internal Batch number (optional)** | **Fuel type** | **Quantity of fuel (litres)** | **Biofuel Feedstock** | **Feedstock Origin** | **Standard** | **Env Level** | **Social Level** | **Land use on 31 Nov 2005** | **Carbon intensity incl LUC g $CO_2e$ / MJ** | **Accuracy level** |
| 33001 | | Bioethanol | 250,000 | Wheat | UK | LEAF | QS | - | Cropland | 61 | 2 |
| 33002 | | Bioethanol | 100,000 | Wheat | France | GlobalGAP | - | - | Grassland | 122 | 2 |
| 33003 | | Bioethanol | 250,000 | Sugar beet | UK | ACCS | QS | - | Cropland | 35 | 5 |
| 33004 | | Bioethanol | 1,000,000 | Sugar cane | Brazil | Meta-Standard | RTFO | RTFO | Cropland | 24 | 2 |
| 33005 | | Bioethanol | 500,000 | Unknown | Unknown | Unknown | - | - | Unknown | 61 | 0 |
| 33006 | | Biodiesel | 1,000,000 | Oilseed rape | UK | ACCS | RTFO | RTFO | Cropland | 55 | 2 |
| 33007 | | Biodiesel | 250,000 | Oilseed rape | Unknown | Unknown | - | - | Unknown | 55 | 2 |
| 33008 | | Biodiesel | 500,000 | Palm oil | Malaysia | RSPO | QS | QS | Cropland | 45 | 2 |
| 33009 | | Biodiesel | 500,000 | Soy | Argentina | Basel | QS | QS | Grassland | 177 | 2 |
| 33010 | | Biodiesel | 250,000 | UCO | UK | By-product | QS | QS | By-product | 13 | 2 |
| 33011 | | Biomethane | 150,000 | Dry manure | UK | By-product | QS | QS | By-product | 36 | 2 |

QS = Qualifying Standard
RTFO = RTFO Meta-standard

**Figure A: Hierarchy of default values used**




## Land use change

Where information on previous land use has been supplied, the Government recommends that the calculation should include the effect on overall GHG savings. Default values for specific land use changes should be based on Intergovernmental Panel on Climate Change guidelines. Where information is not provided (i.e. 'unknown' is reported), the Government recommends that, in the early years of the RTFO, the calculation should **not** require the use of a default value for land-use change impacts. This is because the systems providing assurance on the provenance of fuels are in the very early stages of development, and the Government believes that applying an assumed land-use change carbon impact "penalty" to the fuel in question would be an overly punitive approach. This approach is unlikely to be acceptable in the longer term, however, particularly if biofuels are rewarded on the basis of the amount of carbon saved and if mandatory sustainability standards apply. The Government will make further recommendations on this matter in due course. In the meantime, the Government will ask the RFA to conduct an analysis of the potential emissions associated with 'unknown' land use changes as part of its regular reports to the Secretary of State.

The principal environmental and social risks arising from biofuel production (such as deforestation and loss of biodiversity) arise at the plantation. The Government therefore recommends that the RFA should require transport fuel suppliers to focus on this part of the

supply chain. A future evolution of the scheme may encompass the wider supply chain including processing and transportation of feedstock.

## Environmental and social principles: the "meta-standard" approach

The Government recommends that the RFA should adopt a "meta-standard" approach under which existing voluntary agri-environment and social accountability schemes are benchmarked against an RTFO Sustainable Biofuel Meta-Standard. The Government recommends that the Meta-Standard should comprise the seven principles identified in Table B and that the RFA should benchmark existing schemes against a number of detailed criteria and indicators to assess the extent to which the feedstock produced in accordance with each scheme can be considered sustainable.

**Table B: Environmental and social principles**

| **Environmental principles** |
|---|
| 1. Biomass production will not destroy or damage large above or below ground carbon stocks |
| 2. Biomass production will not lead to the destruction or damage to high biodiversity areas |
| 3. Biomass production does not lead to soil degradation |
| 4. Biomass production does not lead to the contamination or depletion of water sources |
| 5. Biomass production does not lead to air pollution |
| **Social principles** |
| 6. Biomass production does not adversely affect workers rights and working relationships |
| 7. Biomass production does not adversely affect existing land rights and community relations |

As part of the process of developing these recommendations, a comprehensive range of existing standards have been benchmarked as illustrated in Table C. Benchmarked standards that meet the required level of sustainability are called Qualifying Standards. Additional standards should be benchmarked by the RFA in due course as appropriate. The Government recommends that suppliers should be able to report compliance by their feedstock with any standard that has been benchmarked against the Meta-Standard. It is recommended that the RFA establishes a clear process for the regular benchmarking of standards and should review the effectiveness of existing standards on an annual basis. The Government believes that industry and suppliers of feedstocks are best placed to develop new standards. The Government recommends that suppliers should also be able to organise additional supplementary checks to demonstrate that feedstock complies with all the Meta-Standard criteria.

The Government recognises that there are some wider environmental and social issues

(such as land use change arising as an indirect result of biofuel production and/or the impacts of biofuels on commodity prices) that are difficult to monitor and manage effectively at the fuel supplier level. The Government will ask the RFA to report on these potential effects as part of its annual report to Parliament.

**Table C: Benchmarked and Qualifying Standards (see Annex A for further detail)**

| **Benchmarked Standards** | **Qualifying Environmental Standard?** | **Qualifying Social Standard?** |
|---|---|---|
| Linking Environment And Farming Marque (LEAF) | Yes | No |
| Roundtable on Sustainable Palm Oil (RSPO) | Yes | Yes |
| Sustainable Agriculture Network/Rainforest Alliance (SAN/RA) | Yes | Yes |
| Basel criteria for soy (Basel) | Yes | Yes |
| Forest Stewardship Council (FSC) | Yes | No |
| Assured Combinable Crops Scheme (ACCS) | Yes | No |
| Social Accountability 8000 (SA8000) | No | No |
| GlobalGAP | No | No |
| International Federation of Organic Agriculture Movements (IFOAM)3 | No | No |
| Proterra | No | No |

| **Other standards available to report** | **Qualifying Environmental Standard?** | **Qualifying Social Standard?** |
|---|---|---|
| Genesis Crops Module | No | No |
| Scottish Quality Cereals | No | No |
| Qualität und Sicherheit (German Standard) | No | No |
| Fedioil (Finnish Standard) | No | No |

## Treatment of by-products

To minimise the burden on business, the Government recommends that the RFA should not require suppliers to report on criteria where the risk of adverse impacts is minimal. An objective, risk-based metric has been used to develop this principle. Therefore, where a feedstock represents less than 10% of the farm or factory gate value the Government recommends that it should be considered a by-product.

Biofuel producers purchasing these by-products will have little influence on the sustainability of the production process for the original product. For example, a biofuel producer buying tallow will have little or no influence on the standards applied to rearing the cattle. The Government recommends that the RFA should categorise used cooking oil, tallow, municipal solid waste, manure and molasses as by-products and that suppliers should not be required to report on the sustainability standard or land use in respect of biofuels produced from these feedstocks. Instead, the Government recommends that for these feedstocks suppliers should report all general information required and then enter 'by-product' into the remaining sustainability columns within the monthly report. The Government recommends that suppliers should still be required to report the carbon intensity of such fuels, and that this should be derived using the GHG calculation methodology.

## Verification

In order to validate the accuracy of C&S reports a Chain of Custody must be established from the feedstock producer to the fuel supplier. It is recommended that where a qualifying standard operates an existing bulk commodity or mass balance system then that chain of custody method should be accepted for data reporting. However, where such a chain of custody does not exist either a mass-balance approach should be used to set one up, or a book and claim (tradeable certificates) system should be allowed. A "mass balance" approach would require suppliers in the supply chain to account for their product on a "units in – units out" basis but would not require physical separation of certified feedstock or fuel from uncertified feedstock. It should ensure that for every unit of sustainable biofuel sold the corresponding sustainable feedstock has been produced.

A "mass balance approach" requires suppliers throughout the chain to keep input and output records of the feedstock characteristics entering and leaving the plant or process stage. The feedstock or fuel sold will have its C&S characteristics described on an invoice or related document.

The Government recommends that the Chain of Custody used should be specific to the feedstock and standard it represents. It is also recommended that suppliers must be able to demonstrate that the approach they use operates reliably and to the satisfaction of the RFA.

"Equivalence trading" is a practice under the Common Agricultural Policy of the EU under

which crops grown under contract for energy use can be substituted by other material from within the EU which has not been grown under an energy contract. The RTFO will not affect this practice. The Government recommends that the RFA should permit the C&S characteristics of the feedstock to be substituted in such exchanges in line with this operational book and claim system. The Government recommends that the RFA keeps this approach under review in the light of experience. It is recommended that conditions for the transfer of data in an equivalence trade are set by the RFA in order to safeguard against double counting.

The Government recommends that the reliability of claims made in annual C&S reports should be demonstrated through an independent verification (or assurance engagement) and that the verifier's report should be submitted to the RFA with the annual report by the 28 September following the relevant obligation period. The Government recommends that the RFA require that annual reports be verified by auditors who are qualified to carry out audits against the International Standard on Assurance Engagements (ISAE 3000), which defines requirements for limited-scope engagements. The Government also recommends that the RFA should consider cross-referencing existing accredited verifiers for other schemes (such as the EU's Emissions Trading Scheme).

The Government recommends that the RFA should consider making the verifier's statement available to the public, together with the supplier's annual report. The Government also recommends that the RFA should report on the adequacy of the verification arrangements put in place by suppliers.

# Part One: Requirements and Guidance

# 2. Introduction

## The Renewable Transport Fuel Obligation (RTFO)

The UK's Renewable Transport Fuel Obligation (RTFO) will commence on 15 April 2008. It is intended to deliver reductions in carbon dioxide emissions from the road transport sector of 2.6 - 3.0 million tonnes per annum (equivalent to carbon savings of 700,000 - 800,000 tonnes) by 2010, by encouraging the supply of renewable fuels.

The Renewable Transport Fuel Obligations Order 2007 (2007 No. 3072) ("the RTFO Order") imposes a legal obligation on suppliers of fossil fuel for road transport ("obligated suppliers") to produce Renewable Transport Fuel Certificates (RTFCs) demonstrating that an amount of renewable fuel has been supplied which is equivalent to a specified percentage of their total fuel sales. The certificates can be earned from the suppliers' own sales of renewable fuels, or can be acquired from other suppliers of renewable fuels. Alternatively, obligated suppliers can "buy out" of their obligation by paying a buy-out price to the Administrator of the scheme – the Office of the Renewable Fuels Agency (RFA). Suppliers of renewable transport fuels who are not obligated suppliers will also be able to apply for RTFCs.

## Biofuels and the environment

The greenhouse gas (GHG) and sustainability impacts of different biofuels vary significantly. The GHG benefits of biofuels depend, among other things, on the system of cultivation, processing and transportation of feedstock. The production of biofuels can also lead to unintended negative environmental and social impacts. Key issues include potential competition with food crops leading to increased commodity prices. Increased pressure for land may lead directly to deforestation to make way for new plantations with biodiversity impacts and loss of carbon stocks that negate any GHG savings. Changes in land use may also occur indirectly where existing agricultural activities are displaced into forest land by crops for energy.

Some biofuel production has also been associated with social concerns including labour rights, land conflicts and health concerns related to improper use of agrochemicals. Biofuel demand can also create local economic benefits, however, including employment opportunities.

## Managing concerns about biofuels

Maintaining public confidence in biofuels requires Government and the fuels industry to find effective ways to manage potential negative impacts of their increased demand. Most risks can be managed by suppliers through effective assurance schemes that demonstrate that biofuels are sourced sustainably. Competition with food and indirect land use changes should however be managed by national governments and international bodies through other policy mechanisms.

Although there are a number of standards for the sustainable production of some of the

feedstocks used to produce biofuels, there are no internationally agreed standards that define sustainable biofuels. The unilateral adoption by the UK of a mandatory assurance scheme at this early stage could give rise to international trade issues.

Under the RTFO Order it is a pre-condition for issue of an RTFC that a carbon and sustainability report is made to the RFA. The reporting requirement should lead to more information being made public about the impacts of biofuels and should help consumers to compare the environmental and social benefits of the different biofuels supplied to the market.

## About this document

This document is the final version of the Government Recommendation to the RFA on how Carbon and Sustainability reporting should operate under the RTFO. The draft Recommendation was published as a consultation document on 21 June 2007. The consultation closed on 13 September 2007 and this final version of the Recommendation has been amended to take account of the responses received. A summary of responses to the consultation is published by the Government at the same time as this Recommendation and is available at http://www.dft.gov.uk/pgr/roads/environment/rtfo/. As well as inviting written responses, the Government held a number of stakeholder workshops and meetings with individual stakeholders during the consultation period. In parallel, the proposed reporting requirements were piloted with a number of suppliers to test their practical application.

The development of the document was informed by two separate advisory groups comprising representatives from the oil and biofuel industries as well as from environmental NGOs and other key stakeholders. It was overseen by a steering group comprising representatives from the Department for Transport, the Department for Environment Food and Rural Affairs and the Low Carbon Vehicle Partnership.

The detailed contents of the Recommendation derive from two projects by independent consultants to develop:

- a practical methodology for the quantification of the greenhouse gas savings offered by different biofuels; and
- instructions and guidance to enable suppliers both to apply the methodology effectively and to report on the environmental and social aspects of biofuels being supplied to the UK market.

Since the draft Recommendation was published the RTFO Order has been made which implements the RTFO scheme and establishes and appoints the Office of the Renewable Transport Fuels Agency to act as the RTFO Administrator. Final decisions on reporting requirements will be a matter for the RFA which is expected to issue its requirements very shortly.

Suppliers who apply for RTFCs will have to provide C&S reports to the RFA as a pre-condition of certificate issue. The information that is reported requires the engagement of the renewable fuel supply chain and therefore several chapters are also relevant for other entities involved in the production and distribution of biofuels including agricultural

producers, fuel refiners, traders and distributors.

This document is in two parts.

## Part One: Requirements and Guidance

Part One sets out the Government's recommendations for the detail of the reporting scheme including how and what parties should report. Recommendations about reporting frequencies and how information should be passed through the supply chain are also set out in this document. High level default values for the carbon intensity of different renewable fuels are also recommended.

In addition to making recommendations to the RFA, this document also sets out the Government's targets for suppliers' reporting performance. These targets are set by the Government, not the RFA. They have been amended in the light of the consultation responses.

Chapter 3 sets out the basic principles of GHG intensity calculation and the use of standards in determining sustainability of feedstock production.

Chapter 4 sets out the recommended details of the monthly reporting requirements for suppliers who wish to claim RTFCs.

Chapter 5 recommends who should be required to report on an annual basis and what should be included within the annual report. This chapter also recommends how the RFA should use annual reports.

Chapter 6 sets out the Government's targets for supplier reporting performance.

Chapter 7 recommends how the required information within the supply chain should be passed from one party to another within the supply chain and how a chain of custody should be operated.

Chapter 8 recommends verification requirements and provides advice on good practice to assist with the verification process.

Annexes A – F contain detailed recommendations on sustainability reporting including; a list of standards that suppliers may use to report on the sustainability of their renewable fuels and the results of the benchmarking exercise, a list of feedstocks considered by-products and guidance on the definition of idle land.

Annexes G, H and I provide the relevant information the RFA requires on the GHG savings of the fuel supplied. High level default values are provided where little is known about the supply chain.

Annex J recommends "standard terms" to be used for entering data into the RFA's reporting systems.

**Part Two of this** document – *Carbon reporting: Default values and Fuel Chains* – sets out recommendations to the RFA concerning the detail of the fuel chains and how to carry out calculations to asses the carbon intensity of specific fuels chains. Those parties who have

more detailed information on the fuel supply chain, either qualitative information (e.g. the biofuel production facility uses a combined heat and power (CHP) system) or quantitative information (e.g. specific natural gas use in the conversion plant) can, under these recommendations, use it to undertake their own calculations rather than rely on the high level defaults provided in this document.

**Additional documents**

Additional documents that summarise the principles behind the Recommendation are available from the RFA website and comprise:

a) *Sustainability reporting within the RTFO: Framework report.* This document, written by Ecofys, describes the principles behind the reporting requirements for environmental and social issues.

b) *Carbon reporting within the RTFO: Methodology* This document, written by E4tech, provides the principles behind the carbon calculation methodology.

# 3. Scope and Principles for RTFO C&S Reporting

***This chapter provides a high level description of the Government's recommended methodology for greenhouse gas calculation, and the use of standards for sustainability reporting. All statements below should be taken as a recommendation and not as detailed guidance on compliance with the RTFO. Responsibility for issuing detailed guidance lies with the RFA.***

## Greenhouse Gas Calculation Methodology

The methodology recommended by the Government is based on a well-to-wheel calculation that includes all significant sources of GHG emissions. This enables direct comparison of fuel chain GHG saving on a like for like basis. Detailed calculations have been made for the principal feedstocks expected to supply biofuel to the UK at the start of the RTFO scheme[2]:

- Ethanol from: sugar cane, sugar beet, molasses, wheat and corn
- Ethanol converted to ETBE
- FAME biodiesel from: tallow, used cooking oil, palm oil, soy and rapeseed
- Biomethane from anaerobic digestion of MSW and manure.

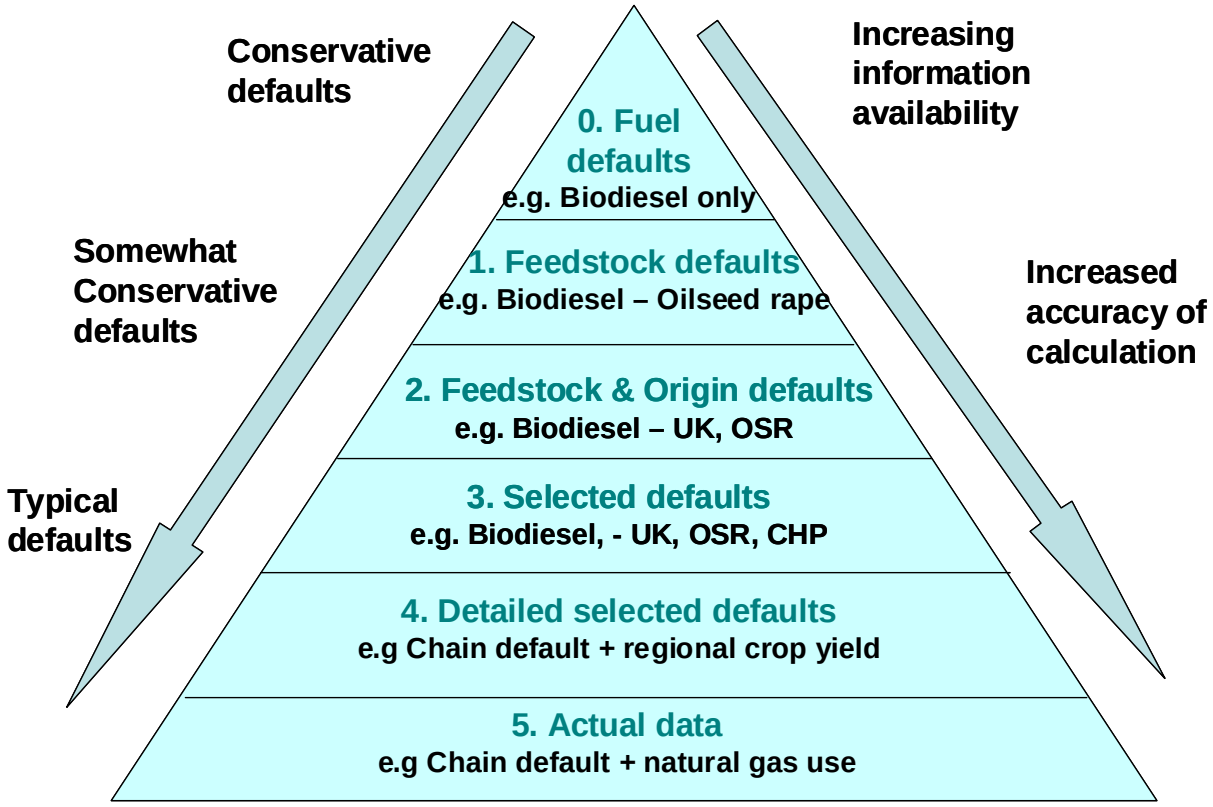
The Recommendation covers all biofuels currently covered by the scheme and the main feedstocks for their production. The Government is likely to extend the RTFO order to other renewable transport fuels if they are introduced into the UK market on a significant scale. It is also possible that new feedstocks or production pathways will become available for existing renewable transport fuels covered by the scheme. In these circumstances, new calculations and default values will need to be developed. This document recommends instructions for reporting on fuel chains not currently defined.

The recommended calculation methodology uses default values that provide estimates of the carbon intensity of different fuel chains. It would enable suppliers with specific information about their supply chain to supply additional qualitative or quantitative data to improve the accuracy of the calculation. The approach is designed to encourage better reporting of data by applying more conservative GHG savings to high level default values (where little is known about the origin of the supply chain); but typical default factors where the calculation includes more detailed information. This is illustrated in Figure 1. This flexible calculation method would provide a practical, cost-effective and credible reporting

[2] Hydrogenated vegetable oil biodiesel chains from palm oil, soy and rapeseed have been defined but HVO will not be eligible for RTFCs under the Renewable Transport Fuel Obligations Order 2007. Any proposed amendment of the 2007 order would require further legislation following consultation.

system. It is recommended that suppliers should also be required to report on the type of information used in their calculations through reporting the levels 0-5 illustrated in Figure 1.

**Figure 1: Hierarchy of default values**




Where information on previous land use has been supplied, the recommended calculation includes the effect on overall GHG savings. Default values for specific land use changes are based on Intergovernmental Panel on Climate Change guidelines. Where information is not provided (i.e. 'unknown' is reported), the calculation does not require the use of a default value for land-use change impacts. This approach is recommended in the initial stages of the RTFO scheme given that the systems providing assurance on the provenance of fuels are in the very early stages of development. However, in the longer term reporting 'unknown' in respect of land use change is unlikely to be acceptable, particularly if there is a direct link between issuing certificates and GHG savings and mandatory sustainability standards apply. The Government recommends that the RFA should keep this matter under review as supply chains mature. The Government will ask the RFA to conduct an analysis of the potential emissions associated with 'unknown' land use changes as part of its regular reports to the Secretary of State.

## Sustainability Reporting

The principal environmental and social risks arising from biofuel production (such as deforestation and loss of biodiversity) arise at the plantation. The recommended sustainability reporting therefore focuses on this part of the supply chain. A future evolution

of the scheme may encompass the wider supply chain including processing and transportation of feedstock.

The recommended sustainability reporting model makes use of existing voluntary agri-environment and social accountability schemes to minimise the cost and administrative burden of compliance. These existing standards have been benchmarked against a recommended RTFO Sustainable Biofuel Meta-Standard. The Meta-Standard comprises seven principles identified in table 1 and includes a number of criteria and indicators (as set out in Annex C) to assess the extent to which the feedstock produced in accordance with each scheme can be considered sustainable.

**Table 1: Environmental and social principles**

| **Environmental principles** |
|---|
| 1. Biomass production will not destroy or damage large above or below ground carbon stocks |
| 2. Biomass production will not lead to the destruction or damage to high biodiversity areas |
| 3. Biomass production does not lead to soil degradation |
| 4. Biomass production does not lead to the contamination or depletion of water sources |
| 5. Biomass production does not lead to air pollution |
| **Social principles** |
| 6. Biomass production does not adversely affect workers rights and working relationships |
| 7. Biomass production does not adversely affect existing land rights and community relations |

The Government recognises that there are some wider environmental and social principles that are difficult to monitor at the fuel supplier level (such as land use change arising as an indirect result of biofuel production and/or the impacts of biofuels on commodity prices). The Government recommends that the Administrator should monitor these principles ex post-facto and will ask the RFA to report on the potential effects as part of its annual report to Parliament.

As part of the process of developing these recommendations, a comprehensive range of existing standards have been benchmarked as illustrated in Table 2. Benchmarked standards that meet the required level of sustainability are called Qualifying Standards. Additional standards should be benchmarked by the RFA in due course as appropriate. The Government recommends that suppliers should be able to report compliance by their feedstock with any standard that has been benchmarked against the Meta-Standard. It is recommended that the RFA establishes a clear process for the regular benchmarking of standards and should review the effectiveness of existing standards on an annual basis. The Government believes that industry and suppliers of feedstocks are best placed to develop new standards.

Qualifying Standards generally meet most, but not all, of the RTFO Sustainable Biofuel Meta-Standard criteria. The criteria which are not fully met by a Qualifying Standard can be called "gap criteria". The Government recommends that suppliers should also be able to organise additional supplementary checks against these "gap criteria" to demonstrate that feedstock complies with all the Meta-Standard criteria.

**Table 2: Benchmarked and Qualifying Standards (see Annex A for further detail)**

| Benchmarked Standards | Qualifying Environmental Standard? | Qualifying Social Standard? |
|---|---|---|
| Linking Environment And Farming Marque (LEAF) | Yes | No |
| Roundtable on Sustainable Palm Oil (RSPO) | Yes | Yes |
| Sustainable Agriculture Network/Rainforest Alliance (SAN/RA) | Yes | Yes |
| Basel criteria for soy (Basel) | Yes | Yes |
| Forest Stewardship Council (FSC) | Yes | No |
| Assured Combinable Crops Scheme (ACCS) | Yes | No |
| Social Accountability 8000 (SA8000) | No | No |
| GlobalGAP | No | No |
| International Federation of Organic Agriculture Movements (IFOAM) | No | No |
| Proterra | No | No |

Stakeholders have identified some standards that have not yet been benchmarked but which nevertheless distinguish feedstocks produced under such standards from feedstocks not produced under a standard, or under an unknown standard. It is recommended that reporting these non-qualifying standards should count towards the target for data reporting, but not for meeting sustainability standards. The standards are shown in Table 3.

**Table 3: Non-qualifying standards that may be reported**

| Other standards available to report | Qualifying Environmental | Qualifying Social Standard? |
|---|---|---|

| | Standard? | |
|---|---|---|
| Genesis Crops Module | No | No |
| Scottish Quality Cereals | No | No |
| Qualität und Sicherheit (German Standard) | No | No |
| Fedioil (Finnish Standard) | No | No |

To minimise the burden on business it is recommended that the RFA should not require suppliers to report on criteria where the risk of adverse impacts is minimal, eg by-products. An objective, risk-based metric has been used to develop this principle. Where a feedstock represents less than 10% of the farm or factory gate value the Government recommends that it should be considered a by-product (see Annex B).

# 4 Monthly reporting

***For simplicity, the C&S reports included in an application for RTFCs are referred to as "monthly" reports throughout this chapter to distinguish them from annual reports.***

***Under the RTFO Order a C&S report is required for every RTFC issued. The detail of the Government's recommendation as to the content and format of monthly reports and as to the timetable for reporting is set out below. All statements below should be taken as recommendations to the RFA and not as detailed requirements or as guidance on compliance with the RTFO.***

***The Government recommends that some of the sustainability data requirements should not be applicable to certain feedstocks: recommended instructions are provided on reporting in these cases.***

***This chapter is likely to be of particular interest to obligated suppliers and any other fuel suppliers who wish to claim RTFCs.***

## Reporting frequency and timetable

The Government recommends that the RFA should require obligated suppliers who wish to claim RTFCs to submit monthly and (if they apply for 450,000 or more certificates in an obligation period) annual C&S reports. The Government recommends that the RFA should require monthly reports from obligated suppliers to be submitted by the 15th day of the month following the month in which the fuel was supplied. This would mean that, for example, reports for the period 15 June 2008 to 14 July 2008 (inclusive) would be due by 15 August 2008. The Government recommends that the RFA should require non-obligated suppliers to report whenever they wish to claim RTFCs.

## What to report

C&S reports on biofuels should be broken down by "administrative batch", where an administrative batch is any amount of product with identical sustainability characteristics which are:

- Fuel type
- Biofuel feedstock
- Feedstock Origin
- Standard(s) (including supplementary checks where these have been performed)

— Land use on 30 November 2005

**The total volume of the administrative batches in a C&S report should equal the volume of fuel reported in the application for certificates i.e. the volume of renewable fuel supplied in the period.**

## Reporting on the sustainability of renewable fuels

As set out in chapter 3, the Government recommends that the RFA should encourage transport fuel suppliers to demonstrate that their biofuel feedstock is produced in accordance with the criteria of the RTFO Sustainable Biofuel Meta-Standard, through certification where possible to an existing accountability scheme (such as the Assured Combinable Crops Scheme (ACCS)).

The Government recommends that transport fuel suppliers should report on whether their feedstock meets a defined level of sustainability for the RTFO. Existing accountability schemes have been classified as meeting either:

- The "Qualifying Standard" for social and/or environmental criteria - representing an acceptable level of sustainability; or
- The 'RTFO Sustainable Biofuel Meta-Standard' - representing a higher level of sustainability - by meeting fully the requirements of the RTFO Sustainable Biofuels Meta-Standard.

The Government recommends that transport fuel suppliers should be able to report that their feedstock meets an accountability scheme that does not achieve these levels of performance, provided it has been benchmarked against the meta-standard (see Annex A).

### The Qualifying Standard

**What is it?**

The Government recommends that existing standards which meet most, but not all, of the RTFO sustainability criteria underlying the principles outlined in Chapter 3 should be counted as meeting an acceptable level of sustainability. These standards are called *Qualifying Standards*.

The RTFO Sustainable Biofuel Meta-Standard criteria which are not fully met by a Qualifying Standard are called the '*gap criteria'* of the relevant Qualifying Standard. The number of criteria that an existing standard should address to be accepted as a Qualifying Standard, is described in Annex A.

Several existing standards only address either environmental issues or social issues. Therefore the Qualifying Standard is defined separately for environmental and social criteria. If the existing standard sufficiently addresses both environmental and social criteria it can be an environmental Qualifying Standard *and* a social Qualifying Standard.

For further details on all the standards that have been benchmarked and can be reported see Annexes A and D.

### How to claim a Qualifying Standard

The Government recommends that for a biofuel supplier to claim that its feedstock was grown in accordance with a Qualifying Standard, it should be able to show that the farm from which the feedstock originates has a certificate which proves that it is certified by the Qualifying Standard. In the case where the Qualifying Standard operates a book-and-claim system with tradable certificates, the biofuel supplier should be able to show sufficient of the relevant certificates for the amount of biofuel claimed. For more details, see Chapter 7 on the Chain of Custody.

The Government recommends that it should also be permissible to report that a feedstock was grown to a standard that is not a Qualifying Standard[3] (see Chapter 3) together with supplementary checks which have been undertaken to show that the farm meets the Qualifying Standard level. In this case proof should be provided of certification against the non-qualifying Standard in addition to documented proof of a successful audit against the gap criteria as they relate to the Qualifying Standard claimed. In this case, the Government recommends that both certification against the existing standard and the supplementary checks must meet the following requirements:

- The certification body is accredited to ISO 65;
- The auditor competencies meet the requirements of ISO 19011 or a justified equivalent.

For several feedstocks standards are still under development e.g. the Better Sugarcane Initiative (BSI) and the Roundtable on Responsible Soy (RTRS). For these situations, short term solutions are recommended for sustainability reporting under the RTFO. These are described in Annex A.

### The RTFO Sustainable Biofuel Meta-Standard

### What is it?

The full RTFO Sustainable Biofuel Meta-Standard sets out the aim for sustainability performance under the RTFO in the medium term. In the short term it is anticipated that companies will focus on using the mechanisms developed by existing sustainability assurance schemes and will primarily aim to report a Qualifying Standard. It is hoped that existing standards will address the *gap criteria* within their standard (e.g. by establishing a reference year for land use change) and will thereby develop towards full equivalence with the RTFO Sustainable Meta-Standard.

### How to claim the RTFO Sustainable Biofuel Meta-Standard

As long as existing standards do not cover all criteria of the RTFO Sustainable Biofuel Meta-Standard, the Government recommends that there should be two alternative methods which can be used to demonstrate compliance with the full RTFO Sustainable Biofuel Meta-Standard:

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3 A "non-Qualifying Standard" is an existing standard that has been benchmarked against the RTFO Sustainable Biofuel Meta-Standard, but that does not reach the level of a Qualifying Standard. A non-Qualifying Standard can be reported. It does count towards a supplier's data capture target, but does not count towards the Qualifying Standard target.

- Proof of certification against one of the Qualifying Standards listed in table 2 **and** proof of a successful audit against the gap criteria between the Qualifying Standard reported and the Meta-Standard. Supplementary checks must be performed by auditors with qualifications relevant to the gap criteria.
- Proof of a successful audit against the full RTFO Sustainable Biofuel Meta-Standard.

In the case of the use of either a Qualifying Standard with gap criteria audit approach, or an audit against the RTFO Sustainable Biofuel Meta-Standard, the Government recommends that the following requirements should be met:

- The certification body is accredited to ISO 65;
- The auditor competencies meet the requirements as set out in ISO 19011 or a justified equivalent.

### How are biofuels produced from by-products treated?

It is recommended that the RFA should not require suppliers to report on criteria where the risk of adverse impacts is minimal. Therefore, where a feedstock represents less than 10% of the farm or factory gate value the Government recommends that it should be considered a by-product. The Government recommends that the RFA should define used cooking oil, tallow, municipal solid waste, manure and molasses as by-products and that suppliers should not be required to report on the sustainability standard or land use in respect of biofuels produced from these feedstocks. Instead, the Government recommends that for these feedstocks suppliers should report all general information required and then enter 'by-product' into the remaining sustainability columns within the monthly report. The Government recommends that suppliers should still be required to report the carbon intensity of such fuels, and that this should be derived using the GHG calculation methodology. Annex B sets out the list of those products that the Government recommends should be considered by-products for the start of the RTFO.

The Government recommends that in a monthly report, suppliers should be required to complete the general batch information columns with information on Biofuel Feedstock and Feedstock Origin, and to report 'by-product' for the sustainability information columns.

The Government recommends that suppliers who report "by-product" in the relevant fields should be considered to have achieved both the environmental and social Qualifying Standard level. It is recommended that the RFA monitor and review the by-products that are exempted and review the overall appropriateness of exempting by-products.

## Filling in the monthly report

The following table and text provides recommendations on the sort of information that the RFA should require within the monthly C&S report. An example summary of reported batches is shown in Table 4 to illustrate particular points.

**Table 4: Illustrative monthly reporting requirement for Carbon and Sustainability information - example data.**

| General Information | | | | | | Sustainability Information | | | | Carbon Information | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Batch number** | **Internal Batch number (optional)** | **Fuel type** | **Quantity of fuel (litres)** | **Biofuel Feedstock** | **Feedstock Origin** | **Standard** | **Env Level** | **Social Level** | **Land use on 30 Nov 2005** | **Carbon intensity incl LUC g $CO_2e$ / MJ** | **Accuracy level** |
| 33001 | | Bioethanol | 250,000 | Wheat | UK | LEAF | QS | - | Cropland | 61 | 2 |
| 33002 | | Bioethanol | 100,000 | Wheat | France | GlobalGAP | - | - | Grassland | 122 | 2 |
| 33003 | | Bioethanol | 250,000 | Sugar beet | UK | ACCS | QS | - | Cropland | 35 | 5 |
| 33004 | | Bioethanol | 1,000,000 | Sugar cane | Brazil | Meta-Standard | RTFO | RTFO | Cropland | 24 | 2 |
| 33005 | | Bioethanol | 500,000 | Unknown | Unknown | Unknown | - | - | Unknown | 61 | 0 |
| 33006 | | Biodiesel | 1,000,000 | Oilseed rape | UK | ACCS | RTFO | RTFO | Cropland | 55 | 2 |
| 33007 | | Biodiesel | 250,000 | Oilseed rape | Unknown | Unknown | - | - | Unknown | 55 | 2 |
| 33008 | | Biodiesel | 500,000 | Palm oil | Malaysia | RSPO | QS | QS | Cropland | 45 | 2 |
| 33009 | | Biodiesel | 500,000 | Soy | Argentina | Basel | QS | QS | Grassland | 177 | 2 |
| 33010 | | Biodiesel | 250,000 | UCO | UK | By-product | QS | QS | By-product | 13 | 2 |
| 33011 | | Biomethane | 150,000 | Dry manure | UK | By-product | QS | QS | By-product | 36 | 2 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Auto-matically gener-ated. | Optional column for company's internal reference number. | For stan-dard termi-nology see Annex J. BioETBE is reported as bioethanol | Report in litres for liquid bio-fuel, and kg for gaseous biofuel. | For stan-dard termi-nology see Annex J or RFA web-site. | Country of feedstock origin See Annex J or RFA website. | See Annex A for a list of standards. See Annex J for a list of standard terms. | See below for explanation of sustainability lev-els. | See Annex H for land use cate-gories. | See Annex G for de-fault values and Annex I for Accuracy Level. |

**Explanations of example data in Table 4 – the summary monthly data report**

**Batch 33001** represents 250,000 litres bioethanol from wheat of UK origin.

- The biofuel supplier can verify that the wheat is LEAF certified - "LEAF" is reported in the "Standard" column.
- LEAF is an environmental Qualifying Standard (see Annex A). The “Env Level” should therefore contain "QS". LEAF is not a social Qualifying Standard therefore the “Social Level” is blank. The ‘QS’ will be added automatically.
- The supplier knows the feedstock and origin of the biofuel but knows no further information. Using Annex G the supplier looks up the relevant default. As the land-use was cropland on the reference date the default tables in Annex H provide a default for the impact of LUC as ‘zero’ and the combined carbon intensity figure for fuel and the impact of land use can be reported. Annex I identifies the Accuracy Level used for the carbon intensity figure as 2 which is reported in the relevant field.

**Batch 33002 and 3309:** both represent biofuels reported with land use change.

- In both cases the land use on 30 November 2005 has been identified as Grassland (definitions provided in Annex H). The default value in Table 26 identifies the carbon intensity impact of this land use change. This is added to the default value for the wheat ethanol of French origin or soy from Argentina found in Table 24. The combined carbon intensity is reported in the relevant field.

**Batches 33003 and 33006:** both represent biofuel from the UK from ACCS certified feedstock.

- Batch 33003 represents a standard case - ACCS is an environmental Qualifying Standard and therefore "QS" is reported in the Env Level column. ACCS is not a social Qualifying Standard therefore the Social Level column is blank. Actual data has been used to carry out the carbon calculation in Batch 33003 rather than relying on the high level defaults and Annex I illustrates that Accuracy Level 5 should be reported where actual data is used.
- In the case of batch 33006, supplementary checks have been carried out on all gap criteria by the ACCS auditor and the farm complies with all the criteria of the RTFO Sustainable Biofuel Meta-Standard. This is illustrated by reporting "RTFO" in the “Env” and “Social” columns.

**Batch 33004:** represents bioethanol from sugar cane of Brazilian origin.

- The sugar cane is not certified by any standard; however a full audit has been carried out against all the criteria of the RTFO Sustainable Biofuel Meta-Standard. “Meta-Standard” is reported in the “Standard” field. The appropriate level of sustainability achieved following the audit should then be reported in the “Env” and “Social Level” columns. In this case the full RTFO Sustainable Biofuel Meta-Standard has been achieved.

**Batches 33005 and 33007:** represent batches with some unknown data.

- For the general and sustainability sections "unknown" should be reported.
- The default value from Table 22 is used to report the carbon intensity and the default value in Table 26 defines the default value of zero in the case of unknown land use.

**Batch 33008:** The palm oil is verified as being RSPO certified.

- RSPO is both an environmental and social Qualifying Standard and therefore "QS" should be reported in both the “Env” and “Social Level” columns.

**Batches 33009 and 33010:** represent biofuels from feedstocks considered by-products.

- The country of origin of the by-product is reported.
- "By-product" should then be entered in the “Standard” and “Land use” fields. "QS" should be reported in both the “Env” “Social Level” fields.
- No detailed information has been used available to calculate the carbon intensity therefore Table 22 is used to look up the relevant default value. Annex I is used to identify the relevant Accuracy Level undertaken for the calculations – in this case a feedstock and origin default represents an Accuracy Level of 2.

**Batch 33011** is biogas, and so the mass is entered, expressed in kilogrammes not litres.

### Providing general batch information

- (Administrative) Batch Number: Each batch number will be unique and generated automatically by the RTFO Operating System. The batch refers to an administrative batch, not necessarily a physical batch. An administrative batch is any amount of fuel with homogeneous sustainability characteristics (Biofuel feedstock, country of origin, standard and Land use on 30 November 2005).
- Internal Batch Number: optional data field for the supplier to record their own batch number for reference purposes.
- Quantity of fuel: expressed in standard litres for liquid fuel or kilogrammes in the case of gas. In the case of BioETBE which is reported as bioethanol in line with HMRC requirements only the renewable component (47% of the volume) should be reported.
- Fuel type: biodiesel, bioethanol, or biomethane. Note that BioETBE should be reported as bioethanol in line with HMRC requirements.
- Biofuel Feedstock: the feedstock type from which the fuel is made e.g. used cooking oil, wheat.
- Feedstock Origin: the country of origin of the feedstock.

### Providing sustainability information for each administrative batch

The Government recommends that suppliers should be able to report any standard which has been benchmarked against the RTFO Sustainable Biofuel Meta-Standard. Table 2 and table 3 contain the full list of standards available to be reported, whether they are Qualifying or non-qualifying.

**“Standard”**

- This column is used to report the sustainability standard to which the feedstock reported was produced.
- If the feedstock is not certified report “none”, or if the data is not known, report

"unknown" (as shown in Batch 33007 in Table 4).

- If the feedstock is a by-product, report "by-product" (as shown in Batch 33009 in Table 4).
- If a specific audit has been carried out on the farm/plantation against the RTFO Meta-Standard criteria (in the absence of an available standard) report "Meta-Standard" (as shown in Batch 33004 in Table 4).

**"Env Level" and "Social Level"**

- The two entry fields labelled "Env Level", for environmental level, and "Social Level" should identify the level of sustainability achieved: either a Qualifying Standard (shown as "QS"), RTFO Sustainable Biofuel Meta-Standard (shown as "RTFO"), or blank if the standard reported does not meet either the Qualifying Standard or the RTFO Meta Standard.
- If supplementary checks have been performed successfully on all of the gap criteria within the existing standard, the Env Level and/or the Social Level fields should illustrate the new level attained - either "QS" or "RTFO" (e.g. Batch 33006 in Table 4).
- Where a specific audit has been carried out on the farm/plantation against the RTFO Meta-Standard and the full RTFO Sustainable Biofuel Meta-Standard level has been reached, "RTFO" should be reported in this field.
- Where a specific audit has been carried out on the farm/plantation against the RTFO Meta-Standard and the equivalent of a Qualifying Standard level has been reached, "QS" should be reported in this field.
- For by-products, "QS" should be reported in the Env Level and Social Level fields.

**"Land-Use"**

- This field is used to report the land use relevant to the feedstock on 30 November 2005,
- For guidance on how to determine the Land use on 30 November 2005, see Annex H.
- If the feedstock is considered a by-product (see Annex B) fill in: 'by-product'.

### Unknown reporting

The Government recommends that for any data field in the general or sustainability information sections for which verifiable information is not available, "unknown" should be reported. It should be noted that the Government aims to move towards mandatory sustainability standards by April 2011, and that 'unknown' reporting is unlikely to be acceptable under such a system. Allowing "unknown" reporting" is a practical solution in the early stages of the RTFO in recognition of the difficulties in obtaining information, however, it is recommended that the RFA reviews this approach as supply chains improve.

### Providing carbon information for each administrative batch

The Government recommends that fuel suppliers should be required to report the carbon intensity of all renewable fuels, including by-products.

**“Carbon intensity”**

- This entry field should be used to report the carbon intensity expressed in g $CO_2e$ / MJ. The carbon intensity calculation, and therefore the figure reported, includes the impact of any direct land-use change.
- For guidance on assessing the carbon intensity of an administrative batch of biofuel see Annex G.
- For guidance on assessing the carbon intensity of the impact of land use change see Annex H.

**“Accuracy Level” column**

- The accuracy level is a measure of the type of data used to derive the carbon intensity of a batch of biofuel.
- For guidance on establishing the Accuracy Level see Annex I.

## Further guidance

For further guidance on environmental and social sustainability standards, see Annex A.

For a full list of criteria and indicators of the RTFO Sustainable Biofuel Meta-Standard, see Annex C.

A detailed overview of the results of the benchmarking of existing standards is provided in Annex D. This Annex also illustrates the gap criteria for each benchmarked standard.

For guidance on the relationship between reporting land use in the monthly report and reporting on production on idle land in the annual report, see Annex E.

## Changing Carbon and Sustainability data after monthly reporting deadline

Under the RTFO Order, if a supplier becomes aware that C&S data already supplied in good faith may be inaccurate, the supplier must inform the RFA within five working days, to avoid liability for a civil penalty. This includes where ‘unknown’ has previously been declared and where new information becomes available meaning that the supplier does actually know the provenance of the fuel. If new evidence about the C&S characteristics of a fuel emerges after a monthly report has been submitted but before RTF certificates have been awarded, the Government recommends that the RFA should allow correction of the data by editing the submitted reports. However, if certificates have already been awarded, suppliers should notify the RFA as required and await advice from the RFA as to how to rectify the inaccuracy, which may involve resubmitting the entire data set for the month.

The time period for notifying the discovery of an inaccuracy to the RFA ends on 28 September following the end of the obligation period in which the C&S information was submitted. An inaccuracy discovered subsequently need not be notified.

## Reporting on purchased certificates

Then Government recommends that it should only be the supplier who first applies for the RTFC who must complete a C&S report. Account holders who purchase an RTFC should

not have any reporting requirements with respect to the purchased RTFC.

## Publication of Information

It is recommended that the RFA publish reports on individual supplier performance in the categories of carbon intensity and sustainability, including a comparison with the targets set out by Government. It is recommended that the RFA do this at least on an annual basis. The RFA may also choose to make available other information on the environmental impact of the RTFO, including information from annual and monthly C&S reports which identifies individual suppliers. The Government recommends that, in a manner which is consistent with the requirements of the Freedom of Information Act 2000 and Environmental Information Regulations 2004, the RFA should make information available in a way that is accessible to consumers and which could inform their purchasing decisions. The Government recommends, however, that in compiling this information the RFA should recognise the commercial sensitivity of information such as individual suppliers' sales volumes or information from which individual suppliers' market shares can be deduced.

It is recommended that the format and scope of monthly reports is kept under review by the RFA.

# 5 Annual reporting

***The Government recommends that the RFA requires transport fuel suppliers to submit annual C&S reports to support and supplement the C&S information included in applications for RTFCs. This chapter sets out the recommended requirements for annual reporting, including the information that fuel suppliers may be expected to report on in their annual reports. This chapter also includes recommendations as to how the RFA may use the C&S information provided.***

***Unlike monthly reports, annual C&S reports will not be linked to the issuing of RTFCs. It is recommended that annual reports should be made publicly available by the RFA.***

***All statements below should be taken as recommendations to the RFA and not as detailed requirements or as guidance on compliance with the RTFO.***

## Small supplier exemption

The Government recommends that suppliers applying for fewer than 450,000 RTFCs during an obligation period should not be required to submit an annual report for that obligation period.

## What to report

It is recommended that the core information in the annual report from the fuel supplier should consist of the aggregated data from monthly reports over a single obligation period (15 April to 14 April inclusive). This aggregated quantitative data must incorporate any changes that have been notified by a supplier (see chapter 4). The annual report should also require fuel suppliers to provide additional qualitative information relevant to the sustainability and GHG saving of their renewable transport fuels.

While it is recommended that the information detailed below should be a requirement of annual reports, it is not recommended that the Chapter structure outlined below should be mandatory; it is intended for guidance.

*Chapter 1*: Introduction. A general introduction setting out the scope and context of the report and the overall approach and philosophy of the supplier in sourcing renewable transport fuels.

*Chapter 2:* Containing the aggregate summaries of the C&S characteristics of the fuel supplied during the obligation period (from the monthly data sheets) in the formats illustrated in table 1 and table 2.

*Chapter 3*: Including information on the following items (where information is available):

- Fuel supplier information:
- Past year's and planned activities to improve the proportion of sustainably sourced

feedstock and reduce average carbon intensity;

- Past year's and planned activities to support standard development for sustainable biofuel feedstock (membership of RSPO, RTRS, BSI, etc);
- Past year's and planned activities to promote feedstock production on idle land and, where possible, an indication of the volume of fuel originating from such idle land. While no universal definition of "idle land" exists a recommended guideline to the interpretation of idle land for the purpose of the RTFO is provided in Annex E[4];
- Past year's and planned activities to improve the type of carbon data which is being used – e.g. the different default values or actual data;
- Environmental management system certificates;
- Existing verified environmental / corporate responsibility reports.

Information on other parties within the supply chain:

- Where fuel suppliers have information on their main crop producers, information should be provided on the percentage of that company's total production which meets respected sustainability standards. If parties do not wish to disclose the identity of crop producers and intermediate processors, anonymous information can be reported. The information has to be verifiable by the verifier but the identity will not be published.
- Environmental management system certificates held, e.g. ISO14001.

It is recommended that suppliers should be free to include any comments or additional information they deem relevant in their annual reports including any comments specific to the verification exercise.

It is also recommended that suppliers should provide information concerning the steps they are taking to obtain more detailed information for reports. It is recommended to the RFA to keep the format and scope of the annual reports under review. It is also recommended that the RFA consider the need for training in order to assist suppliers in complying with the annual reporting requirement.

The Government also recommends that, to fit better with article 23(5) of the RTFO Order (which covers correction of data which is found to be inaccurate after it is provided to the RFA), the deadline for the submission of annual reports should be 28 September.

In addition, it is recommended that the RFA require submission of a verifier's statement with the annual report.

4 In light of experience with C&S reporting under the RTFO, it is recommended that the RFA should assess the possibilities of including reporting on idle land in the monthly reporting process at a later stage.

**Table 5: Annual report table – example data and suggested format. Summary of feedstock mix; Percentage of verifiable data reported; Percentage of feedstock which meets the Qualifying Standards and/or RTFO full Sustainable Biofuel Meta-Standard; average carbon intensity and corresponding GHG savings. Supplier targets should be inserted in the bottom row. This table contains example data.**

| Feedstock | General | | Environmental | Social | Carbon | |
|---|---|---|---|---|---|---|
| | % Fuel supplied by feedstock type (by volume) | % Data reported on biofuel characteristics | % Meeting Qualifying and/or RTFO standard | % Meeting Qualifying and/or RTFO standard | Average carbon intensity g $CO_2$e / MJ | Average % GHG saving |
| **Biodiesel** | | | | | | |
| Palm oil | 10 | 30 | 50 | 50 | 43 | 50 |
| Rapeseed oil | 70 | 40 | 85 | 85 | 77 | 11 |
| Soy oil | 20 | 40 | 40 | 40 | 59 | 31 |
| **Bioethanol** | | | | | | |
| Sugar cane | 20 | 20 | 10 | 10 | 20 | 76 |
| Corn | 10 | 30 | 70 | 70 | 62 | 27 |
| Wheat | 40 | 50 | 80 | 80 | 65 | 23 |
| Sugar beet | 20 | 60 | 75 | 75 | 51 | 40 |
| Unknown | 10 | 0 | 0 | 0 | 78 | 8 |
| **Weighted average (all fuels)** | | **39** | **65** | **65** | **63** | **26** |
| **Target (2008/09)** | **-** | **50%** | **30%** | **-** | **-** | **40%** |

**How to fill in table 1: Annual Summary Table.**

– **Percentage fuel supplied by feedstock type (by volume)**

This column is a summary of the feedstock mix for the whole obligation period. The feedstock mix for each different biofuel should be shown separately. Unknown feedstocks must be included in the table under the appropriate biofuel and the total feedstock mix *per biofuel type* must add up to 100% including any unknown percentage.

*Example: Biodiesel supply during this period was 10% palm oil, 70% rapeseed oil and 20% soy oil.*

– **Percentage of data reported**

This column shows how much actual data has been reported by the supplier, instead of reporting "unknown", for the following fields: "biofuel feedstock"," feedstock origin", "standard" and "land use".

The percentages are calculated on the volume of fuel for which actual data has been reported, not on the number of batches

*Example: A supplier supplies a volume of renewable fuel that represents 80% biodiesel and 20% bioethanol. The biodiesel comprises palm (30%), soy (20%) and oilseed rape (50%).*

*80% of the palm has reported on Feedstock;*

*60% of the palm has also reported on the Origin;*

*50% of the palm has also reported a standard and*

*0% of palm has reported anything under land use (unknown has been reported).*

*Therefore (80% + 60% + 50% + 0%) / 4 = 47.5% has been reported for palm. Palm represents 30% of the volume of biodiesel supplied and biodiesel makes up 80% of the total volume of renewable fuel supplied. Therefore the contribution of palm to the total data capture target for all supplied renewable fuels for this party is 47.5 x 30% x 80% = 11.0%. The same calculation is carried out for the other biodiesel feedstocks as well as the ethanol feedstocks. The sum of the contributions of all feedstocks is reported as the weighted average for all renewable fuels supplied.*

– **Percentage of feedstock which meets the environmental and social Qualifying Standards**

Percentages are calculated for each feedstock as a percentage of the total volume of biofuel from that feedstock for which a Qualifying Standard or RTFO Sustainable Biofuel Meta-Standard has been reported in the monthly data reports. The percentage meeting the environmental Qualifying Standard is not necessarily the same as the percentage meeting the social Qualifying Standard. The percentages meeting a Qualifying Standard should *include* the fraction of feedstock which meets the full RTFO Sustainable Biofuel Meta-Standard.

The percentages are weighted averages with the volume of fuel providing the weighting.

– **Average carbon intensities** are weighted averages, with the volume of fuel providing the weighting. By way of an example consider the first row of Table 2: two batches of palm oil biodiesel have been supplied: Batch 1: 1,000 litres, carbon intensity = 50 g CO2e / MJ; Batch 2: 2,000 litres, carbon intensity = 40 g CO2e . MJ. Batch one contributes 33% of the total volume (1000 / (1000 + 2000) = 33%) and Batch 2 contributes 67% of the total volume (2000 / (1000 + 2000) = 67%). Therefore the weighted average carbon intensity is 43.3 g CO2e / MJ (33% x 50 + 67% x 40 = 43.3).

– **Average GHG saving** is a comparison of the average carbon intensity of the renewable fuel described above against that of the relevant fossil fuel. See Annex G for the relevant fossil reference values.

**Table 6: Example data and suggested format for C&S characteristics of for palm oil.**

| General information | | Sustainability information | | | | Carbon information | |
|---|---|---|---|---|---|---|---|
| % of total palm oil | Feedstock origin | Standard | Env Level | Social Level | Land use on 31 Dec 2006 | Carbon intensity incl LUC (g $CO_2$e / MJ) | GHG saving (%) |
| 20 | Malaysia | RSPO | QS | QS | Cropland | 45 | 48 |
| 60 | Malaysia | Unknown | - | - | Unknown | 45 | 48 |
| 20 | Indonesia | Unknown | - | - | Unknown | 45 | 48 |

It is recommended that a separate table in the annual report be required by the RFA for each feedstock type supplied in the obligation period, e.g. palm oil, rapeseed oil etc. (unless the feedstock represented less than 3% of the annual total volume of biofuel supplied). These tables aggregate all the administrative batches, with weighted average carbon intensity for each aggregation. Any batches of fuel with identical Feedstock, Origin and Sustainability Information may be aggregated into a single row in the table.

– "Percentage of total feedstock" column - (for each individual feedstock, e.g. palm oil). This is the amount of fuel, expressed as a percentage of the total fuel supplied from this feedstock, with the characteristics described.

– The remaining columns correspond directly to the columns in the monthly data reports: Feedstock Origin, Standard, Env Level, Social Level, Land use on **30 November 2005, and Carbon intensity** information.

– Any batches of fuel with identical sustainability information that contributed less than 3% of the fuel from this feedstock may be aggregated or can be identified separately.

Note: carbon data should be presented as a weighted average. See Annex G for information on how to calculate combined carbon intensity figures.

In the example in **Error! Reference source not found.**table 2: 20% of the total palm oil biodiesel from the company was of Malaysian origin and was RSPO certified (RSPO Is both an environmental and social Qualifying Standard); 60% of the palm oil biodiesel was of Malaysian origin but with unknown sustainability characteristics; and the remaining 20% palm oil biodiesel was of Indonesian origin with unknown sustainability characteristics.

If the RSPO certified palm oil had been subject to supplementary checks which showed that the plantation complied with all the criteria in the RTFO Sustainable Biofuel Meta-Standard, "RTFO" would be reported in the "Env Level" and "Social Level" columns.

## When to report

It is recommended that each annual C&S report should cover one obligation period and that the deadline for submission should be the 28 September after the end of the relevant obligation period.

## How will the RFA use annual reporting data?

The following recommendations are made concerning the use of annual reporting data by the RFA:

- Suppliers' annual reports should be used by the RFA in preparing the annual report to Parliament on the operation of the scheme.
- The annual report will not influence the award of RTFCs..
- Annual reports should be made publicly available via the RFA website.
- Annual reports may be used to provide information for comparing supplier performance against the performance targets set by the Government.

# 6 Expected reporting levels and targets

The Secretary of State is setting targets relating to three aspects of the C&S data reporting. There will be no legal penalty for failing to meet the targets, but the targets are intended to illustrate the level of performance which the Government expects fuel suppliers to deliver. The Government will keep these targets under review to ensure that they remain challenging but realistic in the light of suppliers' performance in meeting them, and to take account of the development of new standards for individual feedstocks.

## Sustainability performance targets.

**The first set of targets relate to the percentage of biofuel supplied in each obligation period that should meet a Qualifying Environmental Standard**.

The targets will be overall targets for all feedstock reported by a fuel supplier.

| **Annual supplier target** | **2008-2009** | **2009-2010** | **2010-2011** |
|---|---|---|---|
| Percentage of feedstock meeting a Qualifying Environmental Standard | 30% | 50% | 80% |

The percentage of feedstock that meets an environmental Qualifying Standard is calculated as an overall percentage for all feedstock.

*Example: A supplier supplies a volume of renewable fuel that consists of 80% biodiesel and 20% bioethanol. The biodiesel comprises palm (30%), soy (20%) and oilseed rape (50%). All of the palm oil is RSPO certified, none of the soy meets a Qualifying Environmental Standard and 10% of the oilseed rape is certified to ACCS. Therefore (100% x 30%) + (10% x 50%) = 35% meets a Qualifying Environmental Standard. None of the bioethanol meets a qualifying Environmental Standard, then, as biodiesel represents 80% of the renewable fuel supplied the overall percentage of feedstock meeting a qualifying standard is 35% x 80% = 28.0%.*

## Greenhouse Gas (GHG) saving

The second set of targets relate to **the overall level of GHG saving achieved by the biofuel supplied in each obligation period**.

| **Annual supplier target** | **2008-2009** | **2009-2010** | **2010-2011** |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Annual GHG saving of fuel supplied | 40% | 45% | 50% |

The level of GHG saving is an overall target for all fuels and feedstocks reported by a fuel supplier.

*Example: A supplier supplies a volume of renewable fuel that represents 80% biodiesel and 20% bioethanol. The biodiesel comprises palm (30%). The combined carbon intensity of all the palm oil supplied = 45g CO2e/MJ.*

*The reference value for the carbon intensity of diesel is 86.4g CO2e/MJ. The average GHG saving would be (86.4 - 45) / 86.4 = 48%. Palm represents 30% of the total volume of biodiesel therefore 30% x 48% = 14.4% GHG saving. Biodiesel represents 80% of the fuel supplied (14.4% x 80%). The resulting GHG saving is reported as a combined percentage across all fuels and feedstocks.*

## Data reporting on biofuel characteristics

The Government intends to set targets for **the amount of actual data provided by transport fuel suppliers** as opposed to reporting "unknown" against the four sustainability requests: Biofuel Feedstock, Feedstock Origin, Standard, and Land Use on 30 November 2005. The target is an overall target based on the portfolio of fuels supplied in the obligation period.

| **Annual supplier target** | **2008-2009** | **2009-2010** | **2010-2011** |
|---|---|---|---|
| Data reporting of renewable fuel characteristics | 50% | 70% | 90% |

Whilst "unknown" reporting is permitted, suppliers will be encouraged to identify and report accurate information about the feedstocks used.

Where a by-product has been used as the feedstock, reporting the Biofuel Feedstock and "by-product" for the remaining general information and sustainability information fields will be counted as a completed report. Reporting a non-Qualifying Standard (from table 2 or table 3) is also counted as a completed data field for the Standard column. Where "unknown" or "none" is reported this does not count towards the data capture target.

*Example: A supplier supplies a volume of renewable fuel that represents 80% biodiesel and 20% bioethanol. The biodiesel comprises palm (30%), soy (20%) and oilseed rape (50%).*

*80% of the palm has reported on Feedstock;*

*60% of the palm has also reported on the Origin;*

*50% of the palm has also reported a standard and*

*0% of palm has reported anything under land use (unknown has been reported).*

*Therefore (80% + 60% + 50% + 0%) / 4 = 47.5% has been reported for palm. Palm represents 30% of the volume of biodiesel supplied and biodiesel makes up 80% of the total volume of renewable fuel supplied. Therefore the contribution of palm to the total data capture target for all supplied renewable fuels for this party is 47.5 x 30% x 80% = 11.0%. The same calculation is carried out for the other biodiesel feedstocks as well as the ethanol feedstocks. The sum of the contributions of all feedstocks is reported as the weighted average for all renewable fuels supplied.*

# 7 The Chain of Custody

***Reported C&S data must be verifiable. Therefore the C&S data reported by the fuel supplier has to be traceable back to the party or parties who generated the information. This chapter recommends which types of Chain of Custody systems should be permitted within the RTFO and gives recommended guidance for setting up a (temporary) Chain of Custody where none yet exists.***

***All statements below should be taken as recommendations to the RFA and not as detailed requirements or as guidance on compliance with the RTFO.***

## General

### Terminology

Throughout this chapter the following terminology will be used:

- Administrative batch: any amount of product with identical sustainability characteristics. The sustainability characteristics are:
  - Fuel type
  - Biofuel feedstock
  - Feedstock Origin
  - Standard(s) (including any supplementary checks where these have been performed)
  - Land use on 30 November 2005
- Input: any physical input sourced by any party in the supply chain. For example rapeseed sourced by a rapeseed crusher or rapeseed oil sourced by a biodiesel producer.
- Output: any physical output supplied by any party in the supply chain. For example rapeseed supplied by a rapeseed farm or rapeseed oil supplied by a rapeseed crusher.
- Conversion factor: refers to the amount of output produced per unit of input. For example the oil extraction rate or the amount of biodiesel produced per unit of vegetable oil.
- Inventory: refers to a stock of physical product or C&S data.
- Chain of Custody: for the purpose of the RTFO a Chain of Custody system is a system which links the volumes of biofuel reported to the RFA with certain carbon and sustainability characteristics to the volumes of feedstocks required for this which posses the same carbon and sustainability characteristics. An essential aspect of the Chain of Custody system therefore is that it must be able to guarantee that for each unit of biofuel with certain carbon and sustainability characteristics reported to

the RFA an equivalent amount of feedstock with the same sustainability characteristics has been added to the market.

### Aggregating multiple administrative batches

Multiple batches can be aggregated at any point in the supply chain provided the individual batches have identical sustainability characteristics as defined above. Administrative batches with different carbon intensities but identical sustainability characteristics can be aggregated – the resulting carbon intensity is calculated as a weighted average of the individual batches (based on volume for liquid products) – See Annex G.

## Which Chain of Custody systems should be permitted for C&S reporting under the RTFO?

It is recommended that to validate the accuracy of C&S reports a Chain of Custody must be established from the party which generates the C&S information to the reporting party. In general, three different types of Chain of Custody systems are distinguished:

- Bulk commodity systems (physical segregation)
- Mass-balance systems (units in = units out)
- Book and claim systems (tradable certificates).

The Chain of Custody must operate reliably and prevent abuse such as double counting. It must also be relevant to the feedstock which is used in the production of the biofuel. For example, a biodiesel producer which produces biodiesel from 100% rapeseed oil, is not permitted to report the fuel as being sourced from palm oil.

Where existing bulk commodity or mass balance systems are in operation (as identified in table 7) it is recommended that the RFA should permit their use under the RTFO scheme. Where such a chain of custody does not exist it is recommended that either a mass-balance or a book and claim system should be used to set one up. Book and claim systems are not yet operational for biofuel feedstocks. Should such a system become operational the RFA is recommended to assess the reliability of the Chain of Custody and to determine whether the system is permitted under the RTFO. The Government recommends that the RFA should monitor the effectiveness of such book and claim systems and ensure that adequate safeguards are in place to prevent double-counting.

## When to set up a Chain of Custody

Several existing sustainability standards, such as the Forest Stewardship Scheme (FSC), have defined their own Chain of Custody. In this case a certified Chain of Custody already exists and it is recommended that it can be used. The supplier must be able to provide proof that its producer sourced the relevant feedstocks through the certified Chain of Custody of the existing standard.

However, there are several limitations in using a Chain of Custody system of an existing standard:

- At the time of writing, most of the benchmarked standards do not have an operational Chain of Custody, see table 7.
- Existing sustainability standards currently do not contain GHG data and therefore no claims can be made concerning performance in these cases: default values must be used.
- The Chain of Custody may not be in place between the biofuel producer and the ultimate supplier who is applying for RTFCs.

These limitations suggest that it may be necessary for suppliers to set up their own Chain of Custody: at least until existing standards develop their own Chain of Custody. For these situations more detailed recommended guidance on operating a reliable mass balance type of Chain of Custody is given below. The mass balance type of Chain of Custody is expected to provide the least number of obstacles to short term implementation.

Suppliers may, it is recommended, set up different types of Chain of Custodies if they wish to do so, provided it can be shown a) that they function reliably and are permitted by the RFA and b) are accepted by the standards for which they are used. For example if RSPO sets up a book and claim system for tradable palm oil certificates, the RSPO may not accept market players setting up an alternative book and claim system in which RSPO certificates are issued, traded and redeemed.

**Table 7: Existing Chain of Custody for several standards and initiatives.**

| | Bulk commodity | Mass-balance | Book-and-claim |
|---|---|---|---|
| Forest Stewardship Council (FSC) | Yes | Yes | - |
| Sustainable Agriculture Network/ Rainforest Alliance (SAN/RA) | Yes | - | - |
| International Federation of Organic Agriculture Movements (IFOAM) | Yes | - | - |
| Linking Environment And Farming (LEAF) | - | - | - |
| Roundtable on Sustainable Palm Oil (RSPO) | Under development | Under development | Under development |
| Round Table on Responsible Soy (RTRS) | Under development | | |
| Social Accountability 8000 (SA8000) | - | - | - |

| | | | |
|---|---|---|---|
| Assured Combinable Crops Scheme (ACCS) | - | - | - |
| GlobalGAP, Combinable Crops | - | - | - |

## Recommended Guidance for operating a mass balance type of Chain of Custody

### Scope

Each party in the biofuel supply chain, who is at any point the legal owner of the product, needs to put in place the administration necessary to maintain the Chain of Custody. If any party in the supply chain, who takes legal ownership over the product, does not keep the required records, the Chain of Custody stops at this point and no claims related to C&S data can be made by parties further downstream. The consequences of a break in the Chain of Custody are that the fuel supplier will have to use the default values to report carbon intensity and may have to state that the provenance of their biofuel is “unknown”.

### Responsibilities and procedures

Each company in the Chain of Custody should:

- Appoint a person or position with overall responsibility for compliance with the Chain of Custody procedures explained below.
- Have written procedures and/or work instructions to ensure implementation of the requirements as explained below.

### Selling products with C&S data

- A company that sells products with C&S data must specify the C&S data on the invoice or on a document to which the invoice refers. The invoice or relevant document must include the following information:
  - The name and address of the buyer;
  - The date on which the invoice was issued;
  - Description of the product – this must correspond to the description of the product given in the input and output records;
  - The quantity of the products sold with specific C&S data. If the invoice contains products with different C&S data, these shall be identified separately in such a way that it is clear to which products the C&S data refers.
- A party in the Chain of Custody can not sell more output with specific C&S data than its sourced input with the same C&S data (taking into account the relevant conversion factor). The periodic inventory of C&S data must not be negative.

- For any transaction, the traded amount of C&S data can not exceed the traded amount of physical product.

## Record keeping

Each company party in the Chain of Custody should keep the following records.

- Input and output records of C&S data. Input records refer to the C&S data of products purchased from a supplier. Output records refer to the C&S data of products sold to a buyer. For each administrative batch these records should include at least:
  - Invoice reference(s);
  - A description of the physical product to which the C&S data refer;
  - The volume of physical input/output to which the C&S data refer;
  - The supplying/receiving company;
  - Transaction date;
  - Any C&S data.

All this information should concur with the information on the invoice(s) to which the input record refers.

- Conversion factor records. These records refer to the conversion factor of inputs to outputs (e.g. rapeseed to rapeseed oil). Each party in the supply chain can maintain records of its own conversion factors. A party may have more than one conversion factor. If no records are kept for the conversion factor the default value for the respective conversion factor must be used. For each conversion factor it must be clear from the records:
  - Which input product it refers to;
  - Which output product it refers to;
  - The units in which the conversion factor is expressed;
  - The value of the actual conversion factor;
  - When the specific conversion factor was valid. The period of validity is one year.
- The conversion factors may also be integrated in the input, output or inventory records as long as the requirements listed here are met.
- Periodic inventory of C&S data. These records provide an insight into the balance of C&S data. Besides helping a company to manage its input-output balance these records also assist in the verification of a party's Chain of Custody records. The period between inventories must be no longer than one month and records should include:
  - The inventory of C&S data at the beginning of the respective period (including the carbon intensity of the stock). It must be clearly specified whether this is expressed in input-equivalents (before conversion factor) or output-equivalents

(after conversion factor);

- The volumes of inputs with identical C&S data in the respective period. These volumes must coincide with the input records described above;
- The volume of outputs with identical C&S data in the respective period. These volumes must coincide with the output records described above;
- The conversion factor(s) used in the respective period;
- The inventory of C&S data at the end of the respective period (including the carbon intensity of the stock). It must be clearly specified whether this is expressed in input-equivalents (before conversion factor) or output-equivalents (after conversion factor).

### Records to keep of products from unknown origin

- When the origin of the inputs is unknown, the only information required in the input record is the product description (e.g. rapeseed or rapeseed oil) and the volume.

## Further guidance

Example formats for the records described above are illustrated in Annex F. It is recommended that other formats should be acceptable provided they meet the requirements described.

## Equivalence trading

Equivalence trading refers to the practice under the Common Agricultural Policy of the EU where crops grown under contract for energy use (either grown on set-aside or claiming the EU Energy Aid Payment) can be substituted by other material from within the EU which has not been grown under an energy contract.

It is recommended that, under the RTFO scheme, the C&S characteristics of the feedstock should also be allowed to be substituted in this exchange. This would mean that the C&S characteristics of the contracted farm, which does not actually deliver the physical feedstock, may be used for C&S reporting (in line with a book and claim system).

### Recommended rules for C&S data in the case of equivalence trading

It is recommended that the following requirements must be met to practise C&S data swapping in an equivalence trade:

- All requirements as defined in the Common Agricultural Policy for equivalence trading need to be met.
- Data swapping is only permitted within the same feedstock in an equivalence trade.
- Trade of C&S data through equivalence trading only takes place between the farm providing the data and the first buyer of the feedstock. From the first buyer onwards the trade in C&S data should continue with the certified Chain of Custody where it exists or through the mass balance approach described in this chapter.

- All the C&S data reported must originate from the same contracted farm (i.e. it is not permitted to use carbon intensity data from one farm and sustainability information from the other). In calculating the carbon intensity of the fuel the default transportation distance should be used.
- A verifiable system is in place at the farm which provides the C&S data to prevent double counting of C&S data. If, for example, the farm is LEAF certified and this is claimed by the biofuel chain through equivalence trading, the LEAF mark cannot be claimed again with the sale of the physical product.

It is recommended that the RFA keeps this approach to the transfer of carbon and sustainability data where an equivalence trade has taken place under review.

# 8 Verification of company reporting

***This chapter recommends verification requirements for suppliers who submit annual C&S reports under the RTFO, and provides examples of good practice to assist with verification procedures.***

***All statements below should be taken as recommendations to the RFA and not as detailed requirements or as guidance on compliance with the RTFO. Responsibility for issuing detailed guidance lies with the RFA.***

## General

In order to provide confidence in the C&S reports of suppliers, it is recommended that the RFA requires that the information submitted in the annual RTFO C&S report is subject to independent verification. The RFA may impose a civil penalty on any supplier that does not supply the required independent verification, where the verification is required by the RFA as evidence to substantiate the annual report.

As set out in Chapter 5 it is recommended that the RFA should require the annual report to include aggregated monthly C&S data, including any corrections subsequently made, and other qualitative information about the operations of the fuel supplier as set out in Chapter 4. The Government recognises that the verification audit is likely to be undertaken through a risk-based sampling approach and therefore does not recommend that every single piece of data should be required to be checked.

Following verification, it is recommended that the RFA should require the supplier to obtain a formal limited-assurance opinion (a verification statement) about the quality of the annual reporting. The term ‘limited-assurance’ is defined in the International Standard on Assurance Engagements (ISAE 3000).

It should be the responsibility of reporting suppliers to submit an independent verifier's statement on the annual report to the RFA by 28 September (the recommended deadline for submitting the annual report). This statement should be supplied regardless of the conclusion reached. Organising the verification should be the responsibility of the fuel supplier. It is recommended that the RFA should consider making the verifier's statement available to the public, together with the supplier's annual report.

## Setting up a System for Carbon and Sustainability Reporting

To be able to produce data that is of sufficient quality for reporting, fuel suppliers need to ensure that they and others in their supply chain have effective systems for C&S reporting.

It is considered that for greatest efficiency, fuel suppliers should appoint a single point of contact with responsibility for C&S reporting.

### Recommended Good practice

It is recommended that the RFA give guidance to suppliers on good practice for setting up a reporting system. For example the guidance might be that the supplier should:

- Liaise with the supply chain to ensure awareness of the need for co-operation and for a Chain of Custody.
- Produce data in a manner that is transparent and is as consistent as possible between years (allowing for improvements in method).
- Remove unnecessary complexity from the reporting system.
- Organise internal checks of the data.
- Ensure all people supplying data are aware of the rigour required and that responsibility for supplying the data is allocated.
- Map the data flow within the organisation, such as between spreadsheets.
- Minimise the manual transfer of data.
- Ensure adequate controls around the data,
- Document the system (who does what, when etc.)
- Track data over time to help identify any misstatement.

## Which data will be verified?

It is not recommended that there be no requirement for physical evidence (such as copies of invoices etc) from farms, processors or other suppliers to be passed along the supply chain. It is recommended that the party which generates the carbon and/or sustainability data should retain this evidence. In verifying the C&S data reported by a fuel supplier, the verifier should work back up the supply chain to the source data using the Chain of Custody records. The co-operation of those in the supply chain is therefore vital.

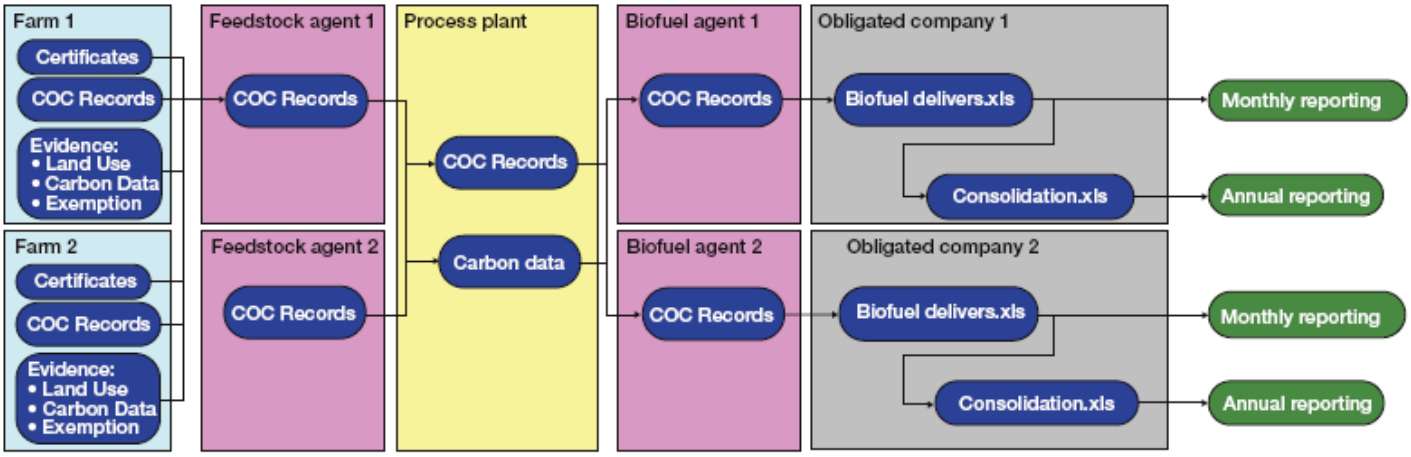
With respect to sustainability data, it is recommended that certificates of Benchmarked Standards are accepted as sufficient proof of compliance with the criteria and indicators of that standard. If it is claimed that the RTFO Sustainable Biofuels Meta-Standard is met, documented proof from the supplementary checks should be required as evidence. (See Annex A for a list of recommended Benchmarked Standards, and Annex D for supplementary checks recommended to achieve the RTFO Sustainable Biofuel Meta-Standard). Similarly, it is recommended that documented proof is required of assessment against gap criteria for a claim of a Qualifying Standard.

Other C&S data should be subject to verification, for example:

- Carbon data;
- Evidence of Land Use on 30 November 2005;
- Chain of Custody records;
- Other information provided in the annual report.

An example of the recommended records to be kept and the data flow with a simplified supply chain is shown below.

**Figure 2 – Example of the records kept by each party in the supply chain**




Note that it is recommended that each party keeps Chain of Custody records but that evidence does not need to be passed to parties downstream in the Chain of Custody. Through the Chain of Custody records, the verifier will be able to trace back to the party that generated the carbon and/or sustainability data to check the evidence.

### Good systems reduce the cost of verification

The greater the confidence that can be placed on controls the less effort that needs to be given to verifying the data for the same level of assurance. The cost of verification can, therefore, be reduced if the verifier has confidence in the system that produced the data. Evidence of the effectiveness of controls can come from internal sources, such as management reviews and internal audits, as well as external audits, for example, of the Chain of Custody.

## How to organise the verification

It is recommended that the fuel supplier is responsible for engaging a verifier approved to carry out a ***limited-assurance*** audit of the annual C&S report. The term 'limited-assurance' is defined in the International Standard on Assurance Engagements (ISAE 3000).

It is recommended that the RFA give guidance to suppliers concerning the selection of a verifier. For example, the verification body could be required to demonstrate that it:

- Is independent of organisations involved in the production of biofuels;
- Has established and maintains personnel records, which demonstrate that the verification personnel are competent;
- Has effective procedures for the training and recruitment of competent staff (employees and contractors);
- Ensures that the personnel involved in verification are competent for the functions they perform;
- Has systems to monitor the performance of auditors and reviewers, which are reviewed regularly;
- Keeps up with verification best practice.

The Government recommends that the RFA require that annual reports be verified by auditors who are qualified to carry out audits against the International Standard on Assurance Engagements (ISAE 3000), which defines requirements for limited-scope engagements. The Government also recommends that the RFA should consider cross-referencing existing accredited verifiers for other schemes (such as the EU's Emissions Trading Scheme).

Limited assurance audits aim to provide moderate assurance that the annual C&S report is without material misstatement. As such verifiers should state that nothing has come to their attention to indicate material misstatement, given an appropriate level of investigation. ISAE 3000 provides guidance to verifiers about how they must go about the audit. It should normally be possible for verifiers to obtain moderate assurance from a site visit to the fuel supplier and telephone interviews along the supply chain.

It is recommended that the RFA should give guidance to suppliers about the steps to take in order to carry out verification of the annual report. For example:

1. Submit the draft annual C&S report to the verifier;
2. Submit supporting information and evidence held by the fuel supplier;
3. Host any visits from the verifier;
4. Respond to any verifier questions;
5. Correct any material misstatement identified by the verifier;
6. Submit the verification opinion with the annual report.

The verifier may wish to visit the fuel supplier and review the consolidation process and meet the person responsible for the submission.

The verifier should work along the supply chain, tracing the data flow and testing controls. The verifier may select a risk-based approach; therefore not every organisation in the supply chain is likely to be contacted. The exact approach may vary with each verifier and supply chain.

The duration of the verification process may take a number of weeks, particularly if the supply chain is complex or long and responses to information requests from the verifier are delayed. It is recommended that suppliers engage the verifier long before the deadline date for submission of the annual report and verification statement to the RFA. The verifier may wish to carry out tests during the year to reduce any end of year bottlenecks.

### Good practice

It is recommended that the RFA give guidance as to good practice in briefing the verifier. For example it is good practice to engage a verifier as early as possible in the process to maximise a supplier's learning from the verifier and to help identify any mistakes as early as possible. Common verification practice is for data to be supplied to the verifier in an organised evidence pack. This would be expected to include:

- The draft annual C&S report;
- High-level description of supply chain (as is known, to help the verifier);
- Chain of Custody records;
- Contact details, of the organisations in the previous stages in the supply chain (at least);
- Calculation spreadsheets (preferably supplied electronically so that verifiers can test the formulae);
- Physical evidence to support qualitative statements which refer to the fuel supplier itself.

All the above information would be needed to verify the data. If not provided in an ordered fashion, the verifier would need to request information, which increases the verification effort required.

## Verifier opinions

It is recommended that the supplier be required to submit to the RFA a statement from the verifier on the annual C&S report at the same time as the annual report.

The verifier should determine whether there is any evidence of material errors in the annual report or the data used to compile monthly reports.

An "unqualified" opinion for the annual C&S report could be worded, for example, as below:

> "Nothing has come to our attention that causes us to believe that internal control is not effective, in all material respects."

If there is evidence of material errors the opinion could be worded, for example, as below:

> "Nothing has come to our attention that causes us to believe that internal control is not effective, in all material respects, with the exception of:
>
> - X
>
> - Y

- Z.”

It is standard practice for the verifier to submit a report, in addition to the opinion, to the client. Such a report may be particularly useful if it includes information on the overall effectiveness of the system in place to generate C&S data as well as recommendations for improvement. This can help suppliers to understand the process and improve their performance. It can also maximise the knowledge transfer of the verifier to the party submitting their verified annual reports.

# Annex A: Guidance on sustainability standards

## Benchmarked standards

A selection of existing standards has already been benchmarked against the RTFO Sustainable Biofuel Meta-Standard. Those that, in the Government's view, meet an acceptable level of sustainability are called Qualifying Standards. The results of the benchmarking exercise are shown in Table 8. It is recommended that any standard that is listed can be reported under the RTFO and will count towards a company's data capture target but only Qualifying Standards count towards a company's Qualifying Standard target.

The detailed results of the benchmarking exercise are included in Annex D. The Government recommends that more standards should be benchmarked by the RFA in due course.

**Table 8: List of benchmarked standards. The table illustrates whether the standard is an environmental or social Qualifying Standard or neither.**

| Benchmarked Standards | Qualifying Environmental Standard? | Qualifying Social Standard? |
|---|---|---|
| Linking Environment And Farming Marque (LEAF) [1] | Yes | No |
| Roundtable on Sustainable Palm Oil (RSPO) | Yes | Yes |
| Sustainable Agriculture Network/Rainforest Alliance (SAN/RA) | Yes | Yes |
| Basel criteria for soy (Basel) | Yes | Yes |
| Forest Stewardship Council (FSC) | Yes | No |
| Assured Combinable Crops Scheme (ACCS) | Yes | No |
| Social Accountability 8000 (SA8000) | No | No |
| GlobalGAP [2] | No | No |
| International Federation of Organic Agriculture Movements (IFOAM)[3] | No | No |
| Proterra [4] | No | No |

| Other standards to report [5] | Qualifying Environmental Standard? | Qualifying Social Standard? |
|---|---|---|
| Genesis Crops Module | No | No |
| Scottish Quality Cereals | No | No |
| Qualität und Sicherheit (German Standard) | No | No |
| Fedioil (Finnish Standard) | No | No |

1) Approximately 10% of LEAF Marque certificates are issued by non-accredited certification bodies. LEAF can only be reported as a Qualifying Environmental Standard if the certificate has been issued by an accredited body.
2) Note that EurepGAP was originally benchmarked against the RTFO Sustainable Biofuel Meta-Standard. Since the original benchmark the standard has been updated and is now named GlobalGAP. Therefore, only GlobalGAP should be reported. It will be recommended that the RFA re-benchmark GlobalGAP as a priority, but It is not anticipated that new GlobalGAP standard will reach the Qualifying Standard level.
3) IFOAM itself is a Meta-Standard. It focuses on accrediting other standards for organic agriculture according to the general requirements set out by IFOAM. Unfortunately, several important criteria are only included as recommendations in IFOAM, thereby giving no guarantees of compliance. While these have not been benchmarked, some of the organic standards accredited by IFOAM may actually include stricter criteria and could therefore meet the Qualifying Standard level.
4) The Proterra criteria and indicators alone suggest that the standard could meet the Qualifying Standard level. However, most of the criteria included in Proterra are not mandatory for certification with no set deadline for meeting them. Therefore Proterra certification currently does not guarantee that these important criteria are indeed complied with. Furthermore, the Proterra standard does not offer an independent accreditation process, and as such does not guarantee the audit quality. It is therefore not currently a Qualifying Standard.
5) The Government recommends that the RFA should benchmark these standards against the RTFO Sustainable Biofuel Meta-Standard in due course. A brief analysis suggests that in their current form these standards would not meet the Qualifying Standard level. It is recommended that the reporting of these standards should be permitted and should count towards a company's data capture target, not count towards a supplier's Qualifying Standard target.

## Short term solutions for standards in development

Several of the benchmarked standards are not yet operational and for sugar cane no initiative with a clear set of draft criteria is available. To offer a short term solution for these

cases the Government recommends that the following alternatives should be accepted for the RTFO:

- Palm oil: the Roundtable on Sustainable Palm Oil (RSPO) has recently approved its auditing and verification systems. In advance of the chain of custody becoming operational the following should be accepted as meeting the RSPO criteria and thereby the qualifying level of sustainability for the RTFO:
  - Successful audit against the RSPO criteria and indicators, and
  - Feedstock producer is a member of the RSPO or equivalent.
- Soy oil: the Round Table on Responsible Soy (RTRS) is not fully operational therefore the following should be accepted as meeting the Basel criteria and thereby the qualifying level of sustainability for the RTFO:
  - Successful audit against the Basel criteria and indicators, except criterion 2.3 on genetically modified material, and
  - Feedstock producer is a member of the RTRS or equivalent.
- Sugar cane: for as long as an accepted standard for sugar cane is not in operation the following should be accepted as meeting the RTFO Sustainable Biofuel Meta-Standard:
  - Successful audit against the RTFO Sustainable Biofuel criteria and indicators, and
  - Feedstock producer is a member of the Better Sugarcane Initiative (BSI) or equivalent.

The audits must meet the following requirements:

- The verification body is accredited to ISO 65;
- The auditor competencies meet the requirements as set out in ISO 19011 or justified equivalent.

## Benchmarking additional standards

The Government recommends that the RFA establishes a clear process for the regular benchmarking of standards and should review the effectiveness of existing standards on an annual basis. It should publish a regular review of the findings of its benchmarking exercises.

In addition, the Government recommends that a transport fuel supplier should be able to request that the RFA benchmark an additional standard that it wishes to use. The exact procedure for this should be determined by the RFA, but the Government suggests that the following represents a suitable procedure:

- The company files a request for benchmark for a particular standard with the RFA which includes at least the following:
  - The formal description of the Standard;

- The most recent version of the Standard's Criteria and Indicators;
- The most recent version of the Standard's procedures and requirements for the auditing/certification process, the auditor and the certifying body.

- The RFA will, as appropriate, benchmark the Standard against the RTFO Sustainable Biofuel Meta-Standard and if it does so will conclude whether it is an Environmental and/or Social Qualifying Standard, or not, considering the guidance given below.
- The results will be made publicly available.

## Guidelines for the RFA for the norm for Qualifying Standards

The following norms were used for the benchmarks and are recommended to the RFA for use in conducting future benchmarks.

### Norm for Qualifying Environmental Standard

To become a Qualifying Environmental Standard the following criteria must be met:

- Full compliance with all criteria referring to compliance with national legislation (2.1, 3.1, 4.1, 5.1);
- On all principles one 'partial compliance' criterion is permitted per principle, with a maximum of three in total.

Full compliance with a criterion is only awarded if the RTFO criterion is met by a corresponding *mandatory* criterion in the benchmarked standard.

### Norm for Qualifying Social Standard

To become a Qualifying Social Standard the following criteria must be met:

- Of the 11 minimum requirement criteria of principle 6, 7 must be fully complied with;
- On principle 7 on land right issues and community relations, one partial compliance is permitted.

Full compliance with a criterion is only awarded if the RTFO criterion is met by a corresponding *mandatory* criterion in the benchmarked standard.

### Norm for benchmark of audit quality

No fixed norm is currently given for the audit requirements because different standards have different approaches to control the quality of the audit and certification process for their standards. This makes it difficult to define a common set of minimum criteria for the audit and certification process. Based on an analysis of audit requirements of existing standards (see background document *Sustainability Reporting within the RTFO: Framework Report*) all currently benchmarked standards are judged to provide sufficient credibility for the purpose of the RTFO, with two exceptions:

- LEAF Marque certificates that have been issued by a body that is not accredited.

Approximately 10% of all LEAF Marque certificates are issued by non-accredited certification bodies. LEAF can therefore only be reported as a Qualifying Environmental Standard if the certificate has been issued by an accredited body.

- The Proterra standard in its current form does not offer an independent accreditation process, and as such does not meet the norm for audit quality. It is therefore not currently a Qualifying Standard.

**Guidelines for future auditing quality requirements**

The Government recommends that the RFA should develop a set of minimum auditing quality requirements for future benchmarks. Guidelines for such future requirements are given below:

Who is responsible for accreditation?

Certification bodies should be accredited by the body that is responsible for the standard in question. Where standard bodies look to national accreditation bodies (such as UKAS) to organise accreditation, accreditation should be achieved through the appropriate national accreditation body. These bodies must be Accreditation Body Members of the International Accreditation Forum (IAF)[1].

What accreditation process is required?

Standards should only be accepted if they have a rigorous accreditation process (compliant with ISO Guide 65, which is due to be replaced by ISO 17021 in 2008), or justified equivalent. ISO Guide 65 sets out the general requirements for bodies operating assessment and certification/ registration of quality systems.

Do all farms need to be audited annually?

The Government recommends that this should be a requirement with surveillance checks being acceptable where a farm has received a full audit within the previous three years. Risk-based auditing should be acceptable where management systems are common and co-ordinated.

How are audit programmes and audits activities to be managed?

As stated in ISO19011, or justified equivalent. The ‘Plan, Do Check and Act’ of the audit programme should be managed appropriately.

What is the required competence of auditors?

As stated in ISO19011, or justified equivalent. Lead auditors should have carried out at least three complete audits for a total of at least 15 days of auditing experience acting in the roles of an audit team leader, under the direction and guidance of an auditor competent as an audit team leader. These three audits should be completed within the last two consecutive years.

What is the level of Stakeholder consultation?

The certification audit should contain sufficient consultation with external stakeholders to

ensure that all relevant issues are identified relating to compliance with the requirements of the standard.

Are public summaries of the certification audit available?

A summary of the results of the certification audit (excluding confidential information) should be made available to interested parties.

1) A full list of IAF Accreditation Body Members are listed on the IAF website (www.iaf.nu).

# Annex B: Eligible by-products

The Government recommends that a feedstock that represents less than 10% of the farm or factory gate value should be defined as a "by-product" for the purposes of c&s reporting under the RTFO.

The biofuel producer purchasing these by-products will have little influence on the sustainability of the production process for the original product. For example, a biofuel producer buying tallow will have little or no influence on the standards applied to rearing the cattle.

For the purpose of the Guidance and Requirements, the Government recommends that the following products should be considered by-products:

- Tallow
- Used cooking oil
- Municipal Solid Waste
- Animal manure
- Molasses

It is recommended that the RFA put in place a procedure for considering a request by a supplier that an additional feedstock be considered as a by-product. A possible procedure would involve the following steps:

- A company requests the RFA to define a specific feedstock as a by-product.
- The RFA agrees to conduct an assessment and makes publicly known on its website that the product is being assessed.
- The RFA determines whether the product meets the criteria of a by-product. In using market price information the RFA will use the average market price of the preceding calendar year.
- The RFA publishes the results and its decision on its website.
- The decision of the RFA will be valid at least for the remainder of the obligation period in which the request is made (from 15 April of one year to 14 April the following year).
- If the RFA chooses not to review the categorisation of a product as a by-product, the decision will remain valid for the next obligation period.
- If the RFA chooses to review the categorisation of a product as a by-product, it will do so before the end of March and publish the renewed results on its website before the end of March. The renewed results will be valid for the next obligation period, starting on 15 April.

# Annex C: Criteria and Indicators of the RTFO Sustainable Biofuel Meta-Standard

## Environmental criteria and indicators

The tables below illustrate the Government's recommended environmental sustainability criteria and indicators for the RTFO Sustainable Biofuel Meta-Standard. All criteria and indicators listed in the tables must be met for the RTFO Sustainable Biofuel Meta-Standard. The 'recommended' criteria and indicators listed below the tables are not required for the RTFO Sustainable Biofuel Meta-Standard but are considered good practice. They indicate factors which the Government recommends as relevant to the long term development of the RTFO Sustainable Biofuel Meta-Standard.

The Government recommends that the RFA should keep the criteria and indicators for the RTFO Sustainable Biofuel Meta-Standard under regular review to ensure their continuing relevance. The status of mandatory and recommended criteria should also be kept under review.

| **Principle 1: CARBON CONSERVATION** | **Biomass production will not destroy or damage large above or below ground carbon stocks** |
|---|---|
| Criterion | Indicators |
| 1.1 Preservation of above and below ground carbon stocks (reference date 30-11-2005). | • Evidence that biomass production has not caused direct land use change with a carbon payback time exceeding 10 years[1].<br>• Evidence that the biomass production unit has not been established on soils with a large risk of significant soil stored carbon losses such as peat lands, mangroves, wetlands and certain grasslands. |

1. Guidance on the 'carbon pay back time' is given in Annex I.

| **Principle 2: BIODIVERSITY CONSERVATION** | **Biomass production will not lead to the destruction or damage of high biodiversity areas** |
|---|---|
| Criterion | Indicators |
| 2.1 Compliance with national laws and regulations relevant to biomass production in the area and surroundings where biomass production takes place. | • Evidence of compliance with national and local laws and regulations with respect to:<br>Environmental Impact Assessment<br>– Land ownership and land use rights<br>– Forest and plantation management<br>– Protected and gazetted areas<br>– Nature and wild life conservation<br>– Land use planning<br>– National rules resulting from the adoption of CBD[1] and CITES[2].<br>• The company should prove that:<br>– It is familiar with relevant national and local legislation<br>– It complies with this legislation<br>– It remains informed on changes in legislation |
| 2.2 No conversion of high biodiversity areas after November 30, 2005 | • Evidence that production does not take place in gazetted areas.<br>• Evidence that production does not take place in areas with one or more HCV areas[3]:<br>– HCV 1, 2, 3 relating to important ecosystems and species<br>– HCV 4, relating to important ecosystem services, especially in vulnerable areas<br>– HCV 5, 6, relating to community livelihoods and cultural values. |

[1] http://www.biodiv.org/com/convention/convention.shtml

[2] http://www.cites.org/eng/disc/text.shtml

[3] The definition of the 6 High Conservation Values can be found at http://www.hcvnetwork.org
Currently no comprehensive maps exist which define HCV areas. For many areas it will therefore still be necessary to assess whether HCV's are present or not.
The following initiatives are helpful in defining areas with one or more HCV's:
• Conservation International – Biodiversity Hotspots
• Birdlife international – Important Bird Areas
• The WWF G200 Ecoregions : the regions classified 'vulnerable' or 'critical/endangered'.
• European High Nature Value Farmland

| | |
|---|---|
| | • Evidence that production does not take place in any areas of high biodiversity. |
| 2.3 The status of rare, threatened or endangered species and high conservation value habitats, if any, that exist in the production site or that could be affected by it, shall be identified and their conservation taken into account in management plans and operations. | • Documentation of the status of rare, threatened or endangered species (resident, migratory or otherwise) and high conservation value habitats in and around the production site.<br>• Documented and implemented management plan on how to avoid damage to or disturbance of the above mentioned species and habitats. |

Recommendation only:
Criterion:
Preservation and/or improvement of surrounding landscape.
Indicators:
Representative samples of existing ecosystems within the landscape shall be protected in their natural state and recorded on maps, appropriate to the scale and intensity of operations and the uniqueness of the affected resources.

| **Principle 3: SOIL CONSERVATION** | **Biomass production does not lead to soil degradation** |
|---|---|
| Criterion | Indicators |
| 3.1 Compliance with national laws and regulations relevant to soil degradation and soil management. | • Evidence of compliance with national and local laws and regulations with respect to:<br>– Environmental Impact Assessment<br>– Waste storage and handling<br>– Pesticides and agro-chemicals<br>– Fertilizer<br>– Soil erosion<br>• Compliance with the Stockholm convention (list of forbidden pesticides).<br>• The company should prove that:<br>– It is familiar with relevant national and local legislation<br>– It complies with this legislation<br>– It remains informed on changes in legislation |
| 3.2 Application of good agricultural | • Documentation of soil management plan aimed at sustainable soil management, erosion prevention |

| | |
|---|---|
| practices with respect to:<br>– Prevention and control of erosion<br>– Maintaining and improving soil nutrient balance<br>– Maintaining and improving soil organic matter<br>– Maintaining and improving soil pH<br>– Maintaining and improving soil structure<br>– Maintaining and improving soil biodiversity<br>– Prevention of salinisation | and erosion control.<br>• Annual documentation of applied good agricultural practices with respect to[1]:<br>– Prevention and control of erosion<br>– Maintaining and improving soil nutrient balance<br>– Maintaining and improving soil organic matter<br>– Maintaining and improving soil pH<br>– Maintaining and improving soil structure<br>– Maintaining and improving soil biodiversity<br>– Prevention of salinisation |

Recommendation only:

Criterion:

The use of agricultural by-products does not jeopardize the function of local uses of the by-products, soil organic matter or soil nutrients balance.

Indicators

Documentation that the use of by-products does not occur at the expense of important traditional uses (such as fodder, natural fertilizer, material, local fuel etc.) unless documentation is available that similar or better alternatives are available and are applied.

Documentation that the use of by-products does not occur at the expense of the soil nutrient balance or soil organic matter balance.

| **Principle 4: SUSTAINABLE WATER USE** | **Biomass production does not lead to the contamination or depletion of water sources** |
|---|---|
| Criterion | Indicators |
| 4.1 Compliance with national laws and regulations relevant to contamination and depletion of water sources. | • Evidence of compliance with national and local laws and regulations with respect to:<br>– Environmental Impact Assessment<br>– Waste storage and handling |

[1] Recommendations only

Records of annual measurements of:

– Soil loss in tonnes soil/ha/y
– N,P,K balance
– SOM and pH in top soil
– Soil salts content

| | |
|---|---|
| | – Pesticides and agro-chemicals<br>– Fertilizer<br>– Irrigation and water usage<br>• The company should prove that:<br>– It is familiar with relevant national and local legislation<br>– It complies with this legislation<br>– It remains informed on changes in legislation |
| 4.2 Application of good agricultural practices to reduce water usage and to maintain and improve water quality. | • Documentation of water management plan aimed at sustainable water use and prevention of water pollution.<br>• Annual documentation of applied good agricultural practices with respect to[1]:<br>– Efficient water usage.<br>– Responsible use of agro-chemicals<br>– Waste discharge |

| **Principle 5: AIR QUALITY** | **Biomass production does not lead to air pollution** |
|---|---|
| Criterion | Indicators |
| 5.1 Compliance with national laws and regulations relevant to air emissions and burning practices | • Evidence of compliance with national and local laws and regulations with respect to:<br>– Environmental Impact Assessment<br>– Air emissions<br>– Waste management<br>– Burning practices<br>• The company should proof that:<br>– It is familiar with relevant national and local legislation |

[1] Recommendations only

Records of annual measurements of:

– Agrochemical inputs (input/ha/y), such as fertilizers and pesticides (specified per agrochemical)
– Water sources used (litres/ha/y)
– BOD level of water on and nearby biomass production and processing.

| | |
|---|---|
| | – It complies with this legislation<br>– It remains informed on changes in legislation |
| 5.2 No burning as part off land clearing or waste disposal. | • Evidence that no burning occurs as part of land clearing or waste disposal, except in specific situations such as described in the ASEAN guidelines on zero burning or other respected good agricultural practices. |

**List of protected areas referred to in criterion 2.2**

- UNESCO World heritage sites[1];
- IUCN List of Protected Areas categories I, II, III and IV[2], according to the list available from 2003[3] or more up to date lists or national data;
- RAMSAR sites (wetlands under the Convention on Wetlands)[4], according to the available list[5] of more up to date lists or national data.

[1] http://whc.unesco.org/en/list

[2] IUCN defines a protected area as: an area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means, and subdivides protected areas into six categories: Ia: Strict nature reserve/wilderness protection area; Ib: Wilderness area; II: National park; III: Natural monument; IV: Habitat/Species management area; V: Protected landscape/seascape; VI: Managed resource protected area.
Source: www.wwf.de/fi leadmin/fm-wwf/pdf-alt/waelder/WWF-position_Protected_Areas_03.pdf

[3] http://www.unep-wcmc.org/wdpa/unlist/2003_UN_LIST.pdf

[4] http://www.ramsar.org/

[5] http://www.ramsar.org/index_list.htm

## Social criteria and indicators

Table 9 illustrates the recommended mandatory social criteria and indicators for the RTFO Sustainable Biofuel Meta-Standard. The RFA should keep these criteria and indicators under review to ensure their continuing relevance. The status of mandatory and good practice criteria should also be kept under review.

**Table 9: Social criteria and indicators for the RTFO Sustainable Biofuel Meta-Standard. All the listed criteria and indicators must be met for the RTFO Sustainable Biofuel Meta-Standard.**

| Criteria | Indicators |
|---|---|
| **6. Biomass production does adversely effect workers rights and working relationships** | |
| C 6.1 Compliance with national law on working conditions and workers rights | Certification applicant must comply with all national law concerning working conditions and workers rights. |
| C 6.2 Contracts | Certification applicant must supply all categories of employees (incl. temporary workers) with a legal contract. |
| C 6.3 Provision of information | Certification applicant must show evidence that all workers are informed about their rights (incl. bargaining rights). |
| C 6.4 Subcontracting | When labour is contracted or subcontracted to provide services for the certification applicant, the certification applicant must demonstrate that the contractor/subcontractor provides its services under the same environmental, social and labour conditions as required for this standard. |
| C 6.5 Freedom of association and right to collective bargaining | Certification applicant must guarantee the rights of workers to organise and negotiate their working conditions (as established in ILO conventions 87 en 98). Workers exercising this right must not be discriminated against or suffer repercussions. |
| C 6.6 Child labour | Certification applicant must guarantee that no children below the age of 15 are employed. Children are allowed to work on family farms if not interfering with children's educational, moral, social and physical development (the workday, inclusive of school and transport time, to be a maximum of 10 hours). |

| Criteria | Indicators |
|---|---|
| C 6.7 Young workers | The work carried out shall not be hazardous or dangerous to the health and safety of young workers (age 15 -17). It shall also not jeopardise their educational, moral, social and physical development. |
| C 6.8 Health and safety | All certification applicants must meet basic requirements including potable drinking water, clean latrines or toilettes, a clean place to eat, adequate protective equipment and access to adequate and accessible (physically and financially) medical care. Accommodation, where provided, shall be clean, safe, and meet the basic needs of the workers. |
| | All certification applicants shall ensure that workers have received regular health and safety training appropriate to the work that they perform. |
| | All certification applicants shall identify and inform workers of hazards, and adopt preventive measures to minimise hazards in the workplace and maintain records of accidents. |
| C 6.9 Wages/ compensation | Wageworkers must be paid wages at least equivalent to the legal national minimum wage or the relevant industry standard, whichever is higher. |
| | Workers must be paid in cash, or in a form that is convenient to them and regularly. |
| C 6.10 Discrimination | In accordance with ILO Conventions 100 and 111, there must be no discrimination (distinction, exclusion, or preference) practised that denies or impairs equality of opportunity, conditions, or treatment based on individual characteristics and group membership or association like: race, caste, national origin, religion, disability, gender, sexual orientation, union membership, political affiliation, age, marital status, those with HIV/AIDS, seasonal, migrant and temporary workers. |
| C 6.11 Forced Labour | Standards shall require that the certification applicant not engage in or support forced labour including bonded labour as defined by ILO conventions 29 and 105. The company must not retain any part of workers' salary, benefits, property, or documents in order to force workers to remain on the farm. The company must also refrain from any form of physical or psychological measure requiring workers to remain employed on the farm. Spouses and children of contracted |

| Criteria | Indicators |
|---|---|
| | workers should not be required to work on the farm. |
| **7. Biomass production does not adversely affect existing land rights and community relations** | |
| C 7.1 Land right issues | The right to use the land can be demonstrated and does not diminish the legal or customary rights of other users and respects important areas for local people. |
| C 7.2 Consultation and communication with local stakeholders | Procedures are in place to consult and communicate with local populations and interest groups on plans and activities that may negatively affect the legal or customary rights, property, resources, or livelihoods of local peoples. |

**List of good practice only social criteria**

It is recommended that the criteria and indicators listed below should not be required for the RTFO Sustainable Biofuel Meta-Standard but should be considered good practice. They indicate the direction the RTFO Sustainable Biofuel Meta-Standard should develop in the long term.

- Criteria: Wages and compensation
  - The certification applicant must pay the workers for unproductive time due to conditions beyond their control.
  - Housing and other benefits shall not be deducted from the minimum wage/or relevant industry wage as an in kind payment without the expressed permission of the worker concerned.
  - Where the certification applicant uses pay by production (piecework) system, the established pay rate must permit the worker to earn the minimum wage or relevant industry average (which ever is higher) during normal working hours and under normal operating conditions.
- Criteria: Working hours
  - Usual working hours shall not exceed eight hours a day and 48 hours a week.
  - Workers must have a min. of 24 hours rest for every seven day period.
  - Overtime during seasonal peaks allowed, needs to be voluntary, should be paid at premium rate. Adequate breaks (every 6 h, 30 minutes). For heavy or dangerous work shorter periods and longer breaks should be allowed.

- Criteria: Growers and mills should deal fairly with smallholders and other local businesses
  - Current and past prices for produce are publicly available.
  - Pricing mechanisms for produce, inputs and services are documented.
  - Evidence is available that all parties understand the contractual agreements they enter into, and that contracts are fair, legal and transparent and that all costs, fees and levies are explained and agreed in advance.
  - Agreed payments are made in a timely manner.

# Annex D: Benchmark of Standards

This annex includes the detailed results of the benchmarks performed of existing or developing sustainability standards against the RTFO Sustainable Biofuel Meta-Standard. Benchmarks have been performed on two aspects:

- The criteria and indicators of the sustainability standard;
- The auditing quality of the sustainability standard (results of the audit quality can be found in the background document *Sustainability Reporting under the RTFO: Framework Report*)

Note that a number of existing standards are recommended to be fully benchmarked against the RTFO Sustainable Biofuel Meta-Standard (see table 3). However a brief overview analysis suggests that in their current form these standards would not meet the Qualifying Standard level. It is recommended that the standards can currently be reported under the RTFO and be counted towards a supplier's data capture target, but not towards a supplier's Qualifying Standard target. It is recommended that the RFA should benchmark these standards fully in due course.

## Criteria and indicators

The table below shows the detailed results of the benchmark performed on the criteria and indicators of existing standards against the RTFO Sustainable Biofuel Meta-Standard criteria and indicators.

Three scores have been assigned in the benchmark:

- Y: Yes the RTFO criterion and its indicators are sufficiently met by the benchmarked standard.
- X: No the RTFO criterion and its indicators are not or insufficiently met by the benchmarked standard.
- P: indicating that the RTFO criterion and its indicators are partially met by the benchmarked standard. There can be three reasons for this:
  - Of the various indicators for one criterion several are met and several are not met.
  - The subject covered by a criterion is addressed but in a less stringent manner. For example, several standards state that destruction of primary forest is forbidden but do not give a reference year. As the reference year is considered important this leads to a partial compliance score “P”.
  - The RTFO Meta-Standard indicators are fully met by the benchmarked standard but are not mandatory for certification.

All Ps and Xs form gap criteria. It is recommended that, in order to be able to claim the full RTFO Sustainable Biofuel Meta-Standard, successful supplementary checks on all gap

criteria of the Qualifying Standard should be required.

It is also recommended that supplementary checks may be used to comply with gap criteria between a non-Qualifying benchmarked standard and the Qualifying Standard level, or indeed to comply with gap criteria between a non-Qualifying Standard and the full RTFO Sustainable Biofuel Meta-Standard level.

Notes on detailed benchmark table:

Note that EurepGAP was originally benchmarked against the RTFO Sustainable Biofuel Meta-Standard. Since the original benchmark the standard has been updated and is now named GlobalGAP. GlobalGAP should therefore be reported. It will be recommended that the RFA re-benchmark GlobalGAP as a priority, but it is not anticipated that new GlobalGAP standard will reach the Qualifying Standard level

## Table 10: Detailed benchmark of existing standards

| Principles and Criteria | SAN/RA | | RSPO | | Basel | | LEAF | | ACCS | | EurepGAP IFA | | FSC | | SA8000 | | IFOAM | | ProTer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **P 1. Carbon Conservation** | | | | | | | | | | | | | | | | | | | |
| C 1.1 Preservation of above and below ground carbon stocks (reference date 01-11-2005). | P | P2 carbon capture C 2.1 (ecosystem conserv') C 9.5 cutting of natural forest cover for new production areas is forbidden | P | 7.3 no conversion primary forest and HCVA nov 2005 7.4 No plantation on peat soil > 3m | P | 3.1.1, no conversion of primary and HCVA july 2004 3.1.2. no forest conversion without compensation 1994 | P | P6 | ✓ | 1.0 Awareness of Defra COPs for soil, air and water Conservation of peat lands 5.16 Assessment of carbon stock changes but no limit | X | | P | 10.1 natural forest conservation and restoration. | X | | P | 2.1.2. clearing of primary ecosystem is prohibited | P | **2.1 co 2.1 co 19** |
| **P2. Biodiversity conservation** | | | | | | | | | | | | | | | | | | | |
| C 2.1 Compliance with national laws and regulations relevant to biomass production and the area where biomass production takes place. | ✓ | 1.1 manage social and environmental aspects in compliance with applicable law 1.6 / 2.4 | ✓ | 2.1 in general | ✓ | 1.1 general | ✓ | 1.4 farm policy need to comply with all regulatory and legislative requirements | ✓ | 1.0, 1.1 compliance with legislation is part of COP compliance | ✓ | Introduction: any applicable legislation stricter than EurepGAP must be complied with | ✓ | P 1 general | X | | X | | P | 1.1 en ge |
| C 2.2 No conversion of high biodiversity areas after 01-11-2005 | P | P9 P2 (ecosystem conservation) 2.2 no specific date | ✓ | 7.3 no conversion primary forest and HCVA **Nov 2005** | ✓ | 3.1.1 No conversion after **31 July '04** 3.1.2 compensation from 1 **Jan '95 - 31 July '04** | P | P6 Extensive set of criteria | ✓ | 5.16 | X | | ✓ | 6.10 no conversion in HCV forest. 10.9 no conversion from natural forest after **November 1994** | X | | P | 2.1.2. clearing of primary ecosystem is prohibited | ✓ | **2.1 co 2.1 co 19** |
| C 2.3 Indentification and conservation of important biodiversity on and around the production unit. | ✓ | 2.3 within 1 km, communication with owner of natural park | ✓ | 5.2 (+on-farm practice) | ✓ | 3.3.1 and 3.3.2 | ✓ | P6 Integrate farming and biodiversity management | ✓ | 5.11 Refers to GAEC and SMR. Assessed for England. | P | 1.6 only recommendations and minor musts. | ✓ | P6 conserve biodiversity | X | | ✓ | 2.1 Organic farming benefits the quality of ecosystems 2.1.2. clearing of primary ecosystem is prohibited | P | 2.1 |
| Recommendations | | | | | | | | | | | | | | | | | | | |
| 2.4 Preservation and/or improvement of surrounding landscape | Note this criterion is substantially changed from when the original benchmark was carried out and is therefore left blank. | | | | | | | | | | | | | | | | | | |

| Principles and Criteria | SAN/RA | | RSPO | | Basel | | LEAF | | ACCS | | EurepGAP IFA | | FSC | | SA8000 | | IFOAM | | ProTerr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **P3. Soil conservation** | | | | | | | | | | | | | | | | | | | |
| C 3.1 Compliance with national laws and regulations relevant to soil degradation and soil management. | ✓ | 1.1 general compliance national law | ✓ | 2.1 | ✓ | 1.1 general | ✓ | 1.2.1 | ✓ | COP for soil and water | ✓ | Introduction: any applicable legislation stricter than EurepGAP must be complied with | ✓ | P 1 general | X | | X | | P | 1.1 env ger |
| C 3.2 Application of best practices to maintain and improve soil quality.<br>o Erosion control<br>o Soil nutrient balance<br>o Soil organic matter<br>o Prevention of salinisation<br>o Soil structure | ✓ | P9 missing salinisation | ✓ | 4.2 / 4.3 missing salinisation | ✓ | 2.1.1 / 2.1.2 / 2.1.3, 2.4.2 missing salinisation | ✓ | 2.2.1 –2.2.10 Soil erosion section, 2.4.1 – 2.4.14 Crop nutrition | ✓ | COP for soil and water | ✓ | 2.3.soil and substrate management / 2.4 fertilizer | ✓ | 6.5 control erosion, 10.6 improve or maintain soil structure, fertility an d biol. Activity | X | | ✓ | 2.1 2.2.1 t-m 2.2.5 4.3.1 en 4.4 | P | 2.1 |
| Recommendations | | | | | | | | | | | | | | | | | | | |
| 3.2 a Measurements | ✓ | P9 | X | | X | | ✓ | 2.4 / 2.10 | ✓ | COP for soil and water | P | 2.4 Records on fertilizer use<br>2.6 records on chemicals | X | | X | | X | | X | |
| C 3.3 The use of agricultural by-products does not jeopardize the function of local uses of the by-products, soil organic matter or soil nutrients balance. | ✓ | 10.1 used as fertilizer | P | 5.3 recycled and reused | X | | ✓ | 2.4 | X | | X | | X | | X | | ✓ | 2.2.3 used as fertilizer | X | |
| **P 4. Sustainable Water Use** | | | | | | | | | | | | | | | | | | | |
| C 4.1 Compliance with national laws and regulations relevant to contamination and depletion of water sources. | ✓ | 4.2 / 4.4 / 4.5 | ✓ | 2.1 | ✓ | 1.1 general | ✓ | 1.2.1 | ✓ | Covered by compliance with soil and water COPs [C.1.1 above] | ✓ | Introduction: any applicable legislation stricter than EurepGAP must be complied with | ✓ | P 1 general | X | | X | | P | 1.1 env ger |
| C 4.2 Application of *best practices* to reduce water usage and to maintain and improve water quality. | ✓ | P4 | ✓ | 4.4 | ✓ | 2.1.4 / 2.1.5 / P 2.2 chemical use | ✓ | 2.7.1 –2.7.8 Irrigation and water storage / 3.7.4 | ✓ | Covered by compliance with soil and water COPs [C.1.1 above] | ✓ | 1.5.2.1 waste man. plan to avoid contamination of water<br>1.6.1.4 advice from water authorities | P | 10.6 impacts on water quality , quantity | X | | ✓ | 2.1 2.2.4 t-m 2.2.6 | P | 2.1 2.2 2.3 |
| Recommendations | | | | | | | | | | | | | | | | | | | |
| 4.2 b Records | ✓ | P4 | X | | X | | ✓ | 2 | X | | P | 2.5.1.3 records of irrigation water usage | X | | X | | X | | X | |
| **P5. Air quality** | | | | | | | | | | | | | | | | | | | |
| C 5.1 Compliance with national laws and regulations relevant to air emissions and burning practices | ✓ | 1.1 / 10.2 / 10.3 / 10.4 / | ✓ | 2.1 | ✓ | 1.1 general | ✓ | 1.2.1 | ✓ | 1.0, 1.1 compliance with legislation is part of COP compliance | ✓ | Introduction: any applicable legislation stricter than EurepGAP must be complied with | ✓ | P 1 general | X | | X | | P | 1.1 env ger |
| C 5.2 No burning as part off land clearing or waste disposal | ✓ | 9.4 / 10.2 | ✓ | 5.5 | ✓ | 3.2.3 no fire for land clearing<br>3.4.1 avoid burning of waste | ✓ | 1.2.1 | ✓ | Covered by compliance with Air COP | X | | X | | X | | ✓ | 2.2.2 restricted to the minimum | P | 2.1 |

| Principles and Criteria | SAN/RA | | RSPO | | Basel | | LEAF | | ACCS | | EurepGAP IFA | | FSC | | SA8000 | | IFOAM | | ProTerr | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **P6. Workers rights and working relationships** | | | | | | | | | | | | | | | | | | | | |
| C 6.1 Compliance with national laws concerning working conditions and workers rights | ✓ | P 5 (ILO, Un. Decl. of Human Rights and Children's right convention) 5.1 Complying with labour laws and internat. Agreements | ✓ | 2.1 | ✓ | 1.1 / 4.2.1 | ✓ | 1.2.1 | X | | ✓ | Introduction: any applicable legislation stricter than EurepGAP must be complied with | ✓ | P 1 general | ✓ | 9.1 general | P | Recommendation all ILO conventions and UN Charter of Rights for children | P | 1.1 |
| C 6.2 Contracts | ✓ | 5.3 | X | | X | | X | | X | | X | | X | | X | | P | 8. Recom. | ✓ | **1.2** |
| C 6.3 Provision of information | ✓ | 5.1 / 5.13 | ✓ | 1.1 / 6.2 | ✓ | 4.2.1 | X | | X | | X | | X | | ✓ | 9.1 | X | | P | 1.1 |
| C 6.4 Subcontracting | ✓ | 1.8 / 5.3 | X | | X | | ✓ | 1.9 (1.2.6) | P | 9.0 not related to working conditions | X | | X | | ✓ | 9.6 till 9.9 | X | | ✓ | **1.2** |
| C 6.5 Freedom to associate and bargain | ✓ | 5.12 | ✓ | 6.6 | ✓ | 4.2.2 ILO (87 & 98) | X | | X | | X | | ✓ | 4.3 as outlined in ILO | ✓ | 4.1 4.2 4.3 | ✓ | 8.4 | P | 1.2 |
| C 6.6 Child labour | ✓ | 5.8 / 5.9 | ✓ | 6.7 no Child labour, except on fam. Farm without interfering with school | ✓ | 4.3.1 No child labour, min 15 under 18 no hazardous work. Child on family farm, without skipping school | X | | X | | X | | X | | ✓ | 1.1 , 1.2 1.3 1.4 should provide school + no longer than 10 hours (school, work and transport) | ✓ | 8.6 | ✓ | **1.2** |
| C 6.7 Young workers (15-17) | ✓ | 5.8 | X | | ✓ | 4.3 | X | | X | | X | | X | | ✓ | 1.3 1.4 | X | | P | **1.2** har not |
| C 6.8 Health and Safety | ✓ | 5.14 (housing) / 5.15 (water quality) / 5.16 (medical services) / P6 (health and safety) | ✓ | 4.7 health and safety plan 4.8 training | ✓ | 4.3.2 health and safety policy 4.3.3 training | X | | P | 2.7.1 | ✓ | 1.4 | ✓ | 4.2 meet all applicable law and regulation covering health and safety of employees + families | ✓ | 3.1 till 3.6 shall point out a responsible, provide trainings, clean bathrooms and dormitories | P | 8. Recom. | P | 1.2 **(BF onl pes** |

| Principles and Criteria | SAN/RA | | RSPO | | Basel | | LEAF | | ACCS | | EurepGAP IFA | | FSC | | SA8000 | | IFOAM | ProTerr | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C 6.9 Wages | ✓ | 5.4 / 5.5 | ✓ | 6.5 at least legal min. standards and sufficient to meet basic needs | ✓ | 4.2.1 at least min wages and adequate standard of living | X | | X | | X | | X | | ✓ | 8.1 8.2 min standards and sufficient to meet basic needs, no deductions for disciplinary purposes | P | 8. Recom. | P | 1.2 |
| C 6.10 Discrimination | ✓ | 5.2 | ✓ | 6.8, 6.9 | ✓ | 4.2.3 equality for all employees and contractors | X | | X | | X | | X | | ✓ | 5.1 5.2 5.3 | ✓ | 8.5 | P | 1.2 111 |
| C 6.11 Forced labour | ✓ | 5.1 | X | | ✓ | 4.3.1 No forced labour | X | | X | | X | | X | | ✓ | 2.1 no support forced labour, nor should personnel be required to lodge deposits or identity papers | ✓ | 8.3 | P | Not hov cor em em |
| Recommendations | | | | | | | | | | | | | | | | | | | | |
| C 6.12 Working hours | ✓ | 5.6 working hours must not exceed legal maximum or ILO<br>5.7 Overtime | X | | X | | X | | X | | X | | X | | ✓ | 7.1 max 48 h /wk | X | | P | 1.2 est spe ava |
| **P 7 Land right issues and community relations** | | | | | | | | | | | | | | | | | | | | |
| C 7.1 Land right issues | ✓ | P7 Community relations | ✓ | 2.2right to use land can be demonstrated 2.3 landuse not diminish legal rights other users 7.5 7.6 | | 4.4.1 right can be demonstrated and local interpretations on land right should be identified | P | 8.3.7 | ✓ | Operating procedures 2 | X | | ✓ | 2.1 till 2.3 / 3.1 till 3.3 | X | | P | 8. Recom. | P | 1.2 |
| C 7.2 Consultation and communication local stakeholders | ✓ | P7 Community relations | ✓ | 1.1 / 2.3 / 6.2 / 6.3 / 6.4 | ✓ | 4.1.2. | ✓ | 1.10 and 1.13 | X | | X | | ✓ | 4.4 | P | 9.12 communication, but no consultation | X | | P | 1.2 |

# Annex E: Guideline on definition of idle land

Displacement effects are considered a significant risk to the sustainability of biofuel production. By producing biofuel feedstock on idle land, displacement effects can be prevented. The Government recommends that the RFA should require suppliers to report the volumes of fuel which they have sourced from plantations on previously idle land in their **annual reports**. For the purposes of the RTFO the Government recommends that the following guideline should be used for the definition of "idle land":

Idle land is land which meets **all** the following criteria:

- Compliance with all criteria of the RTFO Sustainable Biofuel Meta-Standard on Carbon storage (criterion 1.1), i.e. no destruction of large carbon stocks may have taken place.
- Compliance with all criteria of the RTFO Sustainable Biofuel Meta-Standard on Biodiversity (criteria 2.1/2.3), i.e. no conversion in or near areas with one or more High Conservation Values.
- Compliance with all criteria of the RTFO Sustainable Biofuel Meta-Standard on land rights and community relations (criteria 7.1/7.2), i.e. no violation of local people's rights.
- On 30-11-2005, the land was not used for any other significant productive function, unless a viable alternative for this function existed and has been applied which does not cause land use change which is in violation with any of the criteria for 'idle land'.

Note: the Government recommends that in monthly data reports transport fuel suppliers should be required to report land use on 30 November 2005 by selecting one of the land use categories listed in Annex H. These land use categories are based on IPCC definitions and do not relate directly to the definition of idle land above as the IPCC definitions do not include characteristics such as biodiversity and land rights. There is, at present, no internationally agreed definition of idle land.

To meet the definition of idle land stated above, the Government recommends that idle land should be reported in a monthly C&S report as "Grassland without agricultural use".

# Annex F: Example records for Chain of Custody

**Table 11: Example of an output record from a Farm supplying certified rapeseed to crusher C1[1].**

| Order Number | Transaction date | Receiving Company | Quantity (tonne) | Product | Product Origin | Standard | Land use on 30 Nov 2005 | Crop yield (t/ha) | Nitrogen fertiliser (kg/ha) |
|---|---|---|---|---|---|---|---|---|---|
| 22001 | 15-4-2008 | C1 | 1,000 | Rapeseed | UK | LEAF | Cropland | 3.0 | 180 |

**Table 12: Example of an input record from a rapeseed crusher which takes in certified rapeseed from farm F1 and F2 and non-certified rapeseed from farm F3.**

| Order Number | Transaction date | Supplying company | Quantity (tonne) | Product | Product Origin | Standard | Land use on 30 Nov 2005 | Carbon intensity (g $CO_2$e / tonne) |
|---|---|---|---|---|---|---|---|---|
| 22001 | 15-4-2008 | F1 | 1,000 | Rapeseed | UK | LEAF | Cropland | 949 |
| 22002 | 15-4-2008 | F2 | 1,000 | Rapeseed | UK | LEAF | Cropland | 987 |
| 22001 | 15-4-2008 | F3 | 1,000 | Rapeseed | UK | - | Cropland | 987 |

[1] Note: a farmer (or any other supply chain actor) has the option of passing either raw data or a calculated carbon intensity figure along the chain. In this example the farmer has chosen to provide raw data for crop yield and nitrogen fertiliser application rate – the oilseed crusher must then use default values for the remaining inputs to the carbon intensity calculation.

**Table 13: Example record of crusher conversion factor**

| | |
|---|---|
| Name conversion factor | Rapeseed to rapeseed oil |
| Input | Rapeseed |
| Output | Rapeseed oil |
| Unit | kg rapeseed oil / kg rapeseed |
| Value | 0.40 |
| Valid from | 1-1-2008 |
| Valid until | 1-6-2008 |

**Table 14: Example of an output record from a crusher supplying certified rapeseed oil to biofuel producer B. (RSO stands for rapeseed oil.)**

| Order Number | Transaction date | Receiving Company | Quantity (tonne) | Product | Product Origin | Standard | Land use on 30 Nov 2005 | Carbon intensity (g CO2e / tonne) |
|---|---|---|---|---|---|---|---|---|
| 23001 | 20-4-2008 | B | 400 | RSO | UK | LEAF | Cropland | 2287 |
| 23002 | 20-4-2008 | B | 400 | RSO | UK | - | Cropland | 2287 |

**Table 15: Example of an input record from a biofuel producer which takes in certified rapeseed oil from crusher C1.**

| Order Number | Transaction date | Supplying company | Quantity (tonne) | Product | Product Origin | Standard | Land use on 30 Nov 2005 | Carbon intensity (g CO2e / tonne) |
|---|---|---|---|---|---|---|---|---|

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 23001 | 20-4-2008 | C1 | 400 | RSO | UK | LEAF | Cropland | 2287 |
| 23002 | 20-4-2008 | C1 | 400 | RSO | UK | - | Cropland | 2287 |

**Table 16: Example of an inventory record of C&S data for crusher C1.**

| Product | Product Origin | Standard | Land use on 30 Nov 2005 | Carbon intensity (g CO2e / tonne) | Inventory (tonne) 15-4-2008 | Input (tonne) | Output (tonne) | Inventory (tonne) 15-5-2008 |
|---|---|---|---|---|---|---|---|---|
| OSR eq | UK | LEAF | Cropland | 2287 | 1,000 | 800 | 400 | 1,400 |
| OSR eq | Romania | - | Cropland | 2287 | 2,000 | 0 | 0 | 2,000 |
| OSR eq | UK | - | Cropland | 2287 | 0 | 400 | 400 | 0 |

**Table 17: Example of an input record from biofuel company B who takes in several batches of vegetable oil.**

| Order Number | Transaction date | Supplying company | Quantity (tonne) | Product | Feedstock Origin | Standard | Land use on 30 Nov 2005 | Carbon intensity (g CO2e / tonne) |
|---|---|---|---|---|---|---|---|---|
| 22001 | 20-4-2008 | C1 | 1,200 | RSO | UK | LEAF | Cropland | 2287 |
| 22002 | 20-4-2008 | C1 | 4,800 | RSO | Unknown | - | Unknown | 2287 |
| 22005 | 20-4-2008 | C2 | 400 | CPO | Malaysia | RSPO | Cropland | 1343 |
| 22006 | 20-4-2008 | C2 | 600 | CPO | Malaysia | - | Unknown | 1343 |

**Table 18: Example of an output record from biofuel company B who supplies 2,000 tonnes biodiesel to oil major X, of which 400 tonnes meet a reportable standard.**

| Order Number | Transaction period | Receiving company | Quantity (tonne) | Fuel type | Feedstock | Feedstock Origin | Standard | Land use on 30 Nov 2005 | Carbon intensity (g $CO_2$e / tonne) |
|---|---|---|---|---|---|---|---|---|---|
| 33001 | 4-2008 | X | 300 | Biodiesel | RSO | UK | LEAF | Cropland | 2894 |
| 33002 | 4-2008 | X | 1,400 | Biodiesel | RSO | Unknown | - | Unknown | 2894 |
| 33005 | 4-2008 | X | 100 | Biodiesel | PO | Malaysia | RSPO | Cropland | 1861 |
| 33006 | 4-2008 | X | 200 | Biodiesel | PO | Unknown | - | Unknown | 1861 |

**Table 19: Example of an input record from oil major X who receives 2,000 tonnes biodiesel from biodiesel producer B, of which 400 tonnes report a Standard.**

| Order Number | Transaction period | Supplying company | Quantity (tonne) | Fuel type | Feedstock | Feedstock Origin | Standard | Land use on 30 Nov 2005 | Carbon data (g CO2e / tonne) |
|---|---|---|---|---|---|---|---|---|---|
| 33001 | 4-2008 | B | 300 | Biodiesel | RSO | UK | LEAF | Cropland | 2894 |
| 33002 | 4-2008 | B | 1,400 | Biodiesel | RSO | Unknown | - | Unknown | 2894 |
| 33005 | 4-2008 | B | 100 | Biodiesel | PO | Malaysia | RSPO | Cropland | 1861 |
| 33006 | 4-2008 | B | 200 | Biodiesel | PO | Unknown | - | Unknown | 1861 |

# Annex G: Assessing carbon intensity and calculating direct GHG saving

This Annex briefly summarises the Government's recommendations on how transport fuel suppliers should assess the carbon intensity of an administrative batch of biofuel in order to submit carbon data for monthly reports. Further details on assessing carbon intensity are provided Part 2 of the document: *Carbon Reporting – Default values and fuel chains*.

The carbon intensity of a batch of biofuel can be assessed by:

- Collecting information about the way in which it was produced in order to calculate a "known" carbon intensity or;
- Selecting an appropriate "fuel chain default value" based on qualitative information about the fuel.

## Calculating and reporting a "known" carbon intensity

Information about activities which take place during the production of a biofuel can be used to calculate its carbon intensity. The information collected could be either:

- Quantitative **"actual data"** about inputs used during the production of a biofuel – for example, that 9,000 MJ of natural gas are used for every tonne of bioethanol produced.
- Qualitative data about processes used during the production of a biofuel – for example, that the biofuel plant uses biomass to provide heat and power. This qualitative data enables the use of **"selected defaults".** These are default values for aspects of the production process which are generally defined by the RFA. In some cases, it is possible that suppliers might wish to define their own "selected defaults", particularly where they have access to data from, eg, regional surveys. In such cases, the Government recommends that the RFA should satisfy itself that the information provided is accurate: the RFA will, in any case, have the right to withhold certificates if it is not satisfied with the carbon and sustainability data provided.

The procedures set out in part two of this document are intended to enable the calculation of a known carbon intensity value.

There is a large amount of data companies could collect in order to derive a known carbon intensity. However, only a small number of data points can have a significant influence on the final carbon intensity of a biofuel. Table 20 highlights the data points which have the most influence on final carbon intensity and which the Government recommends should be the focus of data collection efforts.

**Table 20: Focus for data collection**

| Step in the supply chain | Focus for data collection |
|---|---|
| Crop production | Nitrogen fertiliser application rate<br>Crop yield & moisture content<br>Fuel consumption for cultivation |
| Feedstock and liquid fuel transport | Transport distances |
| Conversion – either biofuel conversion or oilseed crushing | Yield[1]<br>Fuel demand<br>Electricity demand<br>Co-product treatment |

## Reporting using the fuel chain default values

When information about how a biofuel was produced is not available, a fuel chain default value should be used in order to report its carbon intensity. The RFA should keep these default values under regular review and should develop additional default values as appropriate for new fuel chains. Different types of fuel chain default values are available based on the information which is known about the fuel. The type of fuel chain default value that can be used depends on what is known about:

- The feedstock used to produce the fuel, and
- The country the feedstock originated from.

Table 21 summarises which fuel chain default values the Government recommends should be used on the basis of the information that is known and provides a cross reference to the default value tables below. The appropriate default value selected from the tables below should then be reported in a supplier's monthly C&S report.

NB. The Government recommends that fuel chain default values should be defined 'conservatively' (i.e. a higher carbon intensity) in order to provide an incentive for companies to collect more data. The use of conservative default values means that the values in the tables below should not be interpreted as being an accurate assessment of the GHG saving potential of the biofuels.

1 i.e. tonnes of product (e.g. biodiesel) per tonne of input (e.g. rapeseed oil)

**Table 21: Cross-reference to relevant default value table**

| Origin | Feedstock | Type of default value | Default value table |
|---|---|---|---|
| Unknown | Unknown | Fuel | Table 21 |
| Unknown | **Known** | Feedstock | Table 22 |
| **Known** | **Known** | Feedstock & Origin | Table 23 |

## Default value tables

**Table 22: Fuel default values. Note that these figures are conservative.**

| Fuel | Carbon Intensity |
|---|---|
| | **grams $CO_2e$ / MJ** |
| Bioethanol | 61 |
| Biodiesel | 55 |
| Biomethane | 36 |
| Bio-ETBE | 68 |

**Table 23: Feedstock default values. Note that these figures are conservative.**

| Fuel | Feedstock | Carbon Intensity |
|---|---|---|
| | | **grams $CO_2e$ / MJ** |
| Bioethanol | Wheat | 61 |

| **Fuel** | **Feedstock** | **Carbon Intensity** |
|---|---|---|
| | | **grams $CO_2$e / MJ** |
| | Sugarcane | 61 |
| | Sugar beet | 50 |
| | Molasses | 40 |
| | Corn | 108 |
| Biodiesel (Methyl Ester) | Oilseed rape | 55 |
| | Soy | 78 |
| | Palm | 45 |
| | UCO & tallow | 13 |
| Biodiesel (Hydrogenated vegetable oil) | Oilseed rape | 58 |
| | Soy | 86 |
| | Palm | 49 |
| Biomethane | MSW & manure | 36 |
| ETBE – refinery isobutene | Wheat | 68 |
| | Sugar beet | 63 |
| | Sugar cane | 68 |

| Fuel | Feedstock | Carbon Intensity |
|---|---|---|
| | | grams $CO_2e$ / MJ |
| | Molasses | 59 |
| | Corn | 82 |
| ETBE – imported isobutene | Wheat | 81 |
| | Sugar beet | 77 |
| | Sugar cane | 65 |
| | Molasses | 73 |
| | Corn | 96 |

**Table 24: Feedstock & origin default values. Note that these figures represent worst 'common' practice and do not necessarily represent typical practice.**

| Fuel | Feedstock | Origin | Carbon Intensity |
|---|---|---|---|
| | | | grams CO2e / MJ |
| Bioethanol | Wheat | Canada | 80 |
| | | France | 65 |
| | | Germany | 59 |
| | | Ukraine | 103 |
| | | United Kingdom | 61 |
| | Sugar beet | UK | 50 |

| Fuel | Feedstock | Origin | Carbon Intensity |
|---|---|---|---|
| | | | grams CO2e / MJ |
| | Sugar cane | Brazil | 24 |
| | | Mozambique | 30 |
| | | Pakistan | 115 |
| | | South Africa | 112 |
| | Molasses | Pakistan | 81 |
| | | South Africa | 93 |
| | | UK | 40 |
| | Corn | France | 49 |
| | | USA | 108 |
| Biodiesel (Methyl Ester) | Oilseed rape | Australia | 71 |
| | | Canada | 56 |
| | | Finland | 54 |
| | | France | 46 |
| | | Germany | 48 |
| | | Poland | 45 |
| | | Ukraine | 60 |
| | | United Kingdom | 55 |
| | Soy | Argentina | 48 |

| Fuel | Feedstock | Origin | Carbon Intensity |
|---|---|---|---|
| | | | grams CO2e / MJ |
| | | Brazil | 78 |
| | | USA | 58 |
| | Palm | Malaysia | 45 |
| | | Indonesia | 45 |
| | UCO & tallow | UK | 13 |
| Biodiesel Hydrogenated vegetable oil) | Oilseed rape | Australia | 79 |
| | | Canada | 62 |
| | | Finland | 58 |
| | | France | 50 |
| | | Germany | 52 |
| | | Poland | 48 |
| | | Ukraine | 66 |
| | | United Kingdom | 61 |
| | Soy | Argentina | 52 |
| | | Brazil | 86 |
| | | USA | 63 |
| | Palm | Indonesia | 49 |
| | | Malaysia | 49 |

| Fuel | Feedstock | Origin | Carbon Intensity |
|---|---|---|---|
| | | | grams CO2e / MJ |
| Biomethane | MSW or manure | UK | 36 |
| ETBE – refinery isobutene | Wheat | Canada | 73 |
| | | France | 68 |
| | | Germany | 66 |
| | | Ukraine | 82 |
| | | United Kingdom | 66 |
| | Sugar beet | UK | 63 |
| | Molasses | Pakistan | 73 |
| | | South Africa | 77 |
| | | UK | 59 |
| | Sugar cane | Brazil | 54 |
| | | Mozambique | 56 |
| | | Pakistan | 85 |
| | | South Africa | 84 |
| | Corn | France | 63 |
| | | USA | 82 |
| ETBE – imported isobutene | Wheat | Canada | 86 |
| | | France | 81 |

| Fuel | Feedstock | Origin | Carbon Intensity |
|---|---|---|---|
| | | | grams CO2e / MJ |
| | | Germany | 79 |
| | | Ukraine | 95 |
| | | United Kingdom | 80 |
| | Sugar beet | UK | 77 |
| | Molasses | Pakistan | 87 |
| | | South Africa | 91 |
| | | UK | 73 |
| | Sugar cane | Brazil | 68 |
| | | Mozambique | 70 |
| | | Pakistan | 98 |
| | | South Africa | 97 |
| | Corn | France | 76 |
| | | USA | 96 |

## What to do if there is no appropriate default value

There may be certain situations in which an appropriate default value is not available for a batch of renewable fuel – for example, when a biofuel produced from a new feedstock (e.g. biodiesel from jatropha) or a new type of fuel is imported into the UK.

In this situation Government recommends that the fuel supplier should inform the RFA in order that a new fuel chain may be defined. It is recommended that, until a new fuel chain is defined, the RFA and supplier should between them agree a temporary default value according to the following guidelines:

- Where a renewable fuel is produced from a country of origin not defined in Table 24 use the relevant fuel default in Table 22.
- Where an existing fuel is produced from a new feedstock use the relevant fuel default value in Table 22.
- Where a new fuel type is produced from an existing feedstock (e.g. biobutanol produced from sugar beet) the temporary default should equal the average carbon intensity for biofuels produced from that feedstock. This can be derived through calculating the average carbon intensity of the relevant feedstock types in Table 24.
- Where the renewable fuel is produced from a new feedstock (e.g. biofuel from miscanthus) the temporary default value should equal the average carbon intensity of the bioethanol already supplied into the UK. The RFA should be contacted to supply this information.

Temporary default values should remain valid until such time as a new value has been established and approved by the RFA.

## Calculating direct GHG saving using carbon intensity values.

The direct GHG savings of a biofuel are established by comparing the biofuel's carbon intensity against the displaced fossil fuel's carbon intensity. It is recommended that this comparison should be done using carbon intensity values given on an energy basis i.e. grams $CO_2e$ / MJ. For all fuels it is assumed the energy efficiency (i.e. kilometres per MJ) of vehicles is the same and, therefore, that 1 MJ of biofuel displaces 1 MJ of fossil fuel.

The direct GHG saving (as a percentage) is calculated using the following formula:

$$\text{GHG saving} = \frac{\text{Carbon intensity of fossil fuel displaced} - \text{carbon intensity of biofuel}}{\text{Carbon intensity of fossil fuel}} \times 100$$

Note that a negative result denotes an increase in GHG emissions

The carbon intensities of fossil fuels are as follows:

- Gasoline: 84.8 grams $CO_2e$ / MJ
- Diesel: 86.4 grams $CO_2e$ / MJ
- Natural gas: 62.0 grams $CO_2e$ / MJ
- MTBE: 84.7 grams $CO_2e$ / MJ

**Example: Ethanol replaces gasoline**

A fossil fuel company blends ethanol produced from UK sugar beet with gasoline. The percentage GHG saving is calculated as follows:

Carbon intensity of biofuel = 50 g $CO_2$e / MJ

Carbon intensity of gasoline = 84.8 g $CO_2$e / MJ

$$\text{GHG saving} = \frac{84.8 - 50}{84.8} \times 100 = 41.0\%$$

# Annex H: Assessing the impact of land use change

This Annex summarises the Government's recommendations on how the RFA should require transport fuel suppliers to report on land use and how it should require them to assess the impact of any changes in land use on the carbon intensity of an administrative batch of biofuel.

## Land use on 30 November 2005

The RFA should monitor both direct and indirect changes in land use. Fuel suppliers should therefore be required to report on how the land used to produce a biofuel was being used on 30 November 2005. Table 25 describes the different land use categories which are recommended to be used for these purposes.

**Table 25: Land use type definitions**

| Land use | Description |
|---|---|
| Cropland | This category includes cropped land, (including rice fields and set-aside), and agro-forestry systems where the vegetation structure falls below the thresholds used for the Forest Land category. |
| Forest land | Land spanning more than 0.5 hectare with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural (or urban) land use. |
| Grassland (and other wooded land not classified as forest) with agricultural use | This category includes rangelands and pasture land that are not considered Cropland but which have an agricultural use. It also includes systems with woody vegetation and other non-grass vegetation such as herbs and brushes that fall below the threshold values used in the Forest Land category and which have an agricultural use. It includes extensively managed rangelands as well as intensively managed (e.g., with fertilization, irrigation, species changes) continuous pasture and hay land. |
| Grassland (and other wooded land not classified as | This category includes grasslands without an agricultural use. It also includes systems with woody vegetation and other non-grass vegetation such as herbs and brushes that fall below the threshold values used in the Forest Land category and which do not have an agricultural use. |

| | |
|---|---|
| forest) without agricultural use | |

## Default values

This section provides default values for $CO_2e$ emissions per unit of biofuel in two situations:

i) where default fuel chain values are used (based on feedstock and origin) – see Table 26, and

ii) where actual data is used for the fuel chain – Table 27 .

Table 26 provides a list of default values which should be used in monthly reports based on what is known about:

- Land use on 30 November 2005
- Type of biofuel
- Biofuel feedstock
- Feedstock country of origin.

The default values reported in Table 26 assume the default fuel chain is used to produce each fuel (i.e. crop production and conversion plant yields are taken from the appropriate default fuel chain). The impact of land use change is amortised over a 20 year period (full details on this and other the assumptions made in calculating these default values are available in *Carbon reporting within the RTFO: Methodology*).

**Table 26: Impact of changes in land use on carbon intensity (grams CO2e / MJ bio-fuel). This table should be used to report the carbon intensity impacts of land use change where default fuel chain values are used for the fuel chain (based on feedstock and origin).**

| **Impact of changes in land use on carbon intensity (grams $CO_2e$ / MJ biofuel)** | | | | | |
|---|---|---|---|---|---|
| **Fuel** | **Feedstock** | **Origin** | **Land converted from:** | | |
| | | | **Cropland** | **Forestland** | **Grassland** |
| Bioethanol | Wheat | Canada | 0 | 977 | 126 |
| | | France | 0 | 329 | 83 |
| | | Germany | 0 | 367 | 122 |
| | | UK | 0 | 438 | 116 |

| Impact of changes in land use on carbon intensity (grams $CO_2e$ / MJ biofuel) | | | | | |
|---|---|---|---|---|---|
| **Fuel** | **Feedstock** | **Origin** | **Land converted from:** | | |
| | | | **Cropland** | **Forestland** | **Grassland** |
| | | Ukraine | 0 | 316 | 108 |
| | Sugar beet | UK | 0 | 228 | 60 |
| | Sugar cane | Brazil | 0 | 319 | 88 |
| | | Mozambique | 0 | 203 | 31 |
| | | Pakistan | 0 | 133 | 31 |
| | | South Africa | 0 | 220 | 14 |
| | Molasses | Pakistan | 0 | 927 | 213 |
| | | South Africa | 0 | 1,539 | 96 |
| | | UK | 0 | 1,886 | 498 |
| | Corn | France | 0 | 243 | 61 |
| | | USA | 0 | 214 | 23 |
| Biodiesel (Methyl Ester) | Oilseed rape | Australia | 0 | 1,127 | 111 |
| | | Canada | 0 | 983 | 91 |
| | | Finland | 0 | 380 | 188 |
| | | France | 0 | 335 | 84 |
| | | Germany | 0 | 363 | 121 |
| | | Poland | 0 | 526 | 175 |
| | | UK | 0 | 520 | 137 |
| | | Ukraine | 0 | 470 | 160 |
| | Soy | Argentina | 0 | 1,013 | 132 |
| | | Brazil | 0 | 2,201 | 609 |
| | | USA | 0 | 1,006 | 109 |
| | Palm | Indonesia | 0 | 200 | 113 |

| Impact of changes in land use on carbon intensity (grams $CO_2e$ / MJ biofuel) | | | | | |
|---|---|---|---|---|---|
| **Fuel** | **Feedstock** | **Origin** | **Land converted from:** | | |
| | | | **Cropland** | **Forestland** | **Grassland** |
| | | Malaysia | 0 | 157 | 51 |
| HVO biodiesel | Oilseed rape | Australia | 0 | 1,262 | 125 |
| | | Canada | 0 | 794 | 102 |
| | | Finland | 0 | 307 | 152 |
| | | France | 0 | 375 | 95 |
| | | Germany | 0 | 407 | 136 |
| | | Poland | 0 | 589 | 196 |
| | | UK | 0 | 583 | 154 |
| | | Ukraine | 0 | 379 | 129 |
| | Soy | Argentina | 0 | 1,136 | 148 |
| | | Brazil | 0 | 2,466 | 683 |
| | | USA | 0 | 1,127 | 122 |
| | Palm | Indonesia | 0 | 224 | 127 |
| | | Malaysia | 0 | 176 | 57 |
| BioETBE (any source) | Wheat | Canada | 0 | 325 | 42 |
| | | France | 0 | 110 | 28 |
| | | Germany | 0 | 122 | 41 |
| | | UK | 0 | 146 | 39 |
| | | Ukraine | 0 | 105 | 36 |
| | Sugar beet | UK | 0 | 76 | 20 |
| | Molasses | Pakistan | 0 | 418 | 96 |
| | | South Africa | 0 | 694 | 43 |
| | | UK | 0 | 851 | 225 |

| Impact of changes in land use on carbon intensity (grams $CO_2e$ / MJ biofuel) | | | | | |
|---|---|---|---|---|---|
| **Fuel** | **Feedstock** | **Origin** | **Land converted from:** | | |
| | | | **Cropland** | **Forestland** | **Grassland** |
| | Sugar cane | Brazil | 0 | 106 | 29 |
| | | Mozambique | 0 | 68 | 10 |
| | | Pakistan | 0 | 44 | 10 |
| | | South Africa | 0 | 73 | 5 |
| | Corn | France | 0 | 81 | 20 |
| | | USA | 0 | 71 | 8 |

If a party has actual data for the fuel chain calculation (in particular crop production and conversion plant yields) the impact of carbon intensity in grams CO2e / MJ can be calculated using the default values given in Table 27. An example of how to undertake the calculation is provided below this table.

**Table 27: Impact of changes in land use on carbon intensity (tonnes $CO_2e$ / hectare). This table should be used where a party has actual data on the fuel chain.**

| **Country** | **Land use on 30 November 2005** | | | |
|---|---|---|---|---|
| | **Forest land** | | **Grassland** | |
| | **Annual cropland** | **Perennial cropland** | **Annual cropland** | **Perennial cropland** |
| Argentina | -17 | -15 | -2 | -2 |
| Australia | -23 | -21 | -2 | -2 |
| Brazil | -37 | -26 | -10 | -9 |
| Canada | -17 | -16 | -2 | -2 |
| France | -18 | -14 | -5 | -4 |
| Germany | -21 | -14 | -7 | -7 |
| Indonesia | -33 | -31 | -20 | -18 |

| Country | Land use on 30 November 2005 | | | |
|---|---|---|---|---|
| | Forest land | | Grassland | |
| | Annual cropland | Perennial cropland | Annual cropland | Perennial cropland |
| Malaysia | -37 | -26 | -10 | -9 |
| Poland | -21 | -14 | -7 | -7 |
| United Kingdom | -27 | -20 | -7 | -7 |
| USA | -17 | -16 | -2 | -2 |
| Finland | -15 | -14 | -7 | -7 |
| Mozambique | -24 | -22 | -4 | -3 |
| Pakistan | -16 | -15 | -4 | -3 |
| South Africa | -26 | -25 | -2 | -1 |
| Ukraine | -18 | -18 | -6 | -6 |

Note: the impact of land use change is amortised over a 20 year period. Full details on this and other the assumptions made in calculating these default values are available in *Carbon reporting within the RTFO: Methodology*

The default values in Table 27 are given in units of tonnes (of CO2e emissions) per hectare per year. For monthly reports these values must be converted to grams per MJ of biofuel. To complete this conversion carry out the following steps (using either a default value or actual data):

- Divide the impact of land use value from Table 27 by the feedstock crop yield [tonnes per hectare per year].
- Divide the result by all conversion plant yields (e.g. oilseed crushing plant [tonnes of oil per tonne of feedstock] and biofuel plant yields [tonnes of biofuel per tonne of feedstock (oil or crop)]).
- Multiply the result by any allocation factors given in conversion or crop production modules.
- Convert the result from a weight basis to an energy basis using the lower heating values given in Part II of this document.

For example: If Brazilian soy is produced on land which was forested land in December 2006, the appropriate default value from Table 27 is 26 t $CO_2$e / hectare / year. This value is converted to grams per MJ by:

- Dividing by the default value by the soy yield:
  - 26 [t $CO_2$e / hectare / year] / 2.5 [t soya bean / hectare / year] = 10.4 [t $CO_2$e / t soya bean]
- Dividing the result by the soy crushing conversion yield:
  - 10.4 [t $CO_2$e / t soya bean] / 0.17 [t soy oil / t soya bean] = 61.2 [t $CO_2$e / t soy oil]
- Dividing the result by the biodiesel conversion yield:
  - 61.2 [t $CO_2$e / t soy oil] / 0.95 [t biodiesel / t soy oil] = 64.4 [t $CO_2$e / t biodiesel]
- Multiplying by the biodiesel conversion allocation factor
  - 64.4 [t $CO_2$e / t biodiesel] x 90% = 58.0 [t $CO_2$e / t biodiesel]
- Dividing the result by the lower heating value of biodiesel
  - 58.0 [t $CO_2$e / t biodiesel] / 37,200 [MJ / t biodiesel] = 0.001558 [t $CO_2$e / MJ biodiesel]
- Converting the result from tonnes to grams of $CO_2$e
  - 0.01558 [t $CO_2$e / MJ biodiesel] x 1,000,000 = **1,558** grams $CO_2$e / MJ biodiesel

The figure 1,558 is added to the carbon intensity of the fuel and reported in the monthly report in the column 'carbon intensity incl LUC'

If more detailed information is known (e.g. soil types, climate zones etc) then more accurate calculations can be carried out using the more advanced approaches set out in the IPCC guidelines[1] for assessing the impact of land use change within national reporting on GHG emissions – see Volume 4 *Agriculture, Forestry and Other Land Use*.

## Calculating carbon payback time

The carbon payback time is calculated by dividing the total carbon loss as a result of land use change (not the annualised carbon loss) by the amount of carbon which is saved annually by the type of biofuel which will be grown on the converted land. The total carbon loss is calculated by multiplying the annualised carbon loss in Table 26 by 20 (the period over which land use change emissions have been amortised). The amount of carbon saved is calculated by subtracting the appropriate fuel & origin default value (given in Table 24) from the carbon intensity of the fossil fuel which is displaced, which are as noted below. This comparison must be done using carbon intensity values given on an energy basis i.e. grams $CO_2$e / MJ. For all fuels it is assumed the energy efficiency (i.e. kilometres per MJ) of vehicles is the same and, therefore, that 1 MJ of biofuel displaces 1 MJ of fossil fuel.

[1] IPCC 2006, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan.

- Gasoline: 84.8 grams CO2e / MJ
- Diesel: 86.4 grams CO2e / MJ
- Natural gas: 62.0 grams CO2e / MJ
- MTBE: 84.3 grams CO2e / MJ

In the case of Brazilian soy produced on land which was forested in December 2006, the total emissions based on Table 26 are 2,201 x 20 = 44,020 g CO2e / MJ. The carbon intensity of Brazilian soy based on default values in table 27 is 78 gCO2e / MJ, and the amount of CO2e saved is 86.4 - 78 = 8.4 g CO2e/MJ.

Therefore, the carbon payback time is 44,020 / 8.4 = **5,240 years**.

# Annex I: Accuracy level

In addition to reporting the carbon intensity of an administrative batch of biofuel, it is recommended that suppliers should also be required to report on what "type" of data has been used to derive the carbon intensity which is reported – i.e. whether it is based on a fuel default, feedstock default, feedstock & origin default or whether qualitative or quantitative information was used. The RFA should use this information to understand whether or not companies are collecting actual data about how a biofuel has been produced and to provide an indication of the accuracy of the reported carbon intensities.

It is recommended that each type of data should be attributed a certain accuracy level, based on the amount of effort a company would have to put into data collection. Table 28 shows the accuracy levels which it is recommended should be reported for administrative batches.

**Table 28: Accuracy levels corresponding to type of default value or data used**

| **Type of default value or data** | **Accuracy level** |
|---|---|
| Fuel default | 0 |
| Feedstock default | 1 |
| Feedstock & origin default | 2 |
| Selected default – RFA defined | 3* |
| Selected default – Industry defined | 4* |
| Actual data | 5* |

* Part 2 of the Guidance should be used for detailed calculations (Accuracy Levels 3, 4 and 5).

The Government has not made precise recommendations on the exact requirements of evidence for Accuracy Level 4 – Selected Defaults where suppliers choose to define their own selected defaults for aspects of the production process. In these circumstances, the use of selected defaults should be subject to verification in the same way as actual data and therefore robust evidence should be available. The Government recommends that the RFA should urge suppliers to pay particular attention to areas of potential inconsistency with the RTFO carbon calculation methodology – e.g. scope and boundaries of analysis, treatment of co-products, etc. The RFA should make clear to suppliers that RTFCs may be

withheld where the RFA is not satisfied with the evidence provided.

## Selected defaults or actual data

Scores of 3 or 4 or 5 should only be awarded for use of qualitative of quantitative data for data points which generally contribute 5 percent or more of the GHG emissions within a default fuel chain.

- If a selected default defined by the Renewable Fuels Agency is used for any of the data points specified then a score of 3 is given for that batch of fuel,
- If an industry defined selected default value is used then a score of 4 is given, and

In both cases the data points eligible for a score of 3 or 4 are illustrated in Table 29.

- If actual data is used then a score of 5 is given.

**Table 29: Data points which are eligible for accuracy level scores of 3 (if it is a default value defined by the RFA) or 4 (if it is a default value selected from another source).**

| Section of biofuel chain | Data points eligible for higher accuracy level |
|---|---|
| Crop production | Crop yield; nitrogen fertiliser application rate; nitrogen fertiliser emissions co-efficient; diesel use for cultivation |
| Drying and storage | Moisture removed during drying; amount of fuel used for heating |
| Feedstock transport | Distances and modes (where the default is greater than 300 kilometres by truck, or 1,500 km by ship) |
| Conversion | Process yield; amount of natural gas or other fuel used; emissions co-efficient of fuel used; amount of electricity used; all data related to co-products; amount of methanol used (biodiesel only); treatment of palm oil mill effluent |
| Other | Alternative waste treatment credit (biomethane and UCO & tallow to biodiesel only) |

## Combining batches

When two or more batches of fuel are combined the new accuracy level should be equal to:

- The accuracy level of the old batch which makes up more than 50% (by volume) of the new combined batch.

However, if none of the old batches make up 50% (by volume), then, the new accuracy level should be equal to:

The weighted-average (on a volume basis) of all of the old batches, rounded to zero decimal places.

For example: a company has two batches of fuel: Batch 1 = 1,000 litres, Accuracy Level 5; Batch 2 = 3,000 litres, Accuracy Level 3. The accuracy level of the new, combined batch is equal to 3 – because it makes up more than 50% of the total volume of the new combined batch.

If the company had a third batch: Batch 3 = 3,000 litres, Accuracy Level 4, then the accuracy level will be 4. This new accuracy level must be calculated using a weighted average of the old accuracy levels, because no individual batch makes up more than 50% of the new combined batch (Batch 1 = 14%; Batch 2 = 43%, Batch 3 = 43%). So, the new the accuracy level is equal to: 14% x 5 + 43% x 3 + 43% x 4 = 3.7 and 3.7 rounded to zero decimal places is 4.

# Annex J: Standard Terms

These are standard terms which the Government recommends to the RFA for use in C&S reporting.

**Table 30: Standard terms for reporting the renewable fuel type in C&S reports**

| Full Name | Standard term for report |
|---|---|
| Biodiesel | BIOD |
| Bioethanol* | BIOE |
| BioMethane | BIOM |

* BioETBE should be reported as bioethanol

**Table 31: Standard terms for feedstock origin**

| Country | ISO Country Code |
|---|---|
| ARGENTINA | ARG |
| AUSTRALIA | AUS |
| BELGIUM | BEL |
| BRAZIL | BRA |
| CANADA | CAN |
| FRANCE | FRA |
| GERMANY | DEU |
| INDIA | IND |
| INDONESIA | IDN |
| IRELAND | IRL |
| MALAYSIA | MYS |
| MOZAMBIQUE | MOZ |
| NETHERLANDS | NLD |
| PAKISTAN | PAK |
| POLAND | POL |
| PORTUGAL | PRT |

| Country | ISO Country Code |
|---|---|
| ROMANIA | ROU |
| RUSSIAN FEDERATION | RUS |
| SOUTH AFRICA | ZAF |
| UNITED KINGDOM | GBR |
| UNITED STATES | USA |
| UNKNOWN | U/K |

**Table 32: Standard terms for feedstock type**

| Feedstock Name | Code |
|---|---|
| Oilseed rape | OSR |
| Soy | SOY |
| Palm | PALM |
| UCO | UCO |
| Tallow | TALLO |
| Unknown | UNK |
| Sugar cane | SCANE |
| Sugar beet | SBEET |
| Wheat | WHEAT |
| Corn | CORN |
| Unknown | U/K |
| Molasses | MOL |
| Municipal Solid Waste | MSW |
| Manure | MANURE |

**Table 33: Standard terms for feedstock standard**

| Standard | Code |
|---|---|
| Assured Combinable Crops Scheme | ACCS |
| Basel criteria for soy | Basel |
| By-product | BYPRO |

| Standard | Code |
|---|---|
| Fedioil | FED |
| Forest Stewardship Council | FSC |
| Genesis Crops Module | GEN |
| GlobalGAP | GGAP |
| International Federation of Organic Agriculture Movements | IFOAM |
| Linking Environment And Farming Marque | LEAF |
| None | None |
| ProTerra | PROT |
| Qualität und Sicherheit (German Standard) | QUS |
| RTFO Sustainable Biofuel Meta-Standard | Meta |
| Roundtable on Sustainable Palm Oil | RSPO |
| Social Accountability 8000 | SA8000 |
| Scottish Quality Cereals | SQC |
| Sustainable Agriculture Network/Rainforest Alliance | SANRA |
| Unknown | U/K |

**Table 34: Standard terms for land use on 30 November 2005**

| Land Use | Code |
|---|---|
| Cropland | Crop |
| Unknown | U/K |
| By-product | BYPRD |
| Forest land | FORST |
| Grassland - ag use | GRAG |
| Grassland - non-ag use | GRNAG |

# Part Two: Carbon Reporting – Default values and fuel chains

# Introduction

Part two of this document provides detailed recommendations on the process that the Government suggests should be used for calculating the carbon intensity of a batch of biofuel for the purposes of reporting under the RTFO. It should be read in conjunction with Part one of the document.

It sets out the Government's recommendations to the RFA on how known carbon intensities for biofuels can be calculated where suppliers wish to carry out more detailed calculations (Accuracy Level 3, 4 and 5) rather than relying on the high level default values supplied in Part 1 of the Guidance.

It describes the following ways of using the information collected about the activities involved in producing a biofuel:

- Use of qualitative information to calculate a carbon intensity (Chapter 2);
- Use of actual quantitative data (Chapter 3) to:
    - Edit pre-defined (default) fuel chains;
    - Make adjustments to the structure of existing fuel chains;
    - Construct a new fuel chain.

It provides detailed information on each of the key fuel chains.

# Using qualitative information to calculate a known carbon intensity

The Government recommends that the RFA should define a number of selected "default values" to enable transport fuel suppliers to use qualitative data to calculate a "known" carbon intensity for their biofuels. This document contains the Government's recommendations to the RFA on default values for each of a number of fuel chains. For certain sources of GHG emissions qualitative information can be used to characterise different ways of producing the biofuel – for example the mode of transport (truck, ship, rail etc) or the fuel used in a biofuel plant (coal, natural gas, fuel oil etc). When suppliers have evidence to demonstrate that a batch of fuel is produced in a certain way they can use the appropriate selected default value.

**What selected defaults are available?**

The Government recommends that the RFA should make "selected default values" available to transport fuel suppliers to allow them to change the following parameters within their calculations:

- Type of nitrogen fertiliser. This selected default can be used to calculate emissions from crop production.
- Type of phosphorus fertiliser. This selected default can be used to calculate emissions from crop production.
- Transport mode (e.g. truck, ship, rail etc). This selected default can be used to calculate emissions from transport of any type of product.
- Type of fuel used to provide heat (e.g. diesel, coal, heavy fuel oil, natural gas etc). This selected default can be used to calculate emissions in the following processes:
- Drying of crops (drying and storage),
- Oil crop crushing plants (conversion), and
- Biofuel plants (conversion).

This document contains the Government's recommendations to the RFA on these selected default values. As set out in Part one of the document, the Government recommends that suppliers should be able to define their own "selected default values" where they have access to better data on aspects of the production process. In such cases, the Government recommends that the RFA should satisfy itself that the information provided is accurate: the RFA will, in any case, have the right to withhold certificates if it is not satisfied with the carbon and sustainability data provided

**How are selected defaults used?**

The Government recommends that each default fuel chain should include a “Selected

default options” table which summarises the selected defaults available for that particular fuel chain. The Government recommends that transport fuel suppliers should be able to establish the "known" carbon intensity of a batch of fuel by making use of a selected default value as outlined in section 3 below.

# Editing pre-defined fuel chains with actual data

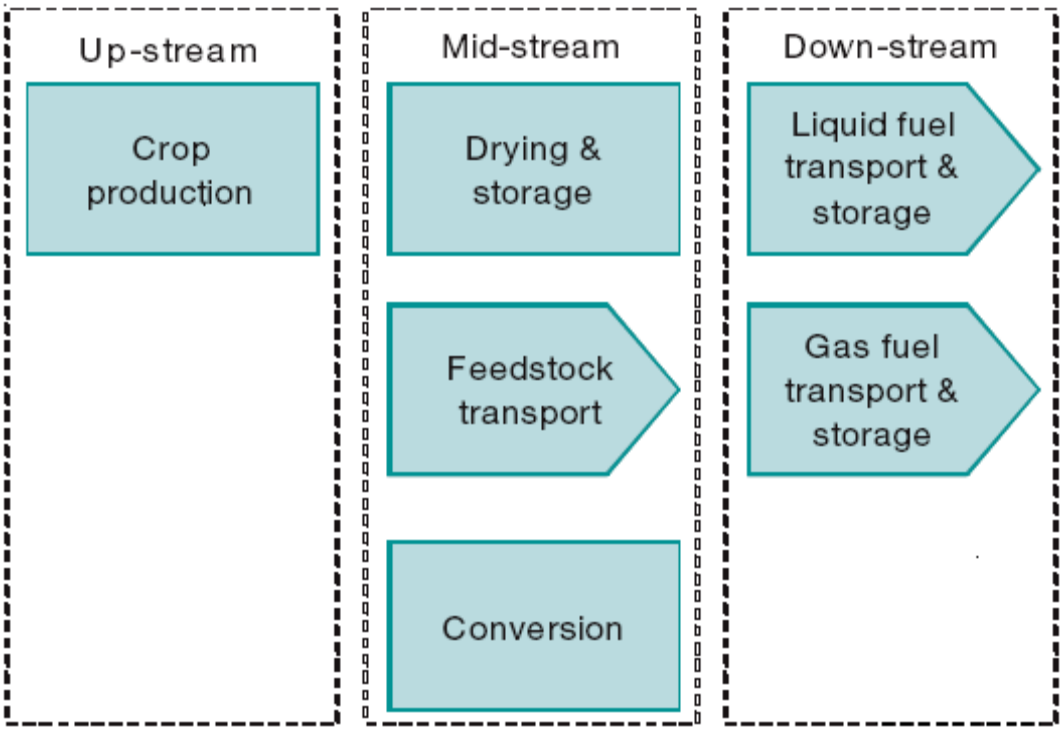
This section forms the Government's recommendations to the RFA on how actual quantitative data and selected default values can be used to calculate a carbon intensity by editing an existing fuel chain. It does not describe how changes might be made to the structure of the fuel chains (e.g. add new conversion or transport steps) – this is addressed below.

**NOTE:** the Government recommends that existing default fuel chains should only be able to be edited when both the type of feedstock and its origin are known.

### Structure of default fuel chains

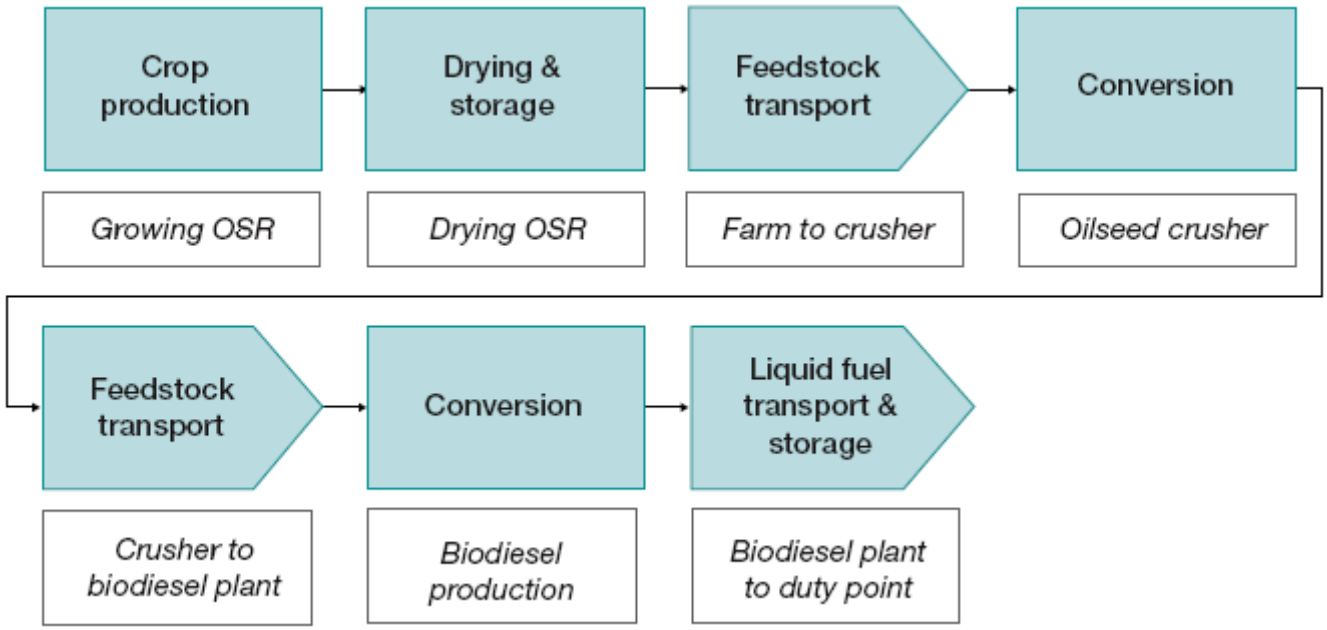
The fuel chains given later in this document are constructed by arranging common "modules" into a series of sequential stages. Figure 1 shows the common modules which make up every fuel chain and Figure 5-3 illustrates how they are arranged into a fuel chain.

**Figure 1 Modules used to define a biofuel fuel chain**



| Module Name | Description |
|---|---|
| Crop production | Growing a biofuel feedstock (e.g. palm, wheat, soy etc) |
| Drying & storage | Drying and storage of biofuel feedstocks (where this is done outside of a biofuel conversion plant) |
| Feedstock transport | Transport of a biofuel feedstock (e.g. from a farm to a biofuel conversion plant) |
| Conversion | Any process which changes the physical nature of a feedstock or a biofuel (e.g. oilseed crushing, fermentation etc). The process will typically also result in the production of co-products (e.g. soy meal). |
| Liquid fuel transport & storage | Transport of a liquid biofuel (e.g. from a biofuel conversion plant to a refinery). |
| Gas fuel transport & storage | Transport of a gaseous biofuel (e.g. from a biofuel conversion plant to a refuelling point). |

**Figure 2 – Example fuel chain defined using common modules**




## Validity of actual data over time

The Government recommends that the data which can be used to edit a default fuel chain should not have to be "real-time" data (e.g. companies should not be required to assess conversion plant characteristics such as yield and natural gas use at the exact moment that a particular batch of biofuel is processed). Instead, the Government recommends that all actual data in conversion modules should be based on characteristics averaged over a 12 month period.

## Actual data for crop production

The Government recommends that it should be permissible for evidence in support of actual data provided for crop production to take the form of a statistically accurate survey of farm level data. Such surveys should be based on data from individual fields (rather than from a whole farm) and would be considered valid for one crop growing season.

For detailed information relating to the default assumptions about crop residue treatment and for a discussion on more sophisticated approaches to calculating N2O emissions from soils please see "*Carbon reporting within the RTFO: Methodology".*

## Editing a fuel chain

The Government recommends that the RFA should require transport fuel suppliers to adopt the following procedures.

NOTE: also see next section if changes are to be made to how co-products are treated.

**Step 1: Select the appropriate default fuel chain to be edited based on**

**the biofuel's feedstock type and origin.**

**Step 2:** Refer to the **compulsory linkages** section below to establish whether there are compulsory links between the actual data to be used and any other data inputs. If there are such a links, actual data must be used for both data inputs.

**Step 3:** **In the appropriate module within the default fuel chain, complete** all the data input fields in the module being edited using the available actual data. Complete the remaining fields in the module using default values obtained from the tables in the relevant section below. The default values in these tables are arranged by "country of origin" – care must be taken to ensure the correct values are used.NOTE: Default values for "emission factors", which are generally in the second column of the module's data input fields, can be found in the General Default Values section. NOTE: If the actual data which is known is not a specific data point, but is the carbon intensity of an entire product (e.g. wheat with 300 kg $CO_2$e/tonne or rapeseed oil with 850 kg $CO_2$e/tonne) it is not necessary to fill in the data input fields for the entire module. Instead, the known carbon intensity value should be inserted directly into the "Fuel Chain Summary" Table – see Step 5[18].

**Step 4:** Perform all the required **calculations** (i.e. in the fields marked "calculation") in the module. Formulas for the calculations are generally found immediately to the left of the calculation fields (some are immediately to the right). The numbers and letters given in formulas are "Field references" which are generally found immediately to the right of a field (some are given inside the field itself). Calculations should be performed working from the top left, to the bottom right of the module – including the three "Total" fields at the very bottom.

**Step 5:** The "**Fuel Chain Summary**" table (which appears at the beginning of the relevant fuel chain) can now be updated with the new total for this module: identify the appropriate module in the "Fuel Chain Summary" table, and replace it with the "Contribution to overall fuel chain" field from the module which has just been recalculated.

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[18] Note that, in this situation, default values for the other upstream stages are not required as these should have already been taken into account in the carbon intensity of the product which has been purchased.

**Step 6:** The new **fuel chain carbon intensity** can be calculated by summing all the rows given in the "Fuel Chain Summary" table for the specified country of origin – including the new value for the module which has been recalculated.

**Step 7:** For reporting to the Renewable Fuels Agency, this value must be converted to carbon intensity per MJ – using the standard energy content values (lower heating values specified in the General Default Values section).

## Providing actual data on co-products

The impact of co-products needs to be taken into account when calculating the carbon intensity of a renewable fuel. The Government's recommendations to the RFA on how this should be done are set out in the following paragraphs.

The approach taken will depend on the co-product and its use. The recommended default fuel chains already indicate how to address the main co-products and fixed credits have already been determined for most of the different uses of the co-products. These credits are provided within the detailed default value tables for each fuel chain. Market prices have also been set for each of the co-products which is treated by market value allocation.

Where a company knows and can verify that the co-product has a different end use to that defined as a default the company should be able to use the appropriate credit within the default value table for the fuel chain. In this case the company need only identify the end-use of the co-product and should not undertake the detailed analysis required to produce the credit.

If a new co-product is being produced that is not listed then an approach to assessing its impact must be selected using the following rules (the approaches are described in more detail below):

- Co-products must, wherever possible, be accounted for using the **substitution** (also known as system expansion) approach.
- Where the data required to undertake the substitution approach is not available, the co-products may be accounted for using the **allocation by market value** approach. Allocation by market value is compatible with the substitution approach (i.e. both can be used simultaneously to assess the impact of different co-products): co-products which have appropriate credit data available are accounted for by substitution and do not form part of the allocation.

If a co-product is not listed within the default fuel chains and it is likely to have a significant impact on the final carbon intensity of the biofuel (i.e. 10 percent or more relative to the carbon intensity of the fuel chain without this co-product) and it will be supplied for a period

of 12 months or more then transport fuel suppliers should be invited to discuss and agree with the RFA the approach taken. For co-products which do not meet these criteria, verifiers should be required to check that the above rules have been correctly applied.

The procedure below should only be required if the co-product end use and fixed credit is not provided by the RFA.

| **Approach** | **Description of approach** | |
|---|---|---|
| Substitution | Step 1: | Identify the "marginal product" which is substituted as a result of the co-product entering the market. |
| | Step 2: | Establish the carbon intensity of the marginal product[19]. |
| | Step 3: | Establish the quantity of the marginal product which is substituted for every tonne of co-product[20]. |
| | Step 4: | Give the biofuel a credit which is equal to the amount of co-product produced (per tonne of biofuel), multiplied by the amount of marginal product which is displaced (per tonne of co-product), multiplied by the carbon intensity of the marginal product (per tonne of marginal product). This credit should be negative (i.e. reduces the carbon intensity of the biofuel) – unless the marginal product has a negative carbon intensity. |
| Allocation by market value | Step 1: | Calculate the market value (based on a three-year average – preferably of the international market price if possible) of the products exported from the conversion plant – expressed per tonne of the biofuel product. Note that market values for existing co-products are fixed by the RFA (i.e. the market value used in the allocation procedure is the one listed in the default value tables, not the price a company receives for its co-product) |

[19] This analysis will need to be verifiable and should be based on public, peer reviewed studies or, for example carried out to a certain standard – e.g. ISO 14040.

[20] In the case where products are not direct substitutes. For example, animal protein feeds might have different protein contents, in which case 1 tonne of the co-product might only substitute 0.8 tonnes of the marginal product.

| Approach | Description of approach | |
|---|---|---|
| | Step 2: | Calculate the total market value of all products exported from the plant (including the biofuel and the co-products) – expressed per tonne of the biofuel product. |
| | Step 3: | Divide the value of a tonne of biofuel product by the total value of all exported products (from Step 2) – this is the allocation factor, the proportion of emissions which should be allocated to the biofuel. |
| | Step 4 | Multiply the emissions which occurred in this module and all upstream emissions by this allocation factor. |

**Example of allocation by market value**

An oilseed rape to biodiesel plant is producing biodiesel, glycerine and potassium sulphate.

**Step 1: Market value of exported products**
Biodiesel: 1 tonne of biodiesel = £340 / tonne of biodiesel
Glycerine: 0.1 tonne glycerine/tonne biodiesel x £345 / tonne of glycerine = £35 / tonne of biodiesel
Potassium sulphate: 40 kg / tonne biodiesel x £75 / tonne = £3 / tonne of biodiesel
**Step 2: Total market value of products exported from plant**
Total market value = 340 + 35 + 3 = £378 / tonne of biodiesel

**Step 3: Divide value of a tonne of biofuel by total value of products per tonne of biofuel**
Allocation factor = 340 / 378 = 90 %

**Step 4: Multiply upstream emissions and this module's emissions by the allocation factor**
Upstream emissions (e.g. production of oilseed rape) = 1,725 kg $CO_2$e/t biodiesel
Conversion plant emissions = 523 kg $CO_2$e/t biodiesel
Carbon intensity of biodiesel = (1725 + 532) x 90 = 2,031 kg $CO_2$e/t biodiesel

## Make adjustments to the structure of existing fuel chains

This section describes how, in the Government's view, the structure of the default fuel chains might be changed in some circumstances. Examples of situations in which suppliers may wish to do this include:

- If a certain transport step does not occur because, for example the oilseed crushing plant and the biodiesel conversion plant are co-located.
- If feedstock drying occurs within the biofuel plant – removing the drying and storage

module would mean that energy consumption for drying and storage could be reported within the biofuel conversion module.

- If oilseed crushing and biodiesel conversion take place within the same plant – using one conversion module means energy consumption could be reported for the plant as a whole and would not have to be allocated between crushing and conversion operations.

The Government recommends that suppliers should be required to maintain evidence that the biofuel was produced in the way represented by the revised fuel chain, for example, that a certain transport step does not occur or that crushing and esterification take place on the same site. If modules are removed from the default fuel chain, suppliers should be required to use actual data for data points down stream of this module which may have been affected by the changes made – verifiers will review the entire fuel chain and the data used to ensure there are no inconsistencies. For example, within a biodiesel chain, it should not be possible for a supplier to claim that oilseed crushing and biodiesel conversion take place within one plant, remove the oilseed crushing conversion module and then rely on default values for the biodiesel conversion module. Any changes to a default fuel chain should be recorded transparently – ideally in a format as close as possible to the existing default fuel chains (either electronic or paper-based). Verifiers may request access to this information.

**Removing modules**

**Step 1:** Select the appropriate **default fuel chain** to be edited based on the biofuel's feedstock type and origin.

**Step 2:** Remove the module(s) that is not required.

**Step 3:** Adjust the structure of the remaining modules to ensure that the new fuel chain is accurate and complete. Changes may need to be made to e.g. :

- Inputs and related units (e.g. for yields and emission totals)
- The types of co-product being exported.

**Step 4:** Actual data must be used in place of single default values for any inputs which might have changed as a result of removing a module.

**Step 5:** Complete all necessary calculations in modules which have been changed – and record changes in the "Fuel Chain Summary" table.

**Step 6:** If any "yields" have been changed then the "contribution to overall fuel chain" of all upstream modules will need to be recalculated and recorded in the "Fuel Chain Summary" table.

**Step 7:** The new **fuel chain carbon intensity** can be calculated by summing all the rows given in the "Fuel Chain Summary" table for the specified country of origin (excluding the module which has been removed)

**Step 8:** For reporting to the RFA, this value must be converted to carbon intensity per MJ – using the standard energy content values (lower heating values specified in the General Default Values Section).

## Adding modules

The Government recommends that, with the exception of crop production, the modules listed in Figure 2 should be capable of being added to an existing default fuel chain. Table 1 provides a list of the most important sources of GHG emissions which need to be considered within each module. This list is not exhaustive and the Government recommends that it should be the reporting supplier's responsibility to ensure that all sources of GHG emission which will influence the final carbon intensity of the biofuel by 1 percent or more are taken into account.

**Table 35 - Most important sources of GHG emissions**

| **Module** | **Major influences of GHG emissions** |
|---|---|
| Drying and storage | Fuel (e.g. diesel, fuel oil, natural gas, coal)<br>Electricity |
| Conversion | Yields[21]<br>Fuel (e.g. natural gas, fuel oil, coal)<br>Electricity<br>Chemicals<br>Co-products |

[21] While yields (i.e. tonne output / tonne input) are not a "source" of GHG emissions, they are required to enable the fuel chain contribution total to be calculated within existing modules that are upstream of the added module.

| | |
|---|---|
| Feedstock transport | Diesel or other fuel for transport |
| Liquid fuel transport & storage | Diesel or other fuel |
| Gaseous fuel transport & storage | Gas or other fuel |

Every module should include two "totals": the module total (kg $CO_2$e/t product[22]) and the fuel chain contribution total (kg $CO_2$e/t biofuel).

**Step 1:** Select the appropriate **default fuel chain** to be edited based on the biofuel's feedstock type and origin.

**Step 2:** Add the new module(s) which is required.

**Step 3:** Adjust the structure of the remaining modules to ensure that the new fuel chain is accurate and complete. Changes may need to be made to e.g.:

- Inputs and related units (e.g. for yields and emission totals)
- The types of co-product being exported.

**Step 4:** Actual data will need to be used for all inputs required within the new module – emission factors may be taken from the General Default Values section. In addition, actual data will be required in place of single default values for any inputs which might have changed as a result of adding the new module.

**Step 5:** Complete all necessary calculations in the modules which have been changed – and record changes in the "Fuel Chain Summary" table (remembering to add the new module as a new row in the table).

**Step 6:** If the new module has a "yield" associated with it and/or if other modules have had their "yields" altered then the "contribution to overall fuel chain" of all upstream modules will need to be recalculated and recorded in the "Fuel Chain Summary" table.

[22] Product at this point in the chain.

**Step 7:** The new **fuel chain carbon intensity** can be calculated by summing all the rows given in the "Fuel Chain Summary" table for the specified country of origin – including the value for the new module which has been added.

**Step 8:** For reporting to the RFA, this value must be converted to carbon intensity per MJ – using the standard energy content values (lower heating values specified in the General Default Values section).

## Building a new fuel chain

An entirely new fuel chain can be constructed; however, it will almost always be easier to edit an existing default fuel chain. If a new fuel or feedstock is being introduced to the UK market and none of the existing default fuel chains represent the production processes, the Government recommends that the RFA should require the procedure outlined below to be followed.

**Step 1:** Define the steps which occur during the production of a biofuel using the modules shown in Figure 2.

**Step 2:** Identify the main product which is exported from each module (e.g. wheat, ethanol etc). All emissions within a module must be calculated per tonne of this product.

**Step 3:** Within each module identify all sources of GHG emissions which will influence the final carbon intensity of the biofuel by 1 percent or more.

**Step 4:** Within each conversion module identify the co-products which will be produced and decide on the most appropriate treatment based on the rules outlined below.

**Step 5:** Ensure that each conversion module contains the yield data which is needed to establish the contribution that upstream emissions make to the final carbon intensity of a biofuel i.e. for deriving the "overall contribution to fuel chain emissions" box.

**Step 6:** Complete a fuel chain structure in the same format which has been used for the default fuel chains below – verifiers may review this template.

**Step 7:** Complete the fuel chain structure using actual data and emission factors from the General Default Values section.

**Step 8:** The new **fuel chain carbon intensity** can be calculated by adding up the contribution of all the different modules.

**Step 9:** For reporting to the RFA, this value must be converted to carbon intensity per MJ – using the standard energy content values (lower heating values specified in the General Default Values section).

## Compulsory linkages

There are several input fields within a carbon intensity calculation which are interdependent – for example, the yield of many crops is influenced heavily by the amount of nitrogen which has been applied. To avoid the possibility of default values being used in an inappropriate fashion the Government recommends that a number of "compulsory linkages" should be defined as listed in Table 2.

If actual data is used for either of the two inputs listed in Table 2, actual data should also be used for the other input. It is possible to have actual data which is equal to the default value; however, the reporting supplier should have evidence to support this claim.

**Table 36 – Compulsory linkages for all fuel chains, by module.**

| Input one | Input two |
|---|---|
| **Crop production** | |
| Crop yield* | Nitrogen fertiliser application rate* |
| **Drying and storage** | |
| Moisture removed | Fuel for heating or electricity |
| **Feedstock transport** | |
| None | |
| **Conversion** | |

| | |
|---|---|
| Yield | Any co-product yield |
| Yield | Fuel or electricity use |
| Electricity or heat exported | Fuel use |
| **Liquid fuel transport** | |
| None | |

* This compulsory linkage does not apply to sugar beet.

## General Default values

The Government recommends that the RFA should adopt the default values set out in table 3 below.

**Table 37– Fertiliser and pesticide emissions factors.**

| Fertiliser Type | Units | Emissions factor | N content (%) |
|---|---|---|---|
| Nitrogen fertiliser | | | |
| Ammonium nitrate (AN) | [kg$CO_2$e/kg N] | 6.80 | 35 |
| Ammonium sulphate (AS) | [kg$CO_2$e/kg N] | 1.62 | 21 |
| Urea | [kg$CO_2$e/kg N] | 1.33 | 46 |
| Calcium nitrate (CN) | [kg$CO_2$e/kg N] | 10.9 | 15.5 |
| Urea ammonium nitrate liquid (UAN) | [kg$CO_2$e/kg N] | 4.09 | 32 |
| NPK (Urea / TSP / MOP) | [kg$CO_2$e/kg N] | 2.00 | 15 |
| Phosphate fertiliser | | | |
| Triple superphosphate (TSP) | [kg$CO_2$e/kg $P_2O_5$] | 0.354 | |
| Rock phosphate | [kg$CO_2$e/kg $P_2O_5$] | 0.095 | |
| Mono ammonium phosphate (MAP) | [kg$CO_2$e/kg $P_2O_5$] | 0.596 | 11 |
| Other fertilisers | | | |
| Potassium Chloride | [kg$CO_2$e/kg | 0.333 | |

| | | | |
|---|---|---|---|
| (K fertiliser) | $K_2O$] | | |
| Lime (CaO) fertiliser | [$kgCO_2e/kg$ CaO] | 0.124 | |
| Magnesium (MgO) fertiliser | [$kgCO_2e/kg$ MgO] | 0.769 | |
| Sodium (Na) fertiliser | [$kgCO_2e/kg$ Na] | 1.62 | |
| Pesticides | | | |
| Pesticides | [$kgCO_2e/kg$ active substance] | 17.3 | |

**Table 38 – Fossil fuel emission factors.**

| | Emissions factor |
|---|---|
| | [$kgCO_2e/MJ$ fuel] |
| Gasoline | 0.085 |
| Diesel | 0.086 |
| LPG | 0.069 |
| Heavy fuel oil | 0.087 |
| Coal | 0.112 |
| Natural gas | 0.062 |

**Table 39– Transport mode fuel efficiency**

| | Emissions factor |
|---|---|
| | [MJ/tonne-km] |
| Truck – OECD North America | 1.46 |
| Truck – OECD Europe | 1.53 |
| Truck – OECD Pacific | 1.61 |
| Truck – FSU | 1.82 |
| Truck – Eastern Europe | 1.72 |
| Truck – China | 1.89 |
| Truck – Other Asia | 1.8 |
| Truck – India | 1.94 |
| Truck – Middle East | 1.89 |
| Truck – Latin America | 1.8 |
| Truck – Africa | 1.94 |
| Rail – OECD North America | 0.19 |
| Rail – OECD Europe | 0.38 |
| Rail – OECD Pacific | 0.38 |
| Rail – FSU | 0.19 |
| Rail – Eastern Europe | 0.24 |

| | Emissions factor |
|---|---|
| | [MJ/tonne-km] |
| Rail – China | 0.33 |
| Rail – Other Asia | 0.24 |
| Rail – India | 0.19 |
| Rail – Middle East | 0.24 |
| Rail – Latin America | 0.24 |
| Rail – Africa | 0.24 |
| International shipping | 0.20 |

**Table 40– Emissions factor for electricity**

| Country/Region | Grid average | Marginal baseload generation |
|---|---|---|
| | kg $CO_2$/MJ | |
| Argentina | 0.076 | * |
| Australia | 0.241 | * |
| Brazil | 0.022 | * |
| France | 0.023 | * |
| Germany | 0.139 | * |
| Indonesia | 0.216 | * |

| Country/Region | Grid average | Marginal baseload generation |
|---|---|---|
| | kg $CO_2$/MJ | |
| Malaysia | 0.137 | * |
| Netherlands | 0.130 | * |
| Poland | 0.184 | * |
| United Kingdom | 0.131 | 0.106 |
| United States | 0.160 | * |

* The baseload generation should be defined. See co-products procedures on Page 120.

**Table 41 – General information about fuels**

| Fuel | Density | Lower heating value | |
|---|---|---|---|
| | kg/litre | MJ/kg | MJ/litre |
| Gasoline | 0.745 | 43.2 | 32.2 |
| Diesel | 0.832 | 43.1 | 35.9 |
| HFO | 0.970 | 40.5 | 39.3 |
| Biodiesel | 0.890 | 37.2 | 33.1 |
| Ethanol | 0.794 | 26.8 | 21.3 |
| ETBE | 0.750 | 36.3 | 27.2 |
| MTBE | 0.745 | 35.1 | 35.1 |

| Fuel | Density | Lower heating value | |
|---|---|---|---|
| | kg/litre | MJ/kg | MJ/litre |
| Biomethane | -- | 45.1 | -- |

**Selected default values**

The following tables contain values for selected defaults. For selected defaults on transport mode fuel efficiency see Table 39.

**Table 42 – Fertiliser emission factors.**

| **Fertiliser Type** | **Units** | **Emissions factor** |
|---|---|---|
| Nitrogen fertiliser | | |
| Ammonium nitrate (AN) | [kg$CO_2$e/kg N] | 6.80 |
| Ammonium sulphate (AS) | [kg$CO_2$e/kg N] | 1.62 |
| Urea | [kg$CO_2$e/kg N] | 1.33 |
| Calcium nitrate (CN) | [kg$CO_2$e/kg N] | 10.9 |
| Urea ammonium nitrate liquid (UAN) | [kg$CO_2$e/kg N] | 4.09 |
| NPK (Urea / TSP / MOP) | [kg$CO_2$e/kg N] | 2.00 |
| Phosphate fertiliser | | |
| Triple superphosphate (TSP) | [kg$CO_2$e/kg $P_2O_5$] | 0.354 |
| Rock phosphate | [kg$CO_2$e/kg $P_2O_5$] | 0.095 |
| Mono ammonium phosphate (MAP) | [kg$CO_2$e/kg $P_2O_5$] | 0.596 |

**Table 9 – Fossil fuel emission factors**

| | Emissions factor [$kgCO_2e/MJ$ fuel] |
|---|---|
| Diesel | 0.086 |
| Heavy fuel oil | 0.087 |
| Coal | 0.112 |
| Natural gas | 0.062 |

# Wheat to ethanol

**Fuel chain summary**

| | Carbon intensity [kg $CO_2$/t ethanol] | | | | |
|---|---|---|---|---|---|
| Module | Canada | France | Germany | Ukraine | United Kingdom |
| 1 – Crop production | 1394 | 1416 | 1234 | 2253 | 1275 |
| 2 – Drying and storage | 45 | 43 | 49 | 47 | 49 |
| 3 – Feedstock transport | 169 | 34 | 34 | 96 | 68 |
| 4 – Feedstock transport | 299 | 27 | 39 | 138 | 0 |
| 5 – Conversion | 231 | 231 | 231 | 231 | 231 |
| 6 – Liquid fuel transport and storage | 0 | 0 | 0 | 0 | 0 |
| TOTAL | 2138 | 1751 | 1587 | 2765 | 1623 |

**Selected default options**

| **Stage** | **Module** | **Input** | **Options** |
|---|---|---|---|
| 1 | Crop production | Nitrogen fertiliser emissions factor | Ammonium nitrate (AN), Ammonium sulphate (AS),Urea, Calcium nitrate (CN), Urea ammonium nitrate liquid (UAN), NPK (Urea / TSP / MOP) |

| Stage | Module | Input | Options |
|---|---|---|---|
| 1 | Crop production | Phosphorus fertiliser emissions factor | Triple superphosphate (TSP), Rock phosphate, Mono ammonium phosphate (MAP) |
| 2 | Drying and storage | Fuel emissions factor | Diesel,<br>Heavy fuel oil,<br>Coal,<br>Natural gas |
| 3 | Feedstock transport (Mode 1) | Transport mode fuel efficiency | Truck (by geographic region),<br>Rail (by geographic region),<br>Shipping |
| 4 | Feedstock transport (Mode 2) | Transport mode fuel efficiency | Truck (by geographic region),<br>Rail (by geographic region),<br>Shipping |
| 5 | Conversion | Fuel emissions factor | Coal, Natural gas, Heavy fuel oil, Biomass |
| 6 | Liquid fuel transport | Transport mode fuel efficiency | Truck (by geographic region), Rail (by geographic region), Shipping |

## Default fuel chain

### Stage 1 - Crop Production

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | Cultivation and harvest of wheat | | | | | | | |
| **Basic Data** | | | | | | | | |
| | Units | | | | | | | |
| Yield @ traded moisture content | [t/ha.a] | value | Y | | | | | |
| Traded moisture content | % | value | | | | | | |
| **Soil Emissions** | | | | | | | | |
| | | | | | Emissions co-efficient [$kgCO_{2e}$/ha] | | Total emissions [$kgCO_{2e}$ / $t_{wheat}$] | |
| N2O emissions | [total kg N/ha.a] | *N_FERT* | x | | *6.163* | ÷ Y = | *calculation* | 1 |
| **Farming Inputs** | | | | | | | | |
| | | Mass of input | | | Emissions co-efficient [$kgCO_{2e}$/kg nutrient] | | Total emissions [$kgCO_{2e}$ / $t_{wheat}$] | |
| N fertiliser | [kg nutrient/ha.a] | *value (N_FERT)* | x | | *value* | ÷ Y = | *calculation* | 2 |
| P fertiliser (P2O5) | [kg nutrient/ha.a] | *value* | x | | *value* | ÷ Y = | *calculation* | 3 |
| K fertiliser (K2O) | [kg nutrient/ha.a] | *value* | x | | *value* | ÷ Y = | *calculation* | 4 |
| Lime (CaO) | [kg nutrient/ha.a] | *value* | x | | *value* | ÷ Y = | *calculation* | 5 |
| | | | | | Emissions co-efficient [$kgCO_{2e}$/kg] | | | |
| Pesticides | [kg /ha.a] | *value* | x | | *value* | ÷ Y = | *calculation* | 6 |
| **Machinery Inputs** | | | | | | | | |
| | | | | | Emissions co-efficient [$kgCO_{2e}$/litre] | | Total emissions [$kgCO_{2e}$ / $t_{wheat}$] | |
| Diesel fuel consumption | [litres/ha.a] | *value* | x | | *value* | ÷ Y = | *calculation* | 7 |
| **Totals** | | | | | | | Total emissions [$kgCO_{2e}$ / $t_{wheat}$] | |
| Module total | | | | | | 1 + 2 + 3 + 4 + 5 + 6 + 7 = | *calculation* | 8 |
| | | | | | | | Total emissions [kg $CO_{2e}$ / t ethanol] | |
| Contribution to fuel chain | | | | | | 8 ÷ z1 = | *calculation* | Stage_1 |

### Stage 2 - Drying and storage

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | Drying of wheat | | | | | | | |
| Moisture removed | % by weight | 2 | | | | | | |
| | | | | | Emissions co-efficient [$kgCO_{2e}$/MJ] | | Total emissions [$kgCO_{2e}$ / $t_{wheat}$] | |
| **Fuel / input type** | | | | | | | | |
| Fuel for heating | [MJ/t wheat] | *value* | x | | *value* | = | *calculation* | 9 |
| Electricity | [MJ/t wheat] | *value* | x | | *value* | = | *calculation* | 10 |
| **Totals** | | | | | | | Total emissions [$kgCO_{2e}$ / $t_{wheat}$] | |
| Module total | | | | | | 9 + 10 = | *calculation* | 11 |
| | | | | | | | Total emissions [kg $CO_{2e}$ / t ethanol] | |
| Contribution to fuel chain | | | | | | 11 ÷ z1 = | *calculation* | Stage_2 |

### Stage 3 - Feedstock Transport

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | Drying facility to ethanol plant (Mode 1) | | | | | | | |
| Transport distance | [km] | *value* | dist_1 | | | | | |
| Fuel consumption | [MJ/t-km] | *value* | FC_1 | | | | | |
| **Totals** | | | | | Emissions co-efficient [$kgCO_{2e}$/MJ] | | Total emissions [$kgCO_{2e}$ / $_{wheat}$] | |
| Module total | [MJ/t wheat] | *= dist_1 x FC_1* | x | | *value* | = | *calculation* | 12 |
| | | | | | | | Total emissions [kg $CO_{2e}$ / t ethanol] | |
| Contribution to fuel chain | | | | | | 12 ÷ z1 = | *calculation* | Stage_3 |

## Stage 4 - Feedstock Transport

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | Drying facility to ethanol plant (Mode 2) | | | | | | | |
| Transport distance | [km] | value | dist_2 | | | | | |
| Fuel consumption | [MJ/t-km] | value | FC_2 | | | | | |
| **Totals** | | | | Emissions co-efficient [$kgCO_{2e}$/MJ] | | Total emissions [$kgCO_{2e}$ / $t_{wheat}$] | | |
| Module total | [MJ/t wheat] | = *dist_2 x FC_2* | x | value | = | calculation | 13 | |
| Contribution to fuel chain | | | | | 13 ÷ z1 = | Total emissions [kg $CO_{2e}$ / t ethanol] calculation | Stage_4 | |

## Stage 5 - Conversion

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | Ethanol plant | | | | | | | |
| **Basic data** | | | | | | | | |
| Plant yield | [t ethanol / t wheat] | value | (z1) | | | | | |
| **Conversion Inputs** | | | | Emissions factor [$kgCO_{2e}$/MJ] | | Emissions [$kgCO_{2e}$/t ethanol] | | |
| Natural gas | [MJ/t pure ethanol] | value | x | value | = | calculation | 14 | |
| **Co-products** | **Description** | **Treatment** | | | | | | |
| Co-product 1: | DDGS - sold as animal feed | Substitution | | | | | | |
| **Co-products treated by substitution** | | | | | | | | |
| **Co-product 1: DDGS** | | | | | | | | |
| *- substitutes US soy, converted to meal in EU* | | | | Credit [$kgCO_{2e}$/t DDGS] | | | | |
| Quantity of DDGS produced & sold as animal feed | [t DDGS / t ethanol] | value | x | value | = | calculation | 15 | |
| **Totals** | | | | | | Total emissions [kg $CO_{2e}$ / t ethanol] | | |
| Module total | | | | | 14 + 15 = | calculation | 16 | |
| Contribution to fuel chain | | | | | 16 = | calculation | Stage_5 | |

## Stage 6 - Liquid fuel transport and storage

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | Ethanol plant to refinery/blending facility | | | | | | | |
| Transport distance | [km] | value | dist_3 | | | | | |
| Fuel consumption | [MJ/t-km] | value | FC_3 | | | | | |
| **Totals** | | | | Emissions co-efficient [$kgCO_{2e}$/ha] | | Total emissions [$kgCO_{2e}$ / $t_{ethanol}$] | | |
| Module total | [MJ/t ethanol] | calculation | x | value | = | calculation | 17 | |
| Contribution to fuel chain | | | | | 17 = | calculation | Stage_6 | |

**Default value tables**

| Stage/Input | Units | Feedstock country of origin | | | | |
|---|---|---|---|---|---|---|
| | | Canada | France | Germany | Ukraine | United Kingdom |

| Stage/Input | Units | Feedstock country of origin | | | | |
|---|---|---|---|---|---|---|
| | | **Canada** | **France** | **Germany** | **Ukraine** | **United Kingdom** |
| **Stage 1 – Crop Production** | | | | | | |
| Yield @ traded moisture content | [t/ha.a] | 2.28 | 6.99 | 7.36 | 2.60 | 7.76 |
| Traded moisture content | % | 15 | 15 | 15 | 15 | 15 |
| N fertiliser | [kg N/ha.a] | 50 | 183 | 165 | 90 | 183 |
| Type of N fertiliser | | AN | AN | AN | AN | AN |
| P fertiliser | [kg $P_2O_5$/ha.a] | 26 | 40 | 30 | 80 | 40 |
| Type of P fertiliser | | TSP | TSP | TSP | TSP | TSP |
| K fertiliser | [kg $K_2O$/ha.a] | 6 | 45 | 40 | 80 | 45 |
| Lime | [kg CaO/ha.a] | 363 | 363 | 363 | 363 | 363 |
| Pesticides | [kg/ha.a] | 0.38 | 0.38 | 0.38 | 0.38 | 0.38 |
| Diesel fuel consumption | [litres/ha.a] | 70 | 141 | 141 | 141 | 141 |
| Straw removed | [t/ha.a] | 0 | 0 | 0 | 0 | 0 |
| Stage 2 – Drying and storage | | | | | | |

| Stage/Input | Units | Feedstock country of origin | | | | |
|---|---|---|---|---|---|---|
| | | Canada | France | Germany | Ukraine | United Kingdom |
| Moisture removed | % by weight | 2 | 2 | 2 | 2 | 2 |
| Fuel for heating | [MJ/t wheat] | 141 | 141 | 141 | 141 | 141 |
| Fuel Type | | Diesel | Diesel | Diesel | Diesel | Diesel |
| Electricity | [MJ/t wheat] | 16 | 16 | 16 | 16 | 16 |
| **Stage 3 – Feedstock Transport** | | | | | | |
| Transport distance | [km] | 3000 | 300 | 300 | 1700 | 150 |
| Fuel consumption | [MJ/t-km] | 0.19 | 0.38 | 0.38 | 0.19 | 1.53 |
| **Stage 4 – Feedstock Transport** | | | | | | |
| Transport distance | [km] | 5000 | 450 | 650 | 2300 | 0 |
| Fuel consumption | [MJ/t-km] | 0.2 | 0.2 | 0.2 | 0.2 | 0 |
| **Stage 5 – Conversion** | | | | | | |
| Yield | [t ethanol/t wheat] | 0.292 | 0.292 | 0.292 | 0.292 | 0.292 |
| Natural gas | [MJ/t pure ethanol] | 12700 | 12700127001270 | 12700 | 12700 | 12700 |

| **Stage/Input** | **Units** | **Feedstock country of origin** | | | | |
|---|---|---|---|---|---|---|
| | | **Canada** | **France** | **Germany** | **Ukraine** | **United Kingdom** |
| Co-products | | | | | | |
| Co-product 1: | DDGS sold as animal feed | Substitutes for US soymeal (converted to beans in EU) | | | | |
| Quantity of DDGS produced & sold as animal feed | [t DDGS/t ethanol] | 1.14 | 1.14 | 1.14 | 1.14 | 1.14 |
| Credit for co-product 1 | [kg $CO_2$e/t DDGS] | -491 | -491 | -491 | -491 | -491 |
| **Stage 6 – Liquid fuel transport and storage** | | | | | | |
| Transport distance | [km] | 0 | 0 | 0 | 0 | |
| Fuel consumption | [MJ/t-km] | 0 | 0 | 0 | 0 | |
| | | | | | | |

# Sugar beet to ethanol

**Fuel chain summary**

| | Carbon intensity [kg $CO_2$/t ethanol] |
|---|---|
| Module | United Kingdom |
| 1 – Crop production | 530 |
| 2 – Feedstock transport | 176 |
| 3 – Conversion | 645 |
| 4 – Liquid fuel transport | 0 |
| TOTAL | 1351 |

**Selected default options**

| **Stage** | **Module** | **Input** | **Options** |
|---|---|---|---|
| 1 | Crop production | Nitrogen fertiliser emissions factor | Ammonium nitrate (AN), Ammonium sulphate (AS),Urea, Calcium nitrate (CN), Urea ammonium nitrate liquid (UAN), NPK (Urea / TSP / MOP) |
| 1 | Crop production | Phosphorus fertiliser emissions factor | Triple superphosphate (TSP), Rock phosphate, Mono ammonium phosphate (MAP) |
| 2 | Feedstock transport | Transport mode fuel efficiency | Truck (by geographic region), |

| Stage | Module | Input | Options |
|---|---|---|---|
| | | | Rail (by geographic region),<br>Shipping |
| 3 | Conversion | Fuel emissions factor | Coal,<br>Natural gas,<br>Heavy fuel oil,<br>Biomass |
| 4 | Liquid fuel transport | Transport mode fuel efficiency | Truck (by geographic region),<br>Rail (by geographic region),<br>Shipping |

**Default fuel chain**

## Stage 1 - Crop Production

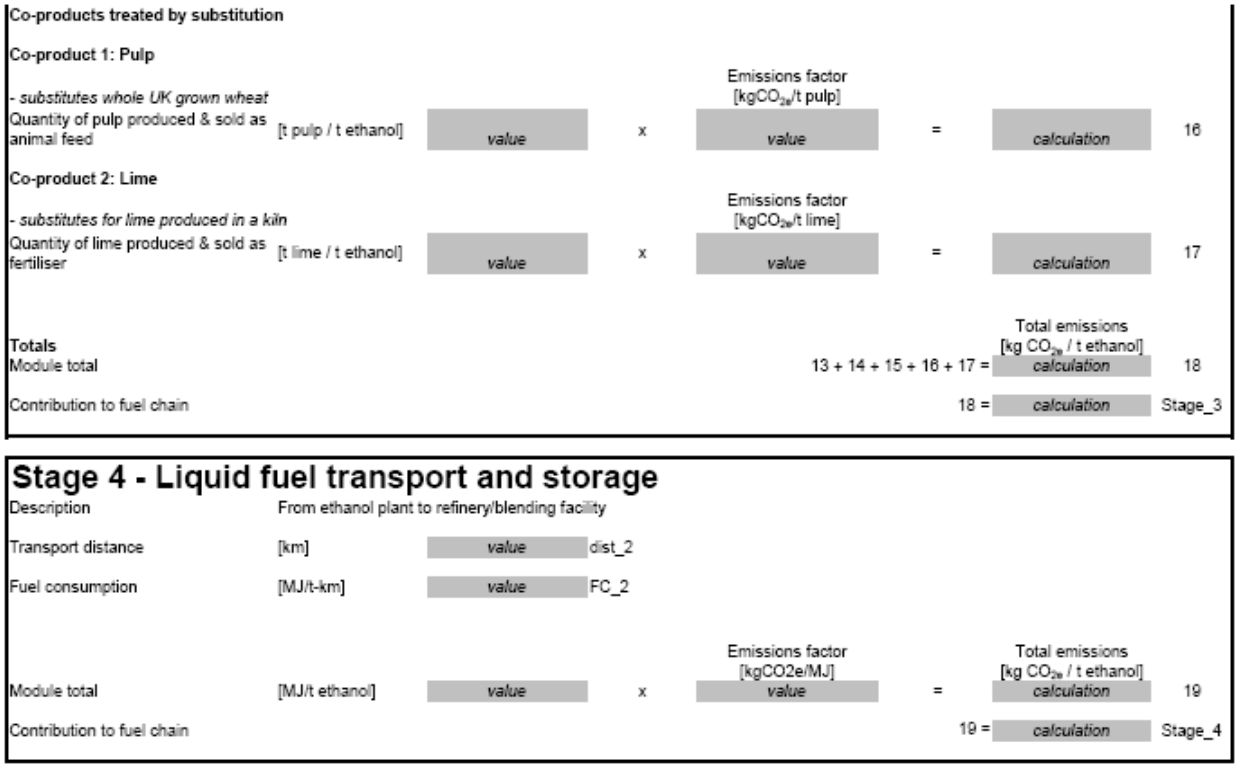
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | Cultivation and harvest of sugar beet | | | | | | | |
| **Basic Data** | | | | | | | | |
| | Units | | | | | | | |
| Yield | [t/ha.a] | *value* | Y | | | | | |
| **Soil Emissions** | | | | | | | | |
| | | | | | Emissions co-efficient [$kgCO_{2e}$/ha] | | Total emissions [$kgCO_{2e}$/t sugar beet] | |
| N2O emissions | [total kg N/ha.a] | *N_FERT* | | x | *6.163* | ÷ Y = | *calculation* | 1 |
| **Farming Inputs** | | | | | | | | |
| | | Mass of input | | | Emissions co-efficient [$kgCO_{2e}$/kg nutrient] | | Total emissions [$kgCO_{2e}$/t sugar beet] | |
| N fertiliser | [kg nutrient/ha.a] | *value (N_FERT)* | | x | *value* | ÷ Y = | *calculation* | 2 |
| P fertiliser (P2O5) | [kg nutrient/ha.a] | *value* | | x | *value* | ÷ Y = | *calculation* | 3 |
| K fertiliser (K2O) | [kg/ha.a] | *value* | | x | *value* | ÷ Y = | *calculation* | 4 |
| Na Fertiliser | [kg nutrient/ha.a] | *value* | | x | *value* | ÷ Y = | *calculation* | 5 |
| Lime (CaO) | [kg nutrient/ha.a] | *value* | | x | *value* | ÷ Y = | *calculation* | 6 |
| | | | | | Emissions co-efficient [$kgCO_{2e}$/kg] | | | |
| Pesticides | [kg/ha.a] | *value* | | x | *value* | ÷ Y = | *calculation* | 7 |
| **Machinery Inputs** | | | | | | | | |
| Diesel fuel consumption | [litres/ha.a] | *value* | | x | *value* | ÷ Y = | *calculation* | 8 |
| On-farm transport to storage clamp | [litres/tonne beet] | *value* | | x | *value* | = | *calculation* | 9 |
| On-farm cleaning and loading | [litres/tonne beet] | *value* | | x | *value* | = | *calculation* | 10 |
| | | | | | | | Emissions [$kgCO_{2e}$/t sugar beet] | |
| **Totals** | | | | | | | | |
| Module total | | | | | 1 + 2 + 3 + 4 + 5 + 6 + 7 + 8 + 9 + 10 = | | *calculation* | 11 |
| | | | | | | | Total emissions [kg $CO_{2e}$ / t ethanol] | |
| Contribution to fuel chain | | | | | | 11 ÷ z1 = | *calculation* | Stage_1 |

## Stage 2 - Feedstock Transport

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | Farm to crushing facility | | | | | | | |
| Transport distance | [km] | *value* | dist_1 | | | | | |
| Fuel consumption | [MJ/t-km] | *value* | FC_1 | | | | | |
| | | | | | Emissions factor [kgCO2e/MJ] | | Emissions [$kgCO_{2e}$/t sugar beet] | |
| **Totals** | | | | | | | | |
| Module total | [MJ/t] | *value* | | x | *value* | = | *calculation* | 12 |
| | | | | | | | Total emissions [kg $CO_{2e}$ / t ethanol] | |
| Contribution to fuel chain | | | | | | 12 ÷ z1 = | *calculation* | Stage_2 |

## Stage 3 - Conversion

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | Ethanol plant | | | | | | | |
| **Basic data** | | | | | | | | |
| Plant yield | [t ethanol / t sugar beet] | *value* | (z1) | | | | | |
| | | | | | Emissions factor [$kgCO_{2e}$/MJ] | | Emissions [$kgCO_{2e}$/t ethanol] | |
| **Conversion Inputs** | | | | | | | | |
| Natural gas | [MJ/t pure ethanol] | *value* | | x | *value* | = | *calculation* | 13 |
| Electricity import | [MJ/t pure ethanol] | *value* | | x | *value* | = | *calculation* | 14 |
| Lime | [kg / t pure ethanol] | *value* | | x | *value* | = | *calculation* | 15 |
| **Co-products** | **Description** | **Treatment** | | | | | | |
| Co-product 1: | Pulp | Substitution | | | | | | |
| Co-product 2: | Lime | Substitution | | | | | | |



| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Co-products treated by substitution** | | | | | | | | |
| **Co-product 1: Pulp** | | | | | | | | |
| *- substitutes whole UK grown wheat* | | | | | Emissions factor [$kgCO_{2e}$/t pulp] | | | |
| Quantity of pulp produced & sold as animal feed | [t pulp / t ethanol] | value | x | value | = | calculation | 16 | |
| **Co-product 2: Lime** | | | | | | | | |
| *- substitutes for lime produced in a kiln* | | | | | Emissions factor [$kgCO_{2e}$/t lime] | | | |
| Quantity of lime produced & sold as fertiliser | [t lime / t ethanol] | value | x | value | = | calculation | 17 | |
| **Totals** | | | | | | Total emissions [kg $CO_{2e}$ / t ethanol] | | |
| Module total | | | | | 13 + 14 + 15 + 16 + 17 = | calculation | 18 | |
| Contribution to fuel chain | | | | | | 18 = calculation | Stage_3 | |

## Stage 4 - Liquid fuel transport and storage

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | From ethanol plant to refinery/blending facility | | | | | | | |
| Transport distance | [km] | value | dist_2 | | | | | |
| Fuel consumption | [MJ/t-km] | value | FC_2 | | | | | |
| | | | | | Emissions factor [kgCO2e/MJ] | | Total emissions [kg $CO_{2e}$ / t ethanol] | |
| Module total | [MJ/t ethanol] | value | x | | value | = | calculation | 19 |
| Contribution to fuel chain | | | | | | 19 = | calculation | Stage_4 |

**Default value tables**

| Stage/Input | Units | Value |
|---|---|---|
| **Stage 1 – Crop Production** | | |
| Yield | [t/ha.a] | 58 |
| N2O emissions from soils | [$kgCO_2e$/ha.a] | 616 |
| N fertiliser | [kg N/ha.a] | 100 |
| Type of N fertiliser | | AN |
| P fertiliser | [kg $P_2O_5$/ha.a] | 50 |
| Type of P fertiliser | | TSP |

| Stage/Input | Units | Value |
|---|---|---|
| K fertiliser | [kg $K_2O$/ha.a] | 120 |
| Na Fertiliser | [kg/ha.a] | 100 |
| Lime | [kg CaO/ha.a] | 300 |
| Pesticides | [kg/ha.a] | 0.3 |
| Diesel fuel consumption | [litres/ha.a] | 168 |
| On-farm transport to storage clamp | [litres/tonne beet] | 0.8 |
| On-farm cleaning and loading | [litres/tonne beet] | 0.5 |
| Stage 2 – Feedstock Transport | | |
| Transport distance | [km] | 100 |
| Fuel consumption | [MJ/t-km] | 1.53 |
| Fuel type | | Diesel |
| **Stage 3 – Conversion** | | |
| Yield | [t ethanol/t sugar beet] | 0.0752 |
| Natural gas | [MJ/t pure ethanol] | 13333 |
| Electricity import | [MJ/t pure ethanol] | 1800 |
| Lime | [kg / t pure ethanol] | 306 |
| Co-products: | | |
| Co-product 1: | Pulp sold as animal feed | Substitutes for UK wheat |

| Stage/Input | Units | Value |
|---|---|---|
| Quantity of pulp produced & sold as animal feed | [t pulp/t ethanol] | 1.25 |
| Credit for co-product 1 | [kg$CO_2$e/t pulp] | -337 |
| Co-production 2: | Lime | Substitutes for agricultural lime |
| Quantity of lime produced & sold as fertiliser | [t lime/t ethanol] | 0.598 |
| Credit for co-product 2 | [kg$CO_2$e/t lime] | -49 |
| **Stage 4 – Liquid fuel transport and storage** | | |
| Transport distance | [km] | 0 |
| Fuel consumption | [MJ/t-km] | 0 |

# Sugar cane to ethanol

**Fuel chain summary**

| | Carbon intensity [kg CO2/t ethanol] | | | |
|---|---|---|---|---|
| **Module** | **Brazil** | **Mozambique** | **Pakistan** | **South Africa** |
| 1 – Crop production | 330 | 407 | 584 | 407 |
| 2 – Feedstock transport | 49 | 53 | 49 | 53 |
| 3 – Conversion | 0 | 0 | 2152 | 2219 |
| 4 – Liquid fuel transport | 94 | 102 | 94 | 102 |
| 5 – Liquid fuel transport | 175 | 237 | 203 | 227 |
| TOTAL | 648 | 790 | 3082 | 3008 |

**Selected default options**

| **Stage** | **Module** | **Input** | **Options** |
|---|---|---|---|
| 1 | Crop production | Nitrogen fertiliser emissions factor | Ammonium nitrate (AN), Ammonium sulphate (AS),Urea, Calcium nitrate (CN), Urea ammonium nitrate liquid (UAN), NPK (Urea / TSP / MOP) |
| 1 | Crop production | Phosphorus fertiliser emissions | Triple superphosphate |

| Stage | Module | Input | Options |
|---|---|---|---|
| | | factor | (TSP), Rock phosphate, Mono ammonium phosphate (MAP) |
| 2 | Feedstock transport | Transport mode fuel efficiency | Truck (by geographic region), Rail (by geographic region), Shipping |
| 4 | Liquid fuel transport | Transport mode fuel efficiency | Truck (by geographic region), Rail (by geographic region), Shipping |
| 5 | Liquid fuel transport | Transport mode fuel efficiency | Truck (by geographic region), Rail (by geographic region), Shipping |

## Default fuel chain

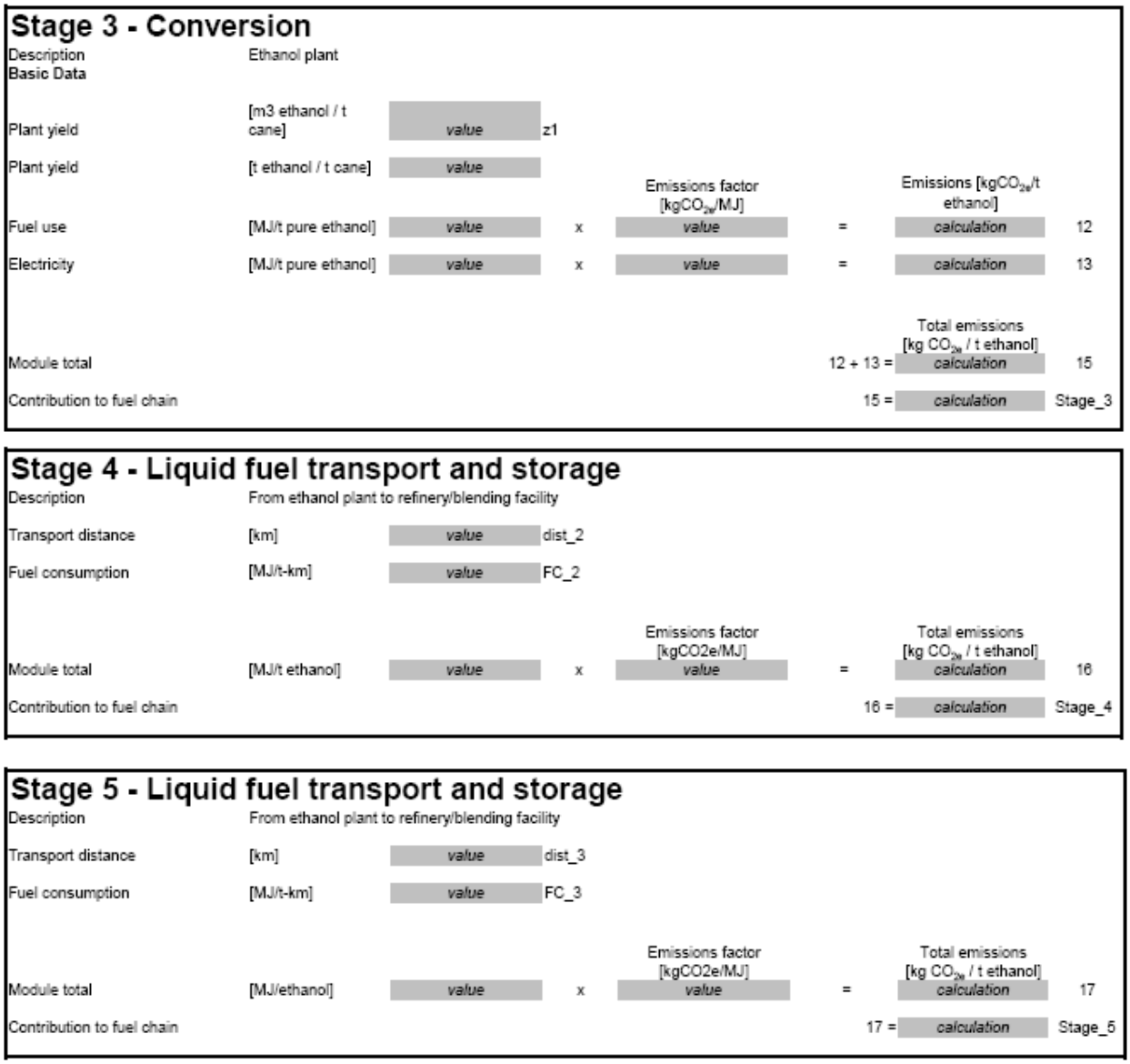
### Stage 1 - Crop Production

| Description | Sugar cane cultivation and harvesting | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Basic Data** | | | | | | | | |
| | Units | | | | | | | |
| Yield | [t/ha.a] | *value* | | | | | | |
| Sucrose % cane | [%] | *value* | S | | | | | |
| Trash yield (% cane) | [%] | *value* | St | | | | | |
| Sugar cane burning area | [%] | *value* | Bc | | | | | |
| Mechanical Harvesting Area | [%] | *value* | Mc | | | | | |
| **Soil Emissions** | | | | | | | | |
| | | | | | Emissions co-efficient [$kgCO_{2e}$/ha] | | Total Emissions [$kgCO_{2e}$/t cane] | |
| N2O emissions | [total kg N/ha.a] | *N_FERT* | x | | *6.163* | ÷ Y = | *calculation* | 1 |
| **Farming Inputs** | | | | | | | | |
| | | Mass of input | | | Emissions co-efficient [$kgCO_{2e}$/kg nutrient] | | Total Emissions [$kgCO_{2e}$/t cane] | |
| N fertiliser | [kg nutrient/ha.a] | *value (N_FERT)* | x | | *value* | ÷ Y = | *calculation* | 2 |
| P fertiliser (P2O5) | [kg nutrient/ha.a] | *value* | x | | *value* | ÷ Y = | *calculation* | 3 |
| K fertiliser (K2O) | [kg nutrient/ha.a] | *value* | x | | *value* | ÷ Y = | *calculation* | 4 |
| Lime (CaO) | [kg nutrient/ha.a] | *value* | x | | *value* | ÷ Y = | *calculation* | 5 |
| | | | | | Emissions co-efficient [$kgCO_{2e}$/kg] | | | |
| Pesticides | [kg/ha.a] | *value* | x | | *value* | ÷ Y = | *calculation* | 6 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Diesel use in agricultural operations** | | | | | | | | |
| Diesel | [litres/ha.a] | *value* | x | | *value* | ÷ Y = | *calculation* | 7 |
| **Emissions from burning sugar cane trash** | | | | | | | | |
| | | | | | Emissions Factor kg CO2 eqv / kg trash | | | |
| $N_2O$ | [kg trash / t cane] | *value* | x | | *value* | x Bc = | *calculation* | 8 |
| Methane | [kg trash / t cane] | *value* | x | | *value* | x Bc = | *calculation* | 9 |
| **Totals** | | | | | | | Emissions [$kgCO_{2e}$/t cane] | |
| Module total | | | | | 1 + 2 + 3 + 4 + 5 + 6 + 7 + 8 + 9 = | | *calculation* | 10 |
| | | | | | | | Total emissions [kg $CO_{2e}$ / t ethanol] | |
| Contribution to fuel chain | | | | | | 10 ÷ z1 = | *calculation* | Stage_1 |

### Stage 2 - Feedstock Transport

| Description | From farm to ethanol plant | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Average transport distance | [km] | *value* | dist_1 | | | | | |
| Fuel consumption | [MJ/t.km] | *value* | FC_1 | | | | | |
| **Totals** | | | | | | Emissions factor [kgCO2e/MJ] | | Total Emissions [$kgCO_{2e}$/t cane] |
| Module total | [MJ/t cane] | *value* | | x | | *value* | = | *calculation* | 11 |
| | | | | | | | | Total emissions [kg $CO_{2e}$ / t ethanol] | |
| Contribution to fuel chain | | | | | | | 11 ÷ z1= | *calculation* | Stage_2 |



## Stage 3 - Conversion

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | Ethanol plant | | | | | | | |
| **Basic Data** | | | | | | | | |
| Plant yield | [m3 ethanol / t cane] | value | z1 | | | | | |
| Plant yield | [t ethanol / t cane] | value | | | | | | |
| | | | | Emissions factor [$kgCO_{2e}$/MJ] | | Emissions [$kgCO_{2e}$/t ethanol] | | |
| Fuel use | [MJ/t pure ethanol] | value | x | value | = | calculation | 12 | |
| Electricity | [MJ/t pure ethanol] | value | x | value | = | calculation | 13 | |
| | | | | | | Total emissions [kg $CO_{2e}$ / t ethanol] | | |
| Module total | | | | | 12 + 13 = | calculation | 15 | |
| Contribution to fuel chain | | | | | 15 = | calculation | Stage_3 | |

## Stage 4 - Liquid fuel transport and storage

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | From ethanol plant to refinery/blending facility | | | | | | | |
| Transport distance | [km] | value | dist_2 | | | | | |
| Fuel consumption | [MJ/t-km] | value | FC_2 | | | | | |
| | | | | Emissions factor [kgCO2e/MJ] | | Total emissions [kg $CO_{2e}$ / t ethanol] | | |
| Module total | [MJ/t ethanol] | value | x | value | = | calculation | 16 | |
| Contribution to fuel chain | | | | | 16 = | calculation | Stage_4 | |

## Stage 5 - Liquid fuel transport and storage

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | From ethanol plant to refinery/blending facility | | | | | | | |
| Transport distance | [km] | value | dist_3 | | | | | |
| Fuel consumption | [MJ/t-km] | value | FC_3 | | | | | |
| | | | | Emissions factor [kgCO2e/MJ] | | Total emissions [kg $CO_{2e}$ / t ethanol] | | |
| Module total | [MJ/ethanol] | value | x | value | = | calculation | 17 | |
| Contribution to fuel chain | | | | | 17 = | calculation | Stage_5 | |

### Default value tables

| **Stage/Input** | **Units** | **Feedstock Country of Origin** | | | |
|---|---|---|---|---|---|
| | | Brazil | Pakistan | South Africa | Mozambique |
| **Stage 1 – Crop Production** | | | | | |
| Yield | [t/ha.a] | 71.6 | 47.3 | 67.2 | 67.2 |
| Trash yield (% cane) | [%] | 14 | 14 | 14 | 14 |

| **Stage/Input** | **Units** | **Feedstock Country of Origin** | | | |
|---|---|---|---|---|---|
| Sugar cane burning area | [%] | 77 | 100 | 100 | 100 |
| Mechanical Harvesting Area | [%] | 34 | 0 | 0 | 0 |
| N fertiliser | [kg N/ha.a] | 80 | 130 | 92 | 92 |
| Type of N fertiliser | | Urea | Urea | Urea | Urea |
| P fertiliser | [kg $P_2O_5$/ha.a] | 60 | 30 | 57 | 57 |
| Type of P fertiliser | | MAP | MAP | MAP | MAP |
| K fertiliser | [kg $K_2O$/ha.a] | 100 | 50 | 133 | 133 |
| Lime | [kg CaO/ha.a] | 60 | 60 | 60 | 60 |
| Pesticides | [kg/ha.a] | 0.2 | 0.2 | 0.2 | 0.2 |
| Diesel use in agricultural operations | [litres/ha.a] | 65 | 65 | 65 | 65 |
| $N_2O$ from burning trash | [kg trash/t cane] | 140 | 140 | 140 | 140 |
| Methane from burning trash | [kg trash/t cane] | 140 | 140 | 140 | 140 |
| **Stage 2 – Feedstock Transport** | | | | | |
| Average transport distance | [km] | 20 | 20 | 20 | 20 |
| Fuel consumption | [MJ/t.km] | 1.8 | 1.8 | 1.8 | 1.8 |
| **Stage 3 – Conversion** | | | | | |
| Yield | [m3 ethanol/t | 0.08 | 0.08 | 0.08 | 0.08 |

| **Stage/Input** | **Units** | **Feedstock Country of Origin** | | | |
|---|---|---|---|---|---|
| | cane] | | | | |
| Yield | [t ethanol / t cane] | 0.0635 | 0.0635 | 0.0635 | 0.0635 |
| No co-products | | | | | |
| **Fuel Use** | | 0 | 18750 | 18750 | 0 |
| Fuel Type | [MJ/t pure ethanol] | Bagasse | Coal | Coal | Bagasse |
| Electricity | [MJ/t pure ethanol] | 0 | 500 | 500 | 0 |
| **Stage 4 – Liquid fuel transport and storage** | | | | | |
| Transport distance | [km] | 600 | 600 | 600 | 600 |
| Fuel consumption | [MJ/t-km] | 1.8 | 1.8 | 1.94 | 1.94 |
| Fuel Type | | Diesel | Diesel | Diesel | Diesel |
| **Stage 5 – Liquid fuel transport and storage** | | | | | |
| Transport distance | [km] | 10,000 | 11600 | 13000 | 13600 |
| Fuel consumption | [MJ/t-km] | 0.2 | 0.2 | 0.2 | 0.2 |
| Fuel Type | | Diesel | Diesel | Diesel | Diesel |

# Molasses to Ethanol

**Fuel chain summary**

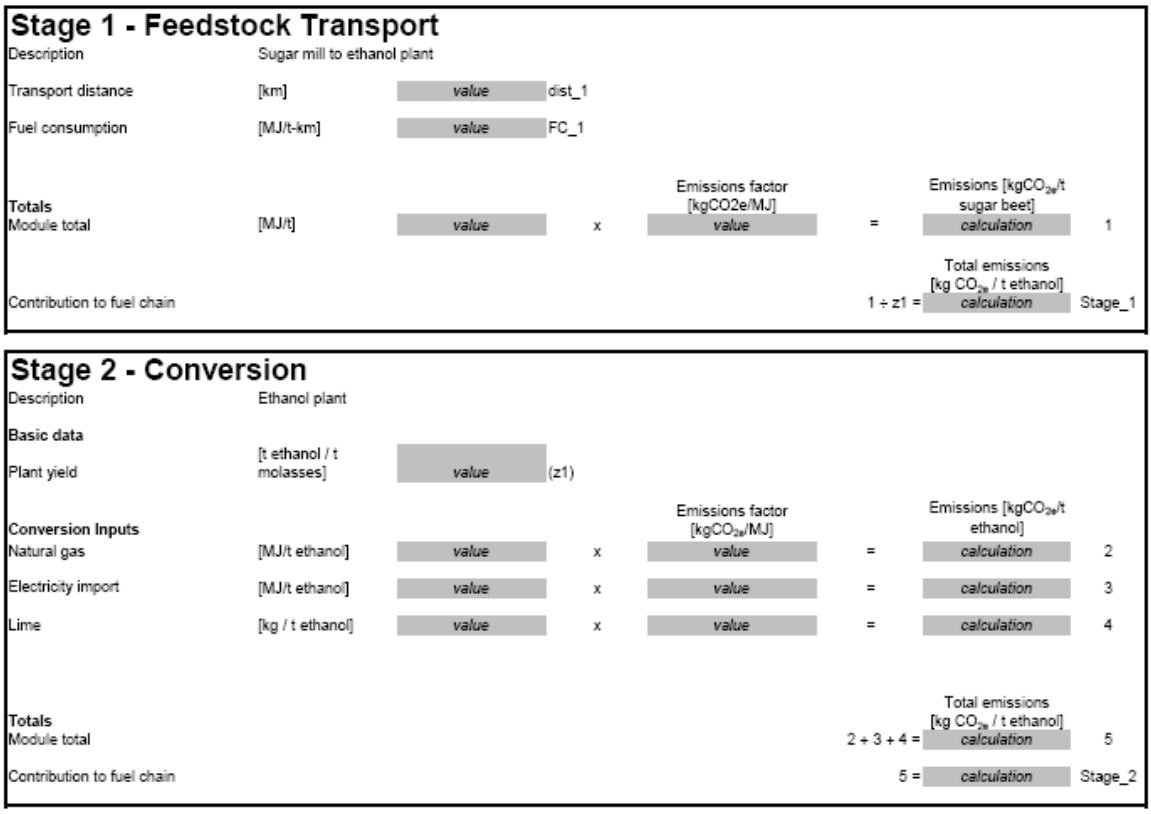
| | Carbon intensity [kg CO2/t ethanol] | | |
|---|---|---|---|
| **Module** | **Pakistan** | **South Africa** | **UK** |
| 1 – Feedstock transport | 205 | 247 | 0 |
| 2 – Conversion | 1679 | 1920 | 1062 |
| 3 – Liquid fuel transport | 93 | 101 | 0 |
| 4 – Liquid fuel transport | 203 | 227 | 0 |
| TOTAL | 2180 | 2495 | 1062 |

**Selected default options**

| **Stage** | **Module** | **Input** | **Options** |
|---|---|---|---|
| 1 | Feedstock transport | Transport mode fuel efficiency | Truck (by geographic region), Rail (by geographic region), Shipping |
| 2 | Conversion | Fuel emissions factor | Coal, Natural gas, Heavy fuel oil, Biomass |
| 3 | Liquid fuel transport | Transport mode fuel efficiency | Truck (by geographic region), |

| Stage | Module | Input | Options |
|---|---|---|---|
| | | | Rail (by geographic region), Shipping |
| 4 | Liquid fuel transport | Transport mode fuel efficiency | Truck (by geographic region), Rail (by geographic region), Shipping |

**Default fuel chain**

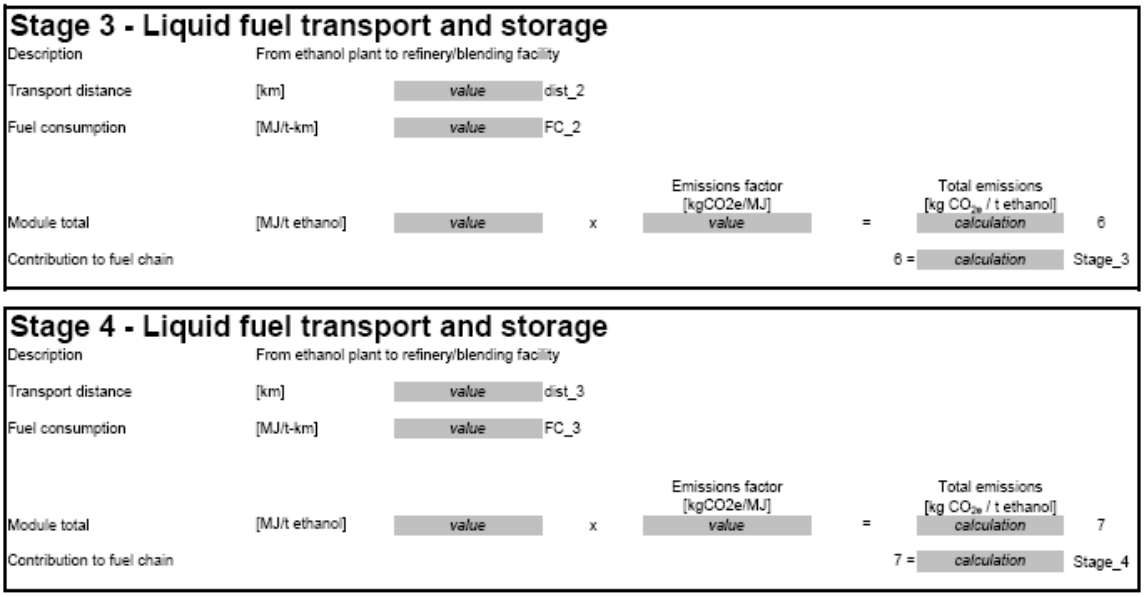


**Stage 1 - Feedstock Transport**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | Sugar mill to ethanol plant | | | | | | | |
| Transport distance | [km] | value | dist_1 | | | | | |
| Fuel consumption | [MJ/t-km] | value | FC_1 | | | | | |
| Totals | | | | | Emissions factor [kgCO2e/MJ] | | Emissions [kgCO2e/t sugar beet] | |
| Module total | [MJ/t] | value | | x | value | = | calculation | 1 |
| Contribution to fuel chain | | | | | | 1 ÷ z1 = | Total emissions [kg CO2e / t ethanol] calculation | Stage_1 |

**Stage 2 - Conversion**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | Ethanol plant | | | | | | | |
| Basic data | | | | | | | | |
| Plant yield | [t ethanol / t molasses] | value | (z1) | | | | | |
| Conversion Inputs | | | | | Emissions factor [kgCO2e/MJ] | | Emissions [kgCO2e/t ethanol] | |
| Natural gas | [MJ/t ethanol] | value | | x | value | = | calculation | 2 |
| Electricity import | [MJ/t ethanol] | value | | x | value | = | calculation | 3 |
| Lime | [kg / t ethanol] | value | | x | value | = | calculation | 4 |
| Totals | | | | | | | Total emissions [kg CO2e / t ethanol] | |
| Module total | | | | | | 2 + 3 + 4 = | calculation | 5 |
| Contribution to fuel chain | | | | | | 5 = | calculation | Stage_2 |




**Default value tables**

| **Stage/Input** | **Units** | **Feedstock Country of Origin** | | |
|---|---|---|---|---|
| | | **Pakistan** | **South Africa** | **UK** |
| **Stage 1 – Feedstock Transport** | | | | |
| Average transport distance | [km] | 150 | 150 | 0 |
| Fuel consumption | [MJ/t.km] | 1.8 | 1.94 | 0 |
| **Stage 2 – Conversion** | | | | |
| Yield | [m3 ethanol/t cane] | 0.231 | 0.231 | 0.231 |
| **Fuel Use** | | 13333 | 13333 | 13333 |
| Fuel Type | [MJ/t pure ethanol] | Coal | Coal | Natural Gas |

| **Stage/Input** | **Units** | **Feedstock Country of Origin** | | |
|---|---|---|---|---|
| Electricity | [MJ/t pure ethanol] | 1800 | 1800 | 1800 |
| **Stage 3 – Liquid fuel transport and storage** | | | | |
| Transport distance | [km] | 600 | 600 | 0 |
| Fuel consumption | [MJ/t-km] | 1.8 | 1.94 | 0 |
| Fuel Type | | Diesel | Diesel | Diesel |
| **Stage 4 – Liquid fuel transport and storage** | | | | |
| Transport distance | [km] | 11,600 | 13,000 | 0 |
| Fuel consumption | [MJ/t-km] | 0.2 | 0.2 | 0 |
| Fuel Type | | HFO | HFO | None |

# Corn to ethanol

**Fuel chain summary**

| | Carbon intensity [kg CO2/t ethanol] | |
|---|---|---|
| **Module** | **USA** | **France** |
| 1 – Crop production | 913 | 999 |
| 2 – Drying and storage | 55 | 19 |
| 3 – Feedstock transport | 33 | 30 |
| 4 – Conversion | 1752 | 263 |
| 5 – Liquid fuel transport and storage | 27 | 8 |
| 6 – Liquid fuel transport and storage | 122 | |
| TOTAL | 2902 | 1319 |

**Selected default options**

| **Stage** | **Module** | **Input** | **Options** |
|---|---|---|---|
| 1 | Crop production | Nitrogen fertiliser emissions factor | Ammonium nitrate (AN), Ammonium sulphate (AS),Urea, Calcium nitrate (CN), Urea ammonium nitrate liquid (UAN), NPK (Urea / TSP / |

| Stage | Module | Input | Options |
|---|---|---|---|
| | | | MOP) |
| 1 | Crop production | Phosphorus fertiliser emissions factor | Triple superphosphate (TSP), Rock phosphate, Mono ammonium phosphate (MAP) |
| 2 | Drying and storage | Fuel emissions factor | Diesel,<br>Heavy fuel oil,<br>Coal,<br>Natural gas |
| 3 | Feedstock transport | Transport mode fuel efficiency | Truck (by geographic region),<br>Rail (by geographic region),<br>Shipping |
| 4 | Conversion | Fuel emissions factor | Coal,<br>Natural gas,<br>Heavy fuel oil,<br>Biomass |
| 5 | Liquid fuel transport | Transport mode fuel efficiency | Truck (by geographic region),<br>Rail (by geographic region),<br>Shipping |

## Default fuel chain - France

### Stage 1 - Crop Production

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | Cultivation and harvest of corn | | | | | | | |
| **Basic Data** | | | | | | | | |
| | Units | | | | | | | |
| Yield @ traded moisture content | [t corn / ha.a] | value | Y | | | | | |
| Traded moisture content | % | value | | | | | | |
| **Soil Emissions** | | | | | | | | |
| | | | | | Emissions co-efficient [$kgCO_{2e}$/ha] | | Total Emissions [kgCO2e/t corn] | |
| N2O emissions | [total kg N/ha.a] | *N_FERT* | | x | 6.163 | ÷ Y = | calculation | 1 |
| **Farming Inputs** | | | | | | | | |
| | | Mass of input | | | Emissions co-efficient [$kgCO_{2e}$/kg nutrient] | | Total Emissions [kgCO2e/t corn] | |
| N fertiliser | [kg nutrient/ha.a] | value (N_FERT) | | x | value | ÷ Y = | calculation | 2 |
| P fertiliser (P2O5) | [kg nutrient/ha.a] | value | | x | value | ÷ Y = | calculation | 3 |
| K fertiliser (K2O) | [kg nutrient/ha.a] | value | | x | value | ÷ Y = | calculation | 4 |
| Lime (CaO) | [kg nutrient/ha.a] | value | | x | value | ÷ Y = | calculation | 5 |
| | | | | | Emissions co-efficient [$kgCO_{2e}$/kg] | | | |
| Pesticides | [kg/ha.a] | value | | x | value | ÷ Y = | calculation | 6 |
| **Machinery Inputs** | | | | | | | | |
| | | | | | Emissions factor [kgCO2e/litre] | | | |
| Diesel fuel consumption | [litres/ha.a] | value | | x | value | ÷ Y = | calculation | 7 |
| **Totals** | | | | | | | Emissions [kgCO2e/t corn] | |
| Module total | | | | | | 1 + 2 + 3 + 4 + 5 + 6 + 7 = | calculation | 8 |
| | | | | | | | Total emissions [kg $CO_{2e}$ / t ethanol] | |
| Contribution to fuel chain | | | | | | 8 ÷ z1 = | calculation | Stage_1 |

### Stage 2 - Drying and storage

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | Drying of corn | | | | | | | |
| Moisture removed | % by weight | value | | | | | | |
| **Fuel / input type** | | | | | Emissions co-efficient [$kgCO_{2e}$/MJ] | | Total emissions [$kgCO_{2e}$ / $t_{corn}$] | |
| Fuel for heating | [MJ/t corn] | value | | x | value | = | calculation | 9 |
| Electricity | [MJ/t corn] | value | | x | value | = | calculation | 10 |
| **Totals** | | | | | | | Total emissions [$kgCO_{2e}$ / $t_{corn}$] | |
| Module total | | | | | | 9 + 10 = | calculation | 11 |
| | | | | | | | Total emissions [kg $CO_{2e}$ / t ethanol] | |
| Contribution to fuel chain | | | | | | 11 ÷ z1 = | calculation | Stage_2 |

### Stage 3 - Feedstock Transport

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | Farm to ethanol plant | | | | | | | |
| | | | | | Emissions factor [kgCO2e/MJ] | | | |
| Transport distance | [km] | value | dist_1 | | | | | |
| Fuel consumption | [MJ/t-km] | value | FC_1 | | | | | |
| **Totals** | | | | | | | Emissions [kgCO2e/t corn] | |
| Module total | [MJ/t] | value | | x | value | = | calculation | 12 |
| | | | | | | | Total emissions [kg $CO_{2e}$ / t ethanol] | |
| Contribution to fuel chain | | | | | | 12 ÷ z1 = | calculation | Stage_3 |

## Stage 4 - Conversion

| Description | Ethanol plant | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Basic data** | | | | | | | | |
| Plant yield | [t ethanol / t corn] | value | (z1) | | | | | |
| **Conversion Inputs** | | | | | | | | |
| | | | | | Emissions factor [kgCO2e/MJ] | | Emissions [$kgCO_{2e}$/t ethanol] | |
| Natural gas | [MJ/t pure ethanol] | value | x | | value | = | calculation | 13 |
| Electricity import | [MJ/t pure ethanol] | value | x | | value | = | calculation | 14 |
| **Co-products** | **Description** | **Treatment** | | | | | | |
| Co-product 1: | DDGS - sold as animal feed | Substitution | | | | | | |
| **Co-products treated by substitution** | | | | | | | | |
| **Co-product 1: DDGS sold as animal feed** | | | | | | | | |
| | | | | | Credit [$kgCO_{2e}$/t DDGS] | | | |
| *- substitutes US soy meal (imported as soy bean)* | | | | | | | | |
| Quantity of DDGS | [t DDGS / t ethanol] | value | x | | value | = | calculation | 15 |
| **Totals** | | | | | | | Total emissions [kg $CO_{2e}$ / t ethanol] | |
| Module total | | | | | | 13 + 14 + 15 = | calculation | 16 |
| Contribution to fuel chain | | | | | | 16 = | calculation | Stage_4 |

## Stage 5 - Liquid fuel transport and storage

| Description | Ethanol plant to refinery/blending facility | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Transport distance | [km] | value | dist_2 | | | | | |
| Fuel consumption | [MJ/t-km] | value | FC_2 | | | | | |
| | | | | | Emissions factor [kgCO2e/MJ] | | Total emissions [kg $CO_{2e}$ / t ethanol] | |
| **Totals** | | | | | | | | |
| Module total | [MJ/t ethanol] | value | x | | value | = | calculation | 17 |
| Contribution to fuel chain | | | | | | 17 = | calculation | Stage_5 |

**Default fuel chain – USA**

## Stage 1 - Crop Production

| Description | Cultivation and harvest of corn | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Basic Data** | | | | | | | | |
| | Units | | | | | | | |
| Yield @ traded moisture content | [t corn / ha.a] | *value* | Y | | | | | |
| Traded moisture content | % | *value* | | | | | | |
| **Soil Emissions** | | | | | | | | |
| | | | | | Emissions co-efficient [$kgCO_{2e}$/ha] | | Total Emissions (kgCO2e/t corn) | |
| N2O emissions | [total kg N/ha.a] | *N_FERT* | x | | *6.163* | ÷ Y = | *calculation* | 1 |
| **Farming Inputs** | | | | | | | | |
| | | Mass of input | | | Emissions co-efficient [$kgCO_{2e}$/kg nutrient] | | Total Emissions (kgCO2e/t corn) | |
| N fertiliser | [kg nutrient/ha.a] | *value (N_FERT)* | x | | *value* | ÷ Y = | *calculation* | 2 |
| P fertiliser (P2O5) | [kg nutrient/ha.a] | *value* | x | | *value* | ÷ Y = | *calculation* | 3 |
| K fertiliser (K2O) | [kg nutrient/ha.a] | *value* | x | | *value* | ÷ Y = | *calculation* | 4 |
| Lime (CaO) | [kg nutrient/ha.a] | *value* | x | | *value* | ÷ Y = | *calculation* | 5 |
| | | | | | Emissions co-efficient [$kgCO_{2e}$/kg] | | | |
| Pesticides | [kg/ha.a] | *value* | x | | *value* | ÷ Y = | *calculation* | 6 |
| **Machinery Inputs** | | | | | | | | |
| | | | | | Emissions factor ($kgCO_{2e}$/litre) | | | |
| Diesel fuel consumption | [litres/ha.a] | *value* | x | | *value* | ÷ Y = | *calculation* | 7 |
| **Totals** | | | | | | | Emissions [kgCO2e/t corn] | |
| Module total | | | | | | 1 + 2 + 3 + 4 + 5 + 6 + 7 = | *calculation* | 8 |
| | | | | | | | Total emissions [kg $CO_{2e}$ / t ethanol] | |
| Contribution to fuel chain | | | | | | 8 ÷ z1 = | *calculation* | Stage_1 |

## Stage 2 - Drying and storage

| Description | Drying of corn | | | | | | |
|---|---|---|---|---|---|---|---|
| Moisture removed | % by weight | *value* | | | | | |
| **Fuel / input type** | | | | Emissions co-efficient [$kgCO_{2e}$/MJ] | | Total emissions [$kgCO_{2e}$ / $t_{corn}$] | |
| Fuel for heating | [MJ/t corn] | *value* | x | *value* | = | *calculation* | 9 |
| Electricity | [MJ/t corn] | *value* | x | *value* | = | *calculation* | 10 |
| **Totals** | | | | | | Total emissions [$kgCO_{2e}$ / $t_{corn}$] | |
| Module total | | | | | 9 + 10 = | *calculation* | 11 |
| | | | | | | Total emissions [kg $CO_{2e}$ / t ethanol] | |
| Contribution to fuel chain | | | | | 11 ÷ z1 = | *calculation* | Stage_2 |

## Stage 3 - Feedstock Transport

| Description | Farm to ethanol plant | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | Emissions factor [kgCO2e/MJ] | | | |
| Transport distance | [km] | *value* | dist_1 | | | | |
| Fuel consumption | [MJ/t-km] | *value* | FC_1 | | | | |
| **Totals** | | | | | | Emissions [kgCO2e/t corn] | |
| Module total | [MJ/t] | *value* | x | *value* | = | *calculation* | 12 |
| | | | | | | Total emissions [kg $CO_{2e}$ / t ethanol] | |
| Contribution to fuel chain | | | | | 12 ÷ z1 = | *calculation* | Stage_3 |

## Stage 4 - Conversion

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | Ethanol plant | | | | | | | |
| **Basic data** | | | | | | | | |
| Plant yield | [t ethanol / t corn] | *value* | (z1) | | | | | |
| **Conversion Inputs** | | | | | | | | |
| | | | | | Emissions factor [kgCO2e/MJ] | | Emissions [kgCO2e/t ethanol] | |
| Coal | [MJ/t pure ethanol] | *value* | x | | *value* | = | *calculation* | 13 |
| **Co-products** | **Description** | **Treatment** | | | | | | |
| **Wet mill** | | | | | | | | |
| Co-product 1: | Corn oil | Substitution | | | | | | |
| Co-product 2: | Corn gluten meal | Substitution | | | | | | |
| Co-product 3: | Corn gluten feed | Substitution | | | | | | |
| Co-product 4: | Electricity | Substitution | | | | | | |
| **Co-products treated by substitution** | | | | | | | | |
| **Co-product 1: Corn oil** | | | | | | | | |
| *- substitutes US soybean oil* | | | | | Credit [kgCO$_{2e}$/t corn oil] | | | |
| Quantity of corn oil produced | [t corn oil / t ethanol] | *value* | x | | *value* | = | *calculation* | 14 |
| **Co-product 2: Corn gluten meal** | | | | | | | | |
| *- substitutes whole corn & nitrogen in urea* | | | | | Credit [kgCO2e/t corn gluten | | | |
| Quantity of corn gluten meal produced | [t corn gluten meal / t ethanol] | *value* | x | | *value* | = | *calculation* | 15 |
| **Co-product 3: Corn gluten feed** | | | | | | | | |
| *- substitutes whole corn & nitrogen in urea* | | | | | Credit [kgCO2e/t corn gluten | | | |
| Quantity of corn gluten feed produced | [t corn gluten feed / t ethanol] | *value* | x | | *value* | = | *calculation* | 16 |
| **Co-product 4: Electricity** | | | | | Credit [kgCO$_{2e}$/MJ electricity] | | | |
| Electricity exported | [MJ electricity export / t ethanol] | *value* | x | | *value* | = | *calculation* | 17 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Totals** | | | | | | | Emissions [kgCO$_{2e}$/t ethanol] | |
| Module total | | | | | 13 + 14 + 15 + 16 + 17 | = | *calculation* | 18 |
| | | | | | | | Total emissions [kg CO$_{2e}$ / t ethanol] | |
| Contribution to fuel chain | | | | | | 18 = | *calculation* | Stage_4 |

## Stage 5 - Liquid fuel transport and storage

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | Ethanol plant to refinery/blending facility | | | | | | | |
| Transport distance | [km] | *value* | dist_2 | | | | | |
| Fuel consumption | [MJ/t-km] | *value* | FC_2 | | | | | |
| | | | | | Emissions factor [kgCO2e/MJ] | | Emissions [kgCO$_{2e}$/t ethanol] | |
| **Totals** | | | | | | | | |
| Module total | [MJ/t ethanol] | *value* | x | | *value* | = | *calculation* | 19 |
| Contribution to fuel chain | | | | | | 19 = | *calculation* | Stage_5 |

## Stage 6 - Liquid fuel transport and storage

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | Ethanol plant to refinery/blending facility | | | | | | | |
| Transport distance | [km] | *value* | dist_3 | | | | | |
| Fuel consumption | [MJ/t-km] | *value* | FC_3 | | | | | |
| | | | | | Emissions factor [kgCO2e/MJ] | | Emissions [kgCO$_{2e}$/t ethanol] | |
| **Totals** | | | | | | | | |
| Module total | [MJ/t ethanol] | *value* | x | | *value* | = | *calculation* | 20 |
| | | | | | | | Total emissions [kg CO$_{2e}$ / t ethanol] | |
| Contribution to fuel chain | | | | | | 20 = | *calculation* | Stage_6 |

**Default value tables**

| **Stage/Input** | **Units** | **Feedstock country of origin** | |
|---|---|---|---|
| | | **USA** | **France** |
| **Stage 1 – Crop Production** | | | |
| Yield @ traded moisture content | [t corn/ha.a] | 8.95 | 8.52 |
| Traded moisture content | % | 15 | 15 |
| N fertiliser | [kg N/ha.a] | 150 | 170 |
| Type of N fertiliser | | AN | AN |
| P fertiliser | [kg $P_2O_5$/ha.a] | 70 | 59 |
| Type of P fertiliser | | TSP | TSP |
| K fertiliser | [kg $K_2O$/ha.a] | 90 | 36 |
| Lime | [kg CaO/ha.a] | 469 | 469 |
| Pesticides | [kg/ha.a] | 4 | 4 |
| Diesel fuel consumption | [litres/ha.a] | 131 | 131 |
| Straw removed | [t/ha.a] | 0 | 0 |

| **Stage/Input** | **Units** | **Feedstock country of origin** | |
|---|---|---|---|
| **Stage 2 – Drying and storage** | | | |
| Moisture removed | % by weight | 3 | 1 |
| Fuel for heating | [MJ/t corn] | 214 | 70 |
| Fuel Type | | | Diesel |
| Electricity | [MJ/t corn] | 24 | 8 |
| **Stage 3 – Feedstock Transport** | | | |
| Transport distance | [km] | 80 | 300 |
| Fuel consumption | [MJ/t-km] | 1.46 | 0.38 |
| **Stage 4 – Conversion** | | | |
| Yield | [t ethanol/t corn] | 0.31 | 0.326 |
| Coal | [MJ/t pure ethanol] | 23038 | 0 |
| Natural gas | [MJ/t pure ethanol] | 0 | 11335 |
| Electricity import | [MJ/t pure ethanol] | 0 | 1260 |
| Co-products | | | |
| Co-product 1 | Corn oil (USA only) | Substitutes for US soybean oil (crushed in US) | |

| **Stage/Input** | **Units** | **Feedstock country of origin** | |
|---|---|---|---|
| Quantity of corn oil produced | [t corn oil/t ethanol] | 0.122 | N/A |
| Credit for co-product 1 | [$kgCO_2e$/t corn oil] | -1655 | N/A |
| Co-product 2 | Corn gluten meal (USA only) | Substitutes for whole corn & nitrogen in urea | |
| Quantity of corn gluten meal produced | [t corn gluten meal/t ethanol] | 0.152 | N/A |
| Credit for co-product 2 | [$kgCO_2e$/t corn gluten meal] | -124 | N/A |
| Co-product 3 | Corn gluten feed | Substitutes for whole corn & nitrogen in urea | |
| Quantity of corn gluten feed produced | [t corn gluten feed/t ethanol] | 0.657 | N/A |
| Credit for co-product 3 | [$kgCO_2e$/t corn gluten feed] | -283 | N/A |
| Co-product 4 | DDGS (France only) | Substitutes US soymeal (crushed in EU) | |
| Quantity of DDGS | [t DDGS/t ethanol] | N/A | 0.961 |

| **Stage/Input** | **Units** | **Feedstock country of origin** | |
|---|---|---|---|
| Credit for co-product 4 | [kg$CO_2$e/t DDGS] | N/A | -491 |
| Co-product 5 | Electricity | | |
| Electricity exported | [MJ electricity export/t ethanol] | 2661 | N/A |
| Credit for co-product 5 | [kgCO**2e**/MJ electricity] | -0.16 | N/A |
| **Stage 5 – Liquid fuel transport and storage** | | | |
| Transport distance | [km] | 1600 | 450 |
| Fuel consumption | [MJ/t-km] | 0.19 | 0.2 |
| **Stage 6 – Liquid fuel transport and storage** | | | |
| Transport distance | [km] | 7000 | 0 |
| Fuel consumption | [MJ/t-km] | 0.2 | 0 |

# Oilseed rape to ME biodiesel

**Fuel chain summary**

| | Carbon intensity [kg CO2/t biodiesel] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Module** | **Australia** | **Canada** | **Finland** | **France** | **Germany** | **Poland** | **Ukraine** | **United Kingdom** |
| 1 - Crop production | 1933 | 1853 | 1903 | 1591 | 1598 | 1475 | 2028 | 1945 |
| 2 - Drying and storage | 0 | 65 | 67 | 62 | 71 | 75 | 68 | 71 |
| 3 - Feedstock transport | 22 | 109 | 29 | 87 | 87 | 87 | 62 | 29 |
| 4 - Feedstock transport | 693 | 0 | 0 | 0 | 0 | 0 | 89 | 0 |
| 5 - Conversion (crushing) | -469 | -490 | -484 | -503 | -466 | -451 | -468 | -468 |
| 6 - Feedstock transport | 8 | 86 | 0 | 7 | 11 | 25 | 0 | 0 |
| 7 - Conversion (esterification) | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 |
| 8 - Liquid fuel transport and storage | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

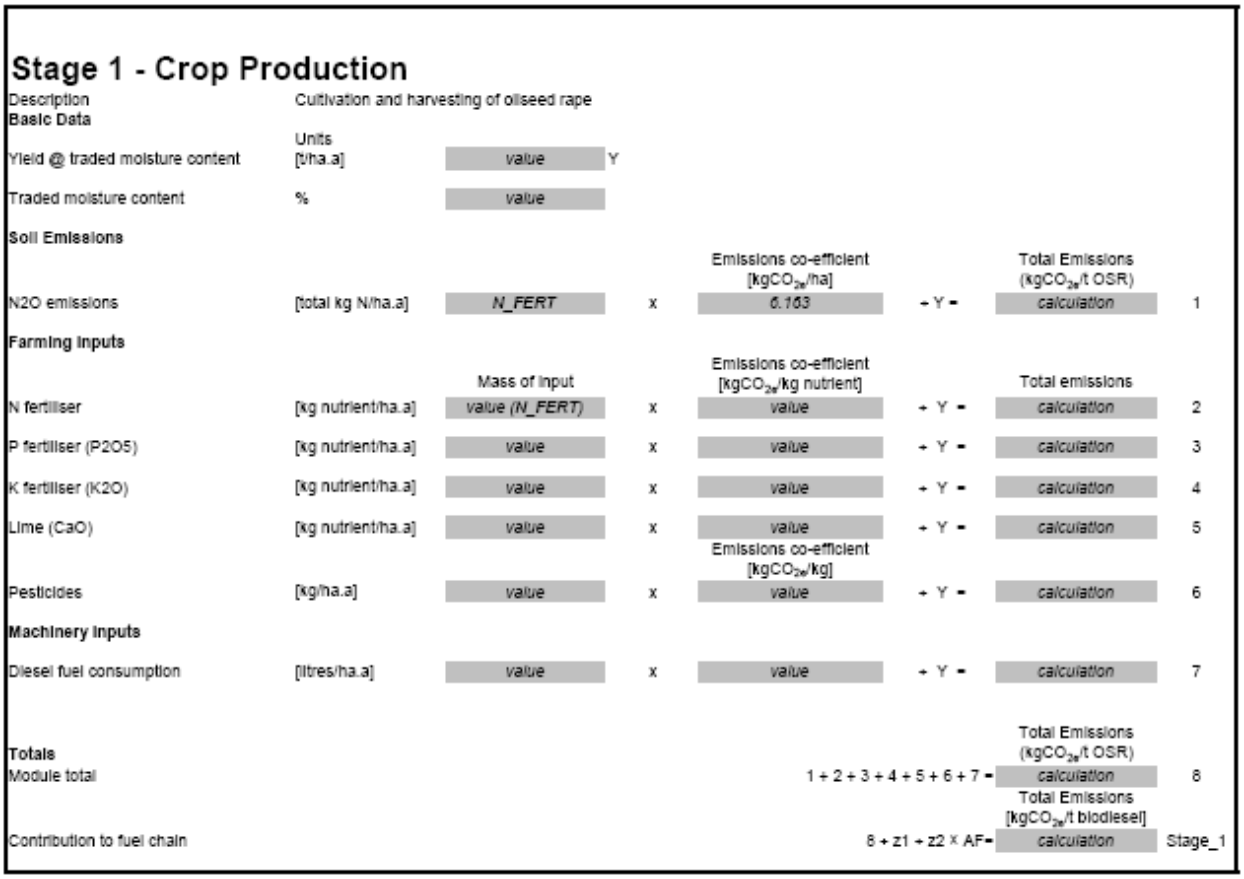
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| TOTAL | 2658 | 2094 | 1986 | 1715 | 1772 | 1682 | 2250 | 2048 |

**Selected default options**

| Stage | Module | Input | Options |
|---|---|---|---|
| 1 | Crop production | Nitrogen fertiliser emissions factor | Ammonium nitrate (AN), Ammonium sulphate (AS),Urea, Calcium nitrate (CN), Urea ammonium nitrate liquid (UAN), NPK (Urea / TSP / MOP) |
| 1 | Crop production | Phosphorus fertiliser emissions factor | Triple superphosphate (TSP), Rock phosphate, Mono ammonium phosphate (MAP) |
| 2 | Drying and storage | Fuel emissions factor | Diesel,<br>Heavy fuel oil,<br>Coal,<br>Natural gas |
| 3 | Feedstock transport | Transport mode fuel efficiency | Truck (by geographic region),<br>Rail (by geographic region),<br>Shipping |
| 4 | Conversion (crushing) | Fuel emissions factor | Coal,<br>Natural gas,<br>Heavy fuel oil,<br>Biomass |
| 5 | Feedstock transport | Transport mode fuel efficiency | Truck (by geographic region),<br>Rail (by geographic region),<br>Shipping |
| 6 | Conversion (esterification) | Fuel emissions factor | Coal,<br>Natural gas,<br>Heavy fuel oil,<br>Biomass |

| Stage | Module | Input | Options |
|---|---|---|---|
| 7 | Liquid fuel transport | Transport mode fuel efficiency | Truck (by geographic region), Rail (by geographic region), Shipping |

**Default fuel chain**



## Stage 1 - Crop Production

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | Cultivation and harvesting of oilseed rape | | | | | | | |
| **Basic Data** | | | | | | | | |
| | Units | | | | | | | |
| Yield @ traded moisture content | [t/ha.a] | value | Y | | | | | |
| Traded moisture content | % | value | | | | | | |
| **Soil Emissions** | | | | | | | | |
| | | | | Emissions co-efficient [$kgCO_{2e}$/ha] | | | Total Emissions ($kgCO_{2e}$/t OSR) | |
| N2O emissions | [total kg N/ha.a] | *N_FERT* | x | *6.163* | ÷ Y = | | *calculation* | 1 |
| **Farming Inputs** | | | | | | | | |
| | | Mass of input | | Emissions co-efficient [$kgCO_{2e}$/kg nutrient] | | | Total emissions | |
| N fertiliser | [kg nutrient/ha.a] | *value (N_FERT)* | x | *value* | ÷ Y = | | *calculation* | 2 |
| P fertiliser (P2O5) | [kg nutrient/ha.a] | *value* | x | *value* | ÷ Y = | | *calculation* | 3 |
| K fertiliser (K2O) | [kg nutrient/ha.a] | *value* | x | *value* | ÷ Y = | | *calculation* | 4 |
| Lime (CaO) | [kg nutrient/ha.a] | *value* | x | *value* | ÷ Y = | | *calculation* | 5 |
| | | | | Emissions co-efficient [$kgCO_{2e}$/kg] | | | | |
| Pesticides | [kg/ha.a] | *value* | x | *value* | ÷ Y = | | *calculation* | 6 |
| **Machinery Inputs** | | | | | | | | |
| Diesel fuel consumption | [litres/ha.a] | *value* | x | *value* | ÷ Y = | | *calculation* | 7 |
| **Totals** | | | | | | | Total Emissions ($kgCO_{2e}$/t OSR) | |
| Module total | | | | | 1 + 2 + 3 + 4 + 5 + 6 + 7 = | | *calculation* | 8 |
| | | | | | | | Total Emissions [$kgCO_{2e}$/t biodiesel] | |
| Contribution to fuel chain | | | | | 8 + z1 + z2 x AF = | | *calculation* | Stage_1 |

## Stage 2 - Drying and storage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Description | Drying and storage of oilseed rape | | | | | | |
| **Basic Data** | | | | | | | |
| Moisture removed | % by weight | value | | | | | |
| | | | | Emissions factor [kgCO2e/MJ] | | Emissions ($kgCO_{2e}$/t OSR) | |
| **Drying and storage inputs** | | | | | | | |
| Fuel for heating | [MJ/t OSR] | value | x | value | = | calculation | 9 |
| Electricity | [MJ/t OSR] | value | x | value | = | calculation | 10 |
| | | | | | | Emissions ($kgCO_{2e}$/t OSR) | |
| **Totals** | | | | | | | |
| Module total | | | | | 9 + 10 = | calculation | 11 |
| | | | | | | Total Emissions [$kgCO_{2e}$/t biodiesel] | |
| Contribution to fuel chain | | | | | 11 + z1 + z2 x AF = | calculation | Stage_2 |

## Stage 3 - Feedstock Transport

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Description | From farm to oilseed crusher | | | | | | |
| | | | | Emissions factor [kgCO2e/MJ] | | | |
| Transport distance | [km] | value | dist_1 | | | | |
| Fuel consumption | [MJ/t-km] | value | FC_1 | | | | |
| | | | | | | Emissions ($kgCO_{2e}$/t OSR) | |
| **Totals** | | | | | | | |
| Module total | [MJ/t OSR] | value | x | value | = | calculation | 12 |
| | | | | | | Total Emissions [$kgCO_{2e}$/t biodiesel] | |
| Contribution to fuel chain | | | | | 12 + z1 + z2 x AF = | calculation | Stage_3 |

## Stage 4 - Feedstock Transport

| Description | From farm to oilseed crusher | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Emissions factor [kgCO2e/MJ] | | | |
| Transport distance | [km] | value | dist_2 | | | | | |
| Fuel consumption | [MJ/t-km] | value | FC_2 | | | | | |
| **Totals** | | | | | | | Emissions ($kgCO_{2e}$/t OSR) | |
| Module total | [MJ/t OSR] | value | x | | value | = | calculation | 13 |
| | | | | | | | Total Emissions [$kgCO_{2e}$/t biodiesel] | |
| Contribution to fuel chain | | | | 13 ÷ z1 ÷ z2 x AF | | = | calculation | Stage_4 |

## Stage 5 - Conversion

| Description | Oil extraction | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Basic Data** | | | | | | | | |
| Plant yield | [t rapeseed oil / t oilseed rape] | value | z1 | | | | | |
| **Conversion Inputs** | | | | | | | | |
| | | | | | Emissions factor [kgCO2e/MJ] | | Emissions ($kgCO_{2e}$/t biodiesel) | |
| Natural gas | [MJ/t rapeseed oil] | value | x | | value | = | calculation | 14 |
| Electricity imported | [MJ/t rapeseed oil] | value | x | | value | = | calculation | 15 |
| **Co-products** | **Description** | **Treatment** | | | | | | |
| Co-product 1: | Rape meal - sold as animal feed | Substitution | | | | | | |
| **Co-products treated by substitution** | | | | | | | | |
| **Co-product 1: rape meal** | | | | | | | | |
| *- substitutes US soy meal (soybeans crushed in EU)* | | | | | Credit [$kgCO_{2e}$/t rape meal] | | | |
| Quantity of rape meal produced & sold as animal feed | [t rape meal / t rapeseed oil] | value | x | | value | = | calculation | 16 |
| **Totals** | | | | | | | | |
| Module total | | | | 14 + 15 + 16 | | = | calculation | 17 |
| | | | | | | | Total Emissions [$kgCO_{2e}$/t biodiesel] | |
| Contribution to fuel chain | | | | 17 ÷ z2 x AF | | = | calculation | Stage_5 |

## Stage 6 - Feedstock Transport

| Description | From extraction facility to biodiesel plant | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Emissions factor [kgCO2e/MJ] | | | |
| Transport distance | [km] | value | dist_3 | | | | | |
| Fuel consumption | [MJ/t-km] | value | FC_3 | | | | | |
| **Totals** | | | | | | | Emissions ($kgCO_{2e}$/t rapeseed oil) | |
| Module total | [MJ / t rapeseed oil] | value | x | value | - | | calculation | 18 |
| Contribution to fuel chain | | | | | 18 ÷ z2 x AF = | | calculation | Stage_6 |

## Stage 7 - Conversion

| Description | Biodiesel plant | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Basic data** | | | | | | | | |
| Plant yield | [t biodiesel / t rapeseed oil] | value | (z2) | | | | | |
| | | | | | Emissions factor [kgCO2e/MJ] | | Emissions ($kgCO_{2e}$/t biodiesel) | |
| **Conversion inputs** | | | | | | | | |
| Natural gas | [MJ/t biodiesel] | value | x | value | - | | calculation | 19 |
| Electricity imported | [MJ/t biodiesel] | value | x | value | - | | calculation | 20 |
| | | | | | Emissions factor (kgCO2e/kg) | | | |
| Methanol | kg/t biodiesel | value | x | value | - | | calculation | 21 |
| Potassium hydroxide | kg/t biodiesel | value | x | value | - | | calculation | 22 |

| **Co-products** | **Description** | **Treatment** |
|---|---|---|
| Co-product 1: | Crude glycerine sold as chemical | Allocation - by market value |
| Co-product 2: | Potassium sulphate | Allocation - by market value |

**Co-products treated by allocation by market value**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Co-product 1: Glycerine** | | | | Market value [£ / t glycerine] | | | | |
| Quantity of crude glycerine produced | [t glycerine / t biodiesel] | value | x | value | - | calculation | | 23 |
| **Co-product 2: Potassium sulphate** | | | | Market value [£ / t potassium sulphate] | | | | |
| Quantity of potassium sulphate produced and sold as chemical | [t potassium suplhate / t biodiesel] | value | | value | - | calculation | | 24 |
| **Primary product: biodiesel** | | | | Market value [£ / t biodiesel] | | | | |
| Market value of biodiesel | | | | value | - | calculation | | 25 |
| **Total market value of products** | | | | | | | | |
| Total market value | [£ / t biodiesel] | | | | | calculation | | 26 |
| Allocation factor (%age of emissions attributable to biodiesel) | % | | | | | calculation | | AF |
| **Totals** | | | | | | Total Emissions [$kgCO_{2e}$/t biodiesel] | | |
| Module total | | | | | (19 + 20 + 21 + 22) x AF - | calculation | | 27 |
| Contribution to fuel chain | | | | | 27 - | calculation | | Stage_7 |

## Stage 8 - Liquid fuel transport and storage

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | From biodiesel plant to refinery / blending facility | | | | | | | |
| Transport distance | [km] | value | dist_4 | | | | | |
| Fuel consumption | [MJ/t-km] | value | FC_4 | | | | | |
| **Totals** | | | | Emissions factor [kgCO2e/MJ] | | Total Emissions [$kgCO_{2e}$/t biodiesel] | | |
| Module total | [MJ/t biodiesel] | value | x | value | - | calculation | | 28 |
| Contribution to fuel chain | | | | | 28 - | calculation | | Stage_8 |

**Default value tables**

| Stage/Input | Units | Feedstock country of origin | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Australia** | **Canada** | **Finland** | **France** | **Germany** | **Poland** | **Ukraine** | **United Kingdom** |
| **Stage 1 – Crop production** | | | | | | | | | |
| Yield @ traded moisture content | [t/ha.a] | 1.19 | 1.46 | 1.30 | 3.18 | 3.44 | 2.38 | 1.12 | 3.03 |
| Traded moisture content | % | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| N fertiliser | [kg N /ha.a] | 61 | 75 | 67 | 155 | 170 | 102 | 60 | 185 |
| Type of N fertiliser | | AN | AN | AN | AN | AN | AN | AN | AN |
| P fertiliser | [kg $P_2O_5$/ha.a] | 16 | 20 | 18 | 45 | 45 | 35 | 15 | 45 |
| Type of P fertiliser | | TSP | TSP | TSP | TSP | TSP | TSP | TSP | TSP |
| K fertiliser | [kg $K_2O$/ha.a] | 12 | 15 | 13 | 80 | 90 | 44 | 12 | 48 |

| Stage/Input | Units | Feedstock country of origin | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Australia** | **Canada** | **Finland** | **France** | **Germany** | **Poland** | **Ukraine** | **United Kingdom** |
| Lime | [kg CaO/ha.a] | 18.9 | 18.9 | 18.9 | 18.9 | 18.9 | 18.9 | 18.9 | 18.9 |
| Pesticides | [kg/ha.a] | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 |
| Diesel fuel consumption | [litres/ha.a] | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 |
| **Stage 2 – Drying and storage** | | | | | | | | | |
| Moisture removed | % by weight | 0 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Fuel for heating | [MJ/t OSR] | 0 | 318 | 318 | 318 | 318 | 318 | 318 | 318 |
| Electricity | [MJ/t OSR] | 0 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| **Stage 3 – Feedstock Transport** | | | | | | | | | |
| Transport distance | [km] | 300 | 3000 | 100 | 300 | 300 | 300 | 1700 | 100 |
| Fuel consumption | [MJ/t-km] | 0.38 | 0.19 | 1.53 | 1.53 | 1.53 | 1.5 | 0 | 1.53 |

| **Stage/Input** | **Units** | **Feedstock country of origin** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Australia** | **Canada** | **Finland** | **France** | **Germany** | **Poland** | **Ukraine** | **United Kingdom** |
| | | | | | | | 3 | | |
| Fuel type | | Diesel | Diesel | Diesel | Diesel | Diesel | Diesel | Diesel | Diesel |
| **Stage 4 – Feedstock Transport** | | | | | | | | | |
| Transport distance | [km] | 18000 | 0 | 0 | 0 | 0 | 0 | 2300 | 0 |
| Fuel consumption | [MJ/t-km] | 0.2 | N/A | N/A | N/A | N/A | N/A | 0.2 | N/A |
| Fuel type | | HFO | N/A | N/A | N/A | N/A | N/A | HFO | N/A |
| **Stage 5 – Conversion** | | | | | | | | | |
| Plant yield | [t rapeseed oil/t oilseed rape] | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 |
| Natural gas | [MJ/t rapeseed oil] | 1986 | 1986 | 1986 | 1986 | 1986 | 1986 | 1986 | 1986 |

| **Stage/Input** | **Units** | **Feedstock country of origin** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Australia** | **Canada** | **Finland** | **France** | **Germany** | **Poland** | **Ukraine** | **United Kingdom** |
| Electricity imported | [MJ/t rapeseed oil] | 337 | 337 | 337 | 337 | 337 | 337 | 337 | 337 |
| Co-product 1: Rape meal – sold as animal feed | | Substitutes US soy meal (soybeans crushed in EU) | | | | | | | |
| Quantity of rape meal | [t rape meal/t rapeseed oil] | 1.32 | 1.32 | 1.32 | 1.32 | 1.32 | 1.32 | 1.32 | 1.32 |
| Credit for co-product 1 | [$kgCO_2e$/t rape meal] | -504 | -504 | -504 | -504 | -504 | -504 | -504 | -504 |
| **Stage 6 – Feedstock Transport** | | | | | | | | | |
| Transport distance | [km] | 500 | 5200 | 0 | 450 | 650 | 1500 | 0 | 0 |
| Fuel consumption | [MJ/t-km] | 0.2 | 0.2 | 0 | 0.2 | 0.2 | 0.2 | 0 | 0 |
| **Stage 7 – Conversion** | | | | | | | | | |

| **Stage/Input** | **Units** | **Feedstock country of origin** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Australia** | **Canada** | **Finland** | **France** | **Germany** | **Poland** | **Ukraine** | **United Kingdom** |
| Plant yield | [t biodiesel/t rapeseed oil] | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |
| Natural gas | [MJ/t biodiesel] | 1690 | 1690 | 1690 | 1690 | 1690 | 1690 | 1690 | 1690 |
| Electricity imported | [MJ/t biodiesel] | 335 | 335 | 335 | 335 | 335 | 335 | 335 | 335 |
| Methanol | kg/t biodiesel | 113 | 113 | 113 | 113 | 113 | 113 | 113 | 113 |
| Potassium hydroxide | kg/t biodiesel | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 |
| Co-products | | | | | | | | | |
| Co-product 1 | Crude glycerine | Allocation – by market value | | | | | | | |
| Quantity of crude glycerine | [t glycerine/t biodiesel] | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |

| **Stage/Input** | **Units** | **Feedstock country of origin** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Australia** | **Canada** | **Finland** | **France** | **Germany** | **Poland** | **Ukraine** | **United Kingdom** |
| Market value of glycerine | [£/t glycerine] | 345 | 345 | 345 | 345 | 345 | 345 | 345 | 345 |
| Co-product 2: | Potassium sulphate | Allocation – by market value | | | | | | | |
| Quantity of potassium sulphate | [t potassium sulphate/t biodiesel] | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 |
| Market value of potassium sulphate | [£/t potassium sulphate] | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 |
| Primary product: biodiesel | | | | | | | | | |
| Market value of biodiesel | [£/t biodiesel] | 340 | 340 | 340 | 340 | 340 | 340 | 340 | 340 |
| Allocation factor | % | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 |
| **Stage 8 – Liquid fuel transport and storage** | | | | | | | | | |

| Stage/Input | Units | Feedstock country of origin | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Australia | Canada | Finland | France | Germany | Poland | Ukraine | United Kingdom |
| Transport distance | [km] | 0 | 0 | 2000 | 0 | 0 | 0 | 0 | 0 |
| Fuel consumption | [MJ/t-km] | 0 | 0 | 0.2 | 0 | 0 | 0 | 0 | 0 |
| Fuel Type | | N/A | N/A | HFO | N/A | N/A | N/A | N/A | N/A |

# Soy to ME biodiesel

**Fuel chain summary**

| | Carbon intensity [kg CO2/t biodiesel] | | |
|---|---|---|---|
| | **Argentina** | **Brazil** | **USA** |
| 1 – Crop production | 1827 | 2062 | 2393 |
| 2 – Drying and storage | 73 | 68 | 61 |
| 3 – Feedstock transport | 286 | 1301 | 70 |
| 4 – Conversion (crushing) | -1101 | -1177 | -984 |
| 5 – Feedstock transport | 0 | 0 | 24 |
| 6 – Feedstock transport | 215 | 166 | 116 |
| 7 – Conversion (esterification) | 471 | 471 | 471 |
| 8 – Liquid fuel transport | 0 | 0 | 0 |
| **TOTAL** | 1771 | 2891 | 2151 |

**Selected default options**

| Stage | Module | Input | Options |
|---|---|---|---|
| 1 | Crop production | Nitrogen fertiliser emissions factor | Ammonium nitrate (AN), Ammonium sulphate (AS),Urea, Calcium nitrate (CN), Urea ammonium nitrate liquid (UAN), NPK (Urea / TSP / MOP) |

| Stage | Module | Input | Options |
|---|---|---|---|
| 1 | Crop production | Phosphorus fertiliser emissions factor | Triple superphosphate (TSP), Rock phosphate, Mono ammonium phosphate (MAP) |
| 2 | Drying and storage | Fuel emissions factor | Diesel,<br>Heavy fuel oil,<br>Coal,<br>Natural gas |
| 3 | Feedstock transport | Transport mode fuel efficiency | Truck (by geographic region),<br>Rail (by geographic region),<br>Shipping |
| 4 | Conversion (crushing) | Fuel emissions factor | Coal,<br>Natural gas,<br>Heavy fuel oil,<br>Biomass |
| 5 | Feedstock transport | Transport mode fuel efficiency | Truck (by geographic region),<br>Rail (by geographic region),<br>Shipping |
| 6 | Feedstock transport | Transport mode fuel efficiency | Truck (by geographic region),<br>Rail (by geographic region),<br>Shipping |
| 6 | Conversion (esterification) | Fuel emissions factor | Coal,<br>Natural gas,<br>Heavy fuel oil,<br>Biomass |
| 7 | Liquid fuel transport | Transport mode fuel efficiency | Truck (by geographic region), Rail (by geographic region), Shipping |

**Default fuel chain**

## Stage 1 - Crop Production

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Description | Cultivation and harvesting of soy | | | | | | |
| **Basic Data** | | | | | | | |
| | Units | | | | | | |
| Yield @ traded moisture content | [t/ha.a] | *value* | Y | | | | |
| Moisture content | % | *value* | MC | | | | |
| **Soil Emissions** | | | | | | | |
| | | | | Emissions factor ($kgCO_{2e}$/ha) | | Total Emissions (kgCO2e/t soy) | |
| N2O from nitrogen fertiliser | [total kg N/ha.a] | *N_FERT* | x | *6.163* | ÷ Y = | *calculation* | 1 |
| N2O from crop residue | | | | Y x (1 - MC / 100) x 157.3 + 141.9 | ÷ Y = | *calculation* | 2 |
| **Farming Inputs** | | | | | | | |
| | | | | Emissions co-efficient ($kgCO_{2e}$/kg) | | Total Emissions (kgCO2e/t soy) | |
| N fertiliser | [kg nutrient/ha.a] | *value (N_FERT)* | x | *value* | ÷ Y = | *calculation* | 3 |
| P fertiliser (P2O5) | [kg nutrient/ha.a] | *value* | x | *value* | ÷ Y = | *calculation* | 4 |
| K fertiliser (K2O) | [kg nutrient/ha.a] | *value* | x | *value* | ÷ Y = | *calculation* | 5 |
| | | | | Emissions co-efficient ($kgCO_{2e}$/kg nutrient) | | | |
| Pesticides | [kg nutrient/ha.a] | *value* | x | *value* | ÷ Y = | *calculation* | 6 |
| Electricity | [kWh/ha.a] | *value* | x | *value* | ÷ Y = | *calculation* | 7 |
| **Machinery Inputs** | | | | | | | |
| Diesel fuel consumption | [litres/ha.a] | *value* | x | *value* | ÷ Y = | *calculation* | 8 |
| **Totals** | | | | | | Emissions (kgCO2e/t soy) | |
| Module total | | | | | 1 + 2 + 3 + 4 + 5 + 6 + 7 + 8 = | *calculation* | 9 |
| | | | | | | Total Emissions ($kgCO_{2e}$/t biodiesel] | |
| Contribution to fuel chain | | | | | 9 ÷ z1 ÷ z2 x AF = | *calculation* | Stage_1 |

## Stage 2 - Drying and storage

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Description | Drying of soy | | | | | | |
| **Basic Data** | | | | | | | |
| Moisture removed | % | value | | | | | |
| | | | | Emissions factor [kgCO2e/MJ] | | | |
| **Drying and storage inputs** | | | | | | | |
| Diesel | [MJ/t soy] | value | x | value | = | calculation | 10 |
| Electricity | [MJ/t soy] | value | x | value | = | calculation | 11 |
| | | | | | | Emissions (kgCO2e/t soy) | |
| **Totals** | | | | | | | |
| Module total | | | | | 10 + 11 = | calculation | 12 |
| | | | | | | Total Emissions [$kgCO_{2e}$/t biodiesel] | |
| Contribution to fuel chain | | | | | 12 ÷ z1 ÷ z2 × AF = | calculation | Stage_2 |

## Stage 3 - Feedstock Transport

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Description | From drying and storage facility to oil extraction plant | | | | | | |
| | | | | Emissions factor [kgCO2e/MJ] | | | |
| Transport distance | [km] | value | dist_1 | | | | |
| Fuel consumption | [MJ/t-km] | value | FC_1 | | | | |
| | | | | | | Emissions (kgCO2e/t soy) | |
| **Totals** | | | | | | | |
| Module total | [MJ/t] | value | x | value | = | calculation | 13 |
| | | | | | | Total Emissions [$kgCO_{2e}$/t biodiesel] | |
| Contribution to fuel chain | | | | | 13 ÷ z1 ÷ z2 × AF = | calculation | Stage_3 |

## Stage 4 - Conversion

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Description | Oil extraction | | | | | | |
| **Basic Data** | | | | | | | |
| Plant yield | [t soy oil / t soy] | value | z1 | | | | |
| | | | | Emissions factor [kgCO2e/MJ] | | Emissions ($kgCO_{2e}$/t biodiesel) | |
| **Conversion Inputs** | | | | | | | |
| Natural gas | [MJ/t soy oil] | value | x | value | = | calculation | 14 |
| Electricity imported | [MJ/t soy oil] | value | x | value | = | calculation | 15 |
| **Co-products** | **Description** | **Treatment** | | | | | |
| Co-product 1: | Soy meal - sold as animal feed | Substitution | | | | | |
| **Co-products treated by substitution** | | | | | | | |
| **Co-product 1: soy meal** | | | | | | | |
| *- substitutes EU wheat* | | | | Credit [$kgCO_{2e}$/t soy meal] | | | |
| Quantity of soy meal produced & sold as animal feed | [t soy meal / t soy oil] | value | x | value | = | calculation | 16 |
| **Totals** | | | | | | | |
| Module total | | | | | 14 + 15 + 16 = | calculation | 17 |
| | | | | | | Total Emissions [$kgCO_{2e}$/t biodiesel] | |
| Contribution to fuel chain | | | | | 17 ÷ z2 × AF = | calculation | Stage_4 |

## Stage 5 - Feedstock Transport

| Description | From crusher to port (Mode 1) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Emissions factor [kgCO2e/MJ] | | | |
| Transport distance | [km] | value | dist_2 | | | | | |
| Fuel consumption | [MJ/t-km] | value | FC_2 | | | | | |
| **Totals** | | | | | | | Emissions (kgCO2e/t soy oil) | |
| Module total | [MJ/t soy oil] | value | | x | value | = | calculation | 18 |
| | | | | | | | Total Emissions [$kgCO_{2e}$/t biodiesel] | |
| Contribution to fuel chain | | | | | | 18 ÷ z2 x AF = | calculation | Stage_5 |

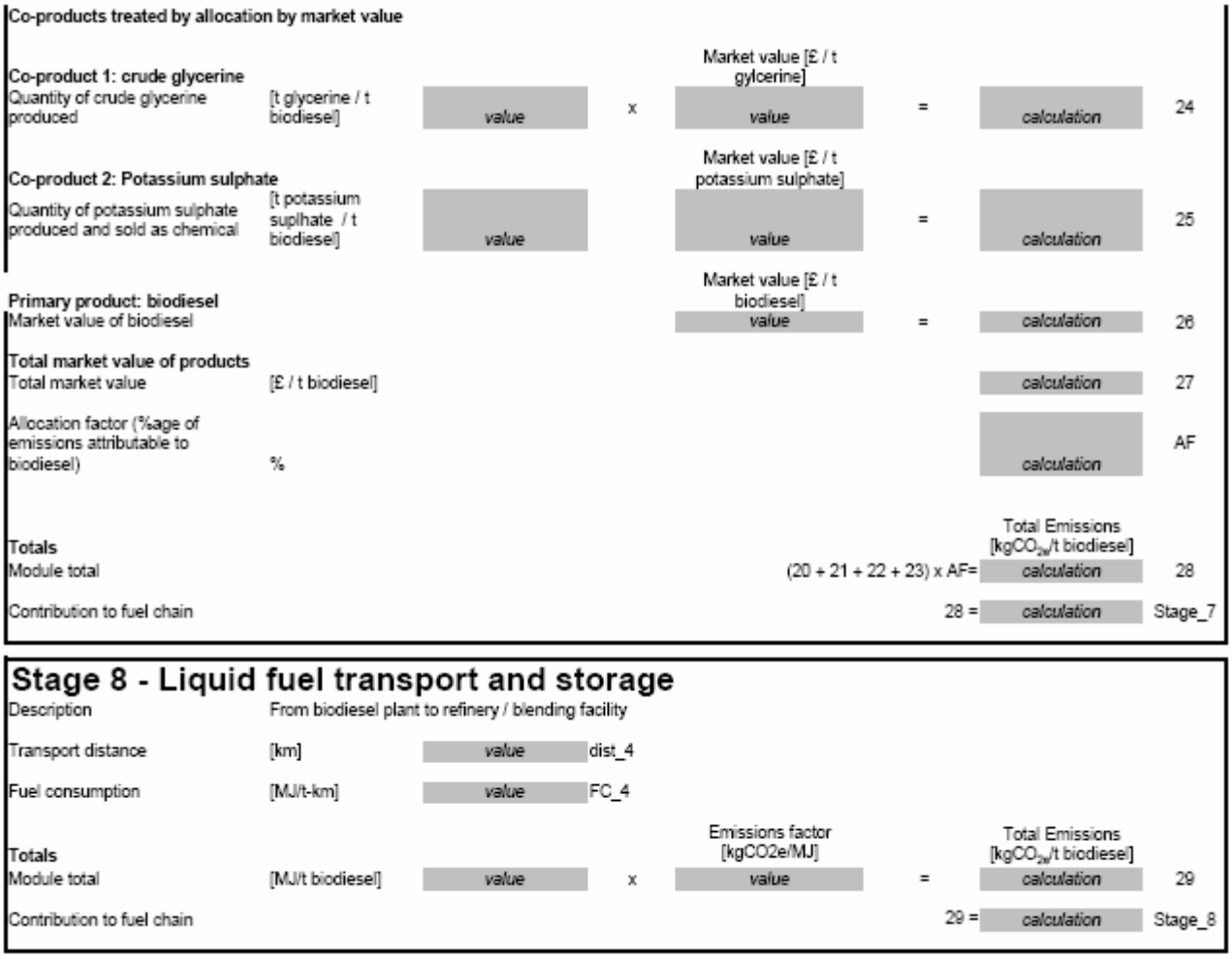
## Stage 6 - Feedstock Transport

| Description | From port to biodiesel plant (Mode 2) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Emissions factor [kgCO2e/MJ] | | | |
| Transport distance | [km] | value | dist_3 | | | | | |
| Fuel consumption | [MJ/t-km] | value | FC_3 | | | | | |
| **Totals** | | | | | | | Emissions (kgCO2e/t soy oil) | |
| Module total | [MJ/t soy oil] | value | | x | value | = | calculation | 19 |
| | | | | | | | Total Emissions [$kgCO_{2e}$/t biodiesel] | |
| Contribution to fuel chain | | | | | | 19 ÷ z2 x AF = | calculation | Stage_6 |

## Stage 7 - Conversion

| Description | Biodiesel plant | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Basic data** | | | | | | | | |
| Plant yield | [t biodiesel / t soy oil] | value | (z2) | | | | | |
| **Conversion Inputs** | | | | | Emissions factor [kgCO2e/MJ] | | Emissions ($kgCO_{2e}$/t biodiesel) | |
| Natural gas | [MJ/t biodiesel] | value | | x | value | = | calculation | 20 |
| Electricity imported | [MJ/t biodiesel] | value | | x | value | = | calculation | 21 |
| | | | | | Emissions factor (kgCO2e/kg) | | | |
| Methanol | kg/t biodiesel | value | | x | value | = | calculation | 22 |
| Potassium hydroxide | kg/t biodiesel | value | | x | value | = | calculation | 23 |

| **Co-products** | **Description** | **Treatment** |
|---|---|---|
| Co-product 1: | Crude glycerine sold as chemical | Allocation - by market value |
| Co-product 2: | Potassium sulphate | Allocation - by market value |



| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Co-products treated by allocation by market value** | | | | | | | |
| **Co-product 1: crude glycerine** | | | | Market value [£ / t gylcerine] | | | |
| Quantity of crude glycerine produced | [t glycerine / t biodiesel] | value | x | value | = | calculation | 24 |
| **Co-product 2: Potassium sulphate** | | | | Market value [£ / t potassium sulphate] | | | |
| Quantity of potassium sulphate produced and sold as chemical | [t potassium suplhate / t biodiesel] | value | | value | = | calculation | 25 |
| **Primary product: biodiesel** | | | | Market value [£ / t biodiesel] | | | |
| Market value of biodiesel | | | | value | = | calculation | 26 |
| **Total market value of products** | | | | | | | |
| Total market value | [£ / t biodiesel] | | | | | calculation | 27 |
| Allocation factor (%age of emissions attributable to biodiesel) | % | | | | | calculation | AF |
| **Totals** | | | | | | Total Emissions [$kgCO_{2e}$/t biodiesel] | |
| Module total | | | | | (20 + 21 + 22 + 23) x AF= | calculation | 28 |
| Contribution to fuel chain | | | | | 28 = | calculation | Stage_7 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Stage 8 - Liquid fuel transport and storage** | | | | | | | |
| Description | From biodiesel plant to refinery / blending facility | | | | | | |
| Transport distance | [km] | value | dist_4 | | | | |
| Fuel consumption | [MJ/t-km] | value | FC_4 | | | | |
| **Totals** | | | | Emissions factor [kgCO2e/MJ] | | Total Emissions [$kgCO_{2e}$/t biodiesel] | |
| Module total | [MJ/t biodiesel] | value | x | value | = | calculation | 29 |
| Contribution to fuel chain | | | | | 29 = | calculation | Stage_8 |

**Default value tables**

| **Stage/Input** | **Units** | **Feedstock country of origin** | | |
|---|---|---|---|---|
| | | **Argentina** | **Brazil** | **USA** |
| **Stage 1 – Crop Production** | | | | |
| Yield @ traded moisture content | [t/ha.a] | 2.54 | 2.54 | 2.60 |
| Moisture content | % | 13 | 13 | 13 |
| N fertiliser | [kg N/ha.a] | 10 | 10 | 24 |

| **Stage/Input** | **Units** | **Feedstock country of origin** | | |
|---|---|---|---|---|
| | | **Argentina** | **Brazil** | **USA** |
| Type of N fertiliser | | Urea | Urea | AN |
| P fertiliser | [kg $P_2O_5$/ha.a] | 5 | 50 | 100 |
| Type of P fertiliser | | MAP | MAP | TSP |
| K fertiliser | [kg $K_2O$/ha.a] | 3 | 60 | 55 |
| Pesticides | [kg/ha.a] | 1.31 | 1.31 | 1.31 |
| Electricity | [kWh/ha.a] | 11.00 | 11.00 | 11.00 |
| Diesel fuel consumption | [litres/ha.a] | 75.6 | 75.6 | 75.6 |
| **Stage 2 – Drying and storage** | | | | |
| Moisture removed | % | 2 | 2 | 2 |
| Fuel for heating | [MJ/t soy] | 138 | 138 | 138 |
| Fuel type | | Diesel | Diesel | Natural gas |
| Electricity | [MJ/t soy] | 15 | 15 | 15 |
| **Stage 3 – Feedstock Transport** | | | | |
| Transport distance | [km] | 330 | 15 | 100 |

| **Stage/Input** | **Units** | **Feedstock country of origin** | | |
|---|---|---|---|---|
| | | **Argentina** | **Brazil** | **USA** |
| | | | 00 | |
| Fuel consumption | [MJ/t-km] | 1.8 | 1.8 | 1.46 |
| Fuel type | | Diesel | Diesel | Diesel |
| **Stage 4 – Conversion** | | | | |
| Yield | [t soy oil/t soy] | 0.17 | 0.17 | 0.17 |
| Natural gas | [MJ/t soy oil] | 5447 | 5447 | 5447 |
| Electricity imported | [MJ/t soy oil] | 1476 | 1476 | 1476 |
| Co-products | Description | Treatment | | |
| Co-product 1: | Soymeal sold as animal feed | Substitutes for EU wheat | | |
| Quantity of soy meal produced & sold as animal feed | [t soy meal/t soy oil] | 4.32 | 4.32 | 4.32 |
| Credit | [kg$CO_2$e/t soy meal] | -373 | -373 | -373 |
| **Stage 5 – Feedstock Transport** | | | | |
| Transport distance | [km] | 0 | 0 | 1500 |
| Fuel consumption | [MJ/t-km] | 0 | 0 | 0.19 |

| **Stage/Input** | **Units** | **Feedstock country of origin** | | |
|---|---|---|---|---|
| | | **Argentina** | **Brazil** | **USA** |
| Fuel type | | None | None | Diesel |
| **Stage 6 – Feedstock Transport** | | | | |
| Transport distance | [km] | 13000 | 10000 | 7000 |
| Fuel consumption | [MJ/t-km] | 0.2 | 0.2 | 0.2 |
| Fuel type | | HFO | HFO | HFO |
| **Stage 7 – Conversion** | | | | |
| Yield | [t biodiesel / t soy oil] | 0.95 | 0.95 | 0.95 |
| Natural gas | [MJ/t biodiesel] | 1690 | 1690 | 1690 |
| Electricity imported | [MJ/t biodiesel] | 335 | 335 | 335 |
| Methanol | kg/t biodiesel | 113 | 113 | 113 |
| Potassium hydroxide | kg/t biodiesel | 26 | 26 | 26 |
| Co-products | | | | |
| Co-product 1 | Crude glycerine | Allocation by market value | | |
| Quantity of crude glycerine | [t glycerine/t | 0.1 | 0.1 | 0.1 |

| **Stage/Input** | **Units** | **Feedstock country of origin** | | |
|---|---|---|---|---|
| | | **Argentina** | **Brazil** | **USA** |
| | biodiesel] | | | |
| Market value of glycerine | [£/t glycerine] | 345 | 345 | 345 |
| Co-product 2: | Potassium sulphate | Allocation by market value | | |
| Quantity of potassium sulphate | [t potassium sulphate/t biodiesel] | 0.04 | 0.04 | 0.04 |
| Market value of potassium sulphate | [£/t potassium sulphate] | 75 | 75 | 75 |
| Primary product: biodiesel | | | | |
| Market value of biodiesel | [£/t biodiesel] | 340 | 340 | 340 |
| Allocation factor | % | 90 | 90 | 90 |
| **Stage 8 – Liquid fuel transport and storage** | | | | |
| Transport distance | [km] | 0 | 0 | 0 |
| Fuel consumption | [MJ/t-km] | 0 | 0 | 0 |

# Palm to ME biodiesel

**Fuel chain summary**

| | Carbon intensity [kg CO2/t biodiesel] | |
|---|---|---|
| | **Indonesia** | **Malaysia** |
| 1 – Crop Production | 240 | 276 |
| 2 – Feedstock transport | 11 | 11 |
| 3 – Conversion (palm oil extraction) | 520 | 520 |
| 4 – Feedstock transport | 63 | 39 |
| 5 – Conversion (palm oil refining) | 117 | 109 |
| 6 – Feedstock transport | 248 | 248 |
| 7 – Conversion (esterification) | 471 | 471 |
| 8 – Liquid fuel transport | 0 | 0 |
| **TOTAL** | 1670 | 1674 |

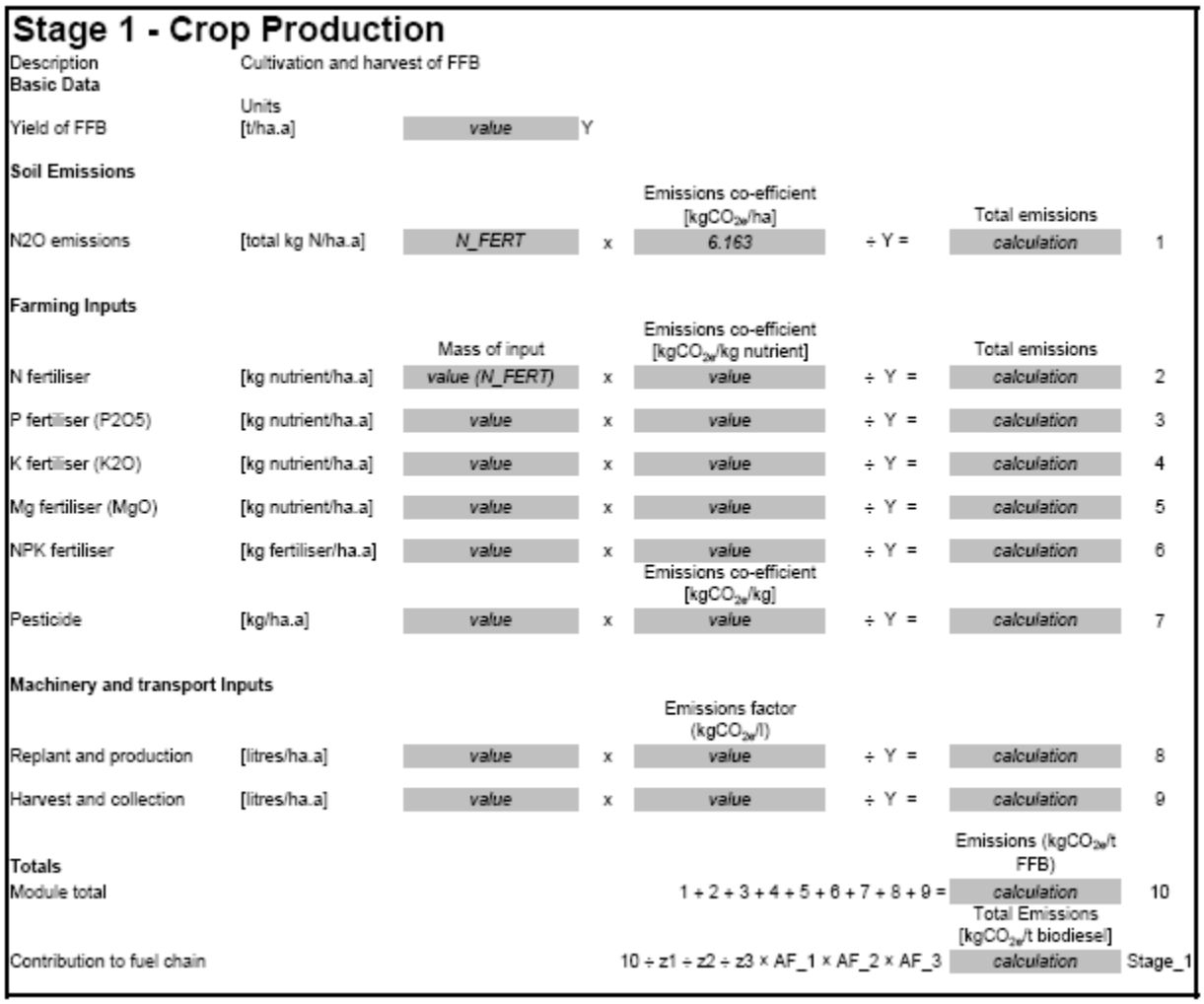
**Selected default options**

| **Stage** | **Module** | **Input** | **Options** |
|---|---|---|---|
| 1 | Crop production | Nitrogen fertiliser emissions factor | Ammonium nitrate (AN), Ammonium sulphate (AS),Urea, |

| Stage | Module | Input | Options |
|---|---|---|---|
| | | | Calcium nitrate (CN), Urea ammonium nitrate liquid (UAN), NPK (Urea / TSP / MOP) |
| 1 | Crop production | Phosphorus fertiliser emissions factor | Triple superphosphate (TSP), Rock phosphate, Mono ammonium phosphate (MAP) |
| 2 | Feedstock transport | Transport mode fuel efficiency | Truck (by geographic region), Rail (by geographic region), Shipping |
| 4 | Feedstock transport | Transport mode fuel efficiency | Truck (by geographic region), Rail (by geographic region), Shipping |
| 5 | Conversion (palm oil refining) | Fuel emissions factor | Coal, Natural gas, Heavy fuel oil, Biomass |
| 6 | Feedstock transport | Transport mode fuel efficiency | Truck (by geographic region), Rail (by geographic region), Shipping |
| 7 | Conversion (esterification) | Fuel emissions factor | Coal, Natural gas, Heavy fuel oil, Biomass |
| 8 | Liquid fuel transport | Transport mode fuel efficiency | Truck (by geographic region), Rail (by geographic |

| Stage | Module | Input | Options |
|---|---|---|---|
| | | | region),<br>Shipping |

**Default fuel chain**



## Stage 1 - Crop Production

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | Cultivation and harvest of FFB | | | | | | | |
| **Basic Data** | | | | | | | | |
| | Units | | | | | | | |
| Yield of FFB | [t/ha.a] | *value* | Y | | | | | |
| **Soil Emissions** | | | | | | | | |
| | | | | Emissions co-efficient [$kgCO_{2e}$/ha] | | | Total emissions | |
| N2O emissions | [total kg N/ha.a] | *N_FERT* | x | *6.163* | | ÷ Y = | *calculation* | 1 |
| **Farming Inputs** | | | | | | | | |
| | | Mass of input | | Emissions co-efficient [$kgCO_{2e}$/kg nutrient] | | | Total emissions | |
| N fertiliser | [kg nutrient/ha.a] | *value (N_FERT)* | x | *value* | | ÷ Y = | *calculation* | 2 |
| P fertiliser (P2O5) | [kg nutrient/ha.a] | *value* | x | *value* | | ÷ Y = | *calculation* | 3 |
| K fertiliser (K2O) | [kg nutrient/ha.a] | *value* | x | *value* | | ÷ Y = | *calculation* | 4 |
| Mg fertiliser (MgO) | [kg nutrient/ha.a] | *value* | x | *value* | | ÷ Y = | *calculation* | 5 |
| NPK fertiliser | [kg fertiliser/ha.a] | *value* | x | *value* | | ÷ Y = | *calculation* | 6 |
| | | | | Emissions co-efficient [$kgCO_{2e}$/kg] | | | | |
| Pesticide | [kg/ha.a] | *value* | x | *value* | | ÷ Y = | *calculation* | 7 |
| **Machinery and transport Inputs** | | | | | | | | |
| | | | | Emissions factor ($kgCO_{2e}$/l) | | | | |
| Replant and production | [litres/ha.a] | *value* | x | *value* | | ÷ Y = | *calculation* | 8 |
| Harvest and collection | [litres/ha.a] | *value* | x | *value* | | ÷ Y = | *calculation* | 9 |
| **Totals** | | | | | | | Emissions ($kgCO_{2e}$/t FFB) | |
| Module total | | | | | 1 + 2 + 3 + 4 + 5 + 6 + 7 + 8 + 9 = | | *calculation* | 10 |
| | | | | | | | Total Emissions [$kgCO_{2e}$/t biodiesel] | |
| Contribution to fuel chain | | | | | 10 ÷ z1 ÷ z2 ÷ z3 × AF_1 × AF_2 × AF_3 | | *calculation* | Stage_1 |

## Stage 2 - Feedstock Transport

| Description | Transport of FFB from field to palm oil mill | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Emissions factor [kgCO2e/MJ] | | | | |
| Transport distance | [km] | *value* | dist_1 | | | | | |
| Fuel consumption | [MJ/t-km] | *value* | FC_1 | | | | | |
| **Totals** | | | | | | | Emissions ($kgCO_{2e}$/t FFB) | |
| Module total | [MJ/t FFB] | *value* | x | *value* | = | | *calculation* | 11 |
| | | | | | | | Total Emissions [$kgCO_{2e}$/t biodiesel] | |
| Contribution to fuel chain | | | | 11 ÷ z1 ÷ z2 ÷ z3 × AF_1 × AF_2 × AF_3 = | | | *calculation* | Stage_2 |

## Stage 3 - Conversion

| Description | Processing FFB to extract palm oil and palm kernels | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Basic Data** | | | | | | | | |
| Palm oil mill yield | [t CPO / t FFB] | *value* | z1 | | | | | |
| **Extraction Inputs** | | | | | | | Emissions ($kgCO_{2e}$/t CPO) | |
| Steam | [MJ/t CPO] | *value* | | | | | | |
| Electricity | [MJ/t CPO] | *value* | | | | | | |
| CHP plant efficiency | % | *value* | | | | | | |
| | | | | Emissions factor [kgCO2e/MJ] | | | | |
| Fibre & Shell, CHP plant | [MJ/t CPO] | *value* | x | *value* | = | | *calculation* | 12 |
| | | | | Emissions factor (kgCO2e/kg) | | | | |
| Mill effluent emissions (POME) | [kg/t CPO] | *value* | x | *value* | = | | *calculation* | 13 |

| **Co-products** | **Description** | **Treatment** |
|---|---|---|
| Co-product 1: | EFB | Considered within system boundaries |
| Co-product 2: | Fibre | Considered within system boundaries |
| Co-product 3: | Shell | Considered within system boundaries |
| Co-product 4: | POME | Considered within system boundaries |
| Co-product 5: | Palm kernel | Allocation by market value |

**Co-products treated by allocation by market value**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Co-product 5: Palm kernel** | | | | Market value [RM / t palm kernel] | | | | |
| Quantity of palm kernel produced | [t palm kernel / t CPO] | *value* | x | *value* | = | *calculation* | | 14 |
| **Primary product: crude palm oil** | | | | Market value [RM / t CPO] | | | | |
| Market value of crude palm oil | | | | *value* | = | *calculation* | | 15 |
| **Total market value of products** | | | | | | | | |
| Total market value | [RM / t CPO] | | | | | *calculation* | | 16 |
| Allocation factor (%age of emissions attributable to biodiesel) | % | | | | | *calculation* | | AF_1 |
| **Totals** | | | | | | Emissions ($kgCO_{2e}$/t CPO) | | |
| Module total | | | | | ( 12 + 13 ) x AF_1 = | *calculation* | | 17 |
| | | | | | | Total Emissions [$kgCO_{2e}$/t biodiesel] | | |
| Contribution to fuel chain | | | | | 17 ÷ z2 ÷ z3 × AF_2 × AF_3 = | *calculation* | | Stage_3 |

## Stage 4 - Feedstock Transport

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | Transport of CPO from palm oil mill to refinery | | | | | | | |
| | | | | Emissions factor [kgCO2e/MJ] | | | | |
| Transport distance | [km] | *value* | dist_2 | | | | | |
| Fuel consumption | [MJ/t-km] | *value* | FC_2 | | | | | |
| **Totals** | | | | | | Emissions ($kgCO_{2e}$/t CPO) | | |
| Module total | [MJ/t CPO] | *value* | x | *value* | = | *calculation* | | 18 |
| | | | | | | Total Emissions [$kgCO_{2e}$/t biodiesel] | | |
| Contribution to fuel chain | | | | | 18 ÷ z2 ÷ z3 × AF_2 × AF_3 = | *calculation* | | Stage_4 |

# Stage 5 - Conversion

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Description | Refining, bleaching and deodorising of CPO, and fractionation to produce palm olein | | | | | | |
| **Basic Data** | | | | | | | |
| Refinery yield | [t palm olein / t CPO] | *value* | z2 | | | | |
| **Conversion Inputs** | | | | | | | |
| | | | | Emissions factor [kgCO2e/MJ] | | Emissions ($kgCO_{2e}$/t palm olein) | |
| Natural gas | [MJ/t palm olein] | *value* | x | *value* | = | *calculation* | 19 |
| Electricity imported | [MJ/t palm olein] | *value* | x | *value* | = | *calculation* | 20 |
| **Co-products** | **Description** | **Treatment** | | | | | |
| Co-product 1: | Palm stearin | Allocation by market value | | | | | |
| Co-product 2: | Palm olein | Allocation by market value | | | | | |
| **Co-products treated by allocation by market value** | | | | | | | |
| | | | | Market value [US$ / t palm stearin] | | | |
| **Co-product 1: Palm stearin** | | | | | | | |
| Quantity of palm stearin produced | [t palm stearin / t palm olein] | *value* | x | *value* | = | *calculation* | 21 |
| | | | | Market value [US$ / t palm olein] | | | |
| **Primary product: palm olein** | | | | | | | |
| Market value of palm olein | | | | *value* | = | *calculation* | 22 |
| **Total market value of products** | | | | | | | |
| Total market value | [RM / t CPO] | | | | | *calculation* | 23 |
| Allocation factor (%age of emissions attributable to palm olein) | % | | | | | *calculation* | AF_2 |
| | | | | | | Emissions ($kgCO_{2e}$/t palm olein) | |
| **Totals** | | | | | | | |
| Module total | | | | | (19 + 20) x AF_2 = | *calculation* | 24 |
| | | | | | | Total Emissions [$kgCO_{2e}$/t biodiesel] | |
| Contribution to fuel chain | | | | | 24 ÷ z3 x AF_3 = | *calculation* | Stage_5 |

## Stage 6 - Transport of palm olein

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | Transport of palm olein from refinery to biodiesel plant | | | | | | | |
| | | | | Emissions factor [kgCO2e/MJ] | | | | |
| Transport distance | [km] | *value* | dist_3 | | | | | |
| Fuel consumption | [MJ/t-km] | *value* | FC_3 | | | | | |
| | | | | | | Emissions ($kgCO_{2e}$/t palm olein) | | |
| **Totals** | | | | | | | | |
| Module total | [MJ/t palm olein] | *value* | x | *value* | = | *calculation* | 25 | |
| | | | | | | Total Emissions [$kgCO_{2e}$/t biodiesel] | | |
| Contribution to fuel chain | | | | | 25 ÷ z3 × AF_3 = | *calculation* | Stage_6 | |

## Stage 7 - Conversion

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | Biodiesel plant | | | | | | | |
| **Basic data** | | | | | | | | |
| Biodiesel plant yield | [t biodiesel / t palm olein] | *value* | (z3) | | | | | |
| | | | | Emissions factor [kgCO2e/MJ] | | Emissions ($kgCO_{2e}$/t biodiesel) | | |
| **Conversion Inputs** | | | | | | | | |
| Natural gas | [MJ/t biodiesel] | *value* | x | *value* | = | *calculation* | 26 | |
| Electricity imported | [MJ/t biodiesel] | *value* | x | *value* | = | *calculation* | 27 | |
| | | | | Emissions factor (kgCO2e/kg) | | | | |
| Methanol | kg/t biodiesel | *value* | x | *value* | = | *calculation* | 28 | |
| Potassium hydroxide | kg/t biodiesel | *value* | x | *value* | = | *calculation* | 29 | |

| **Co-products** | **Description** | **Treatment** |
|---|---|---|
| Co-product 1: | Crude glycerine sold as chemical | Allocation - by market value |
| Co-product 2: | Potassium sulphate | Allocation - by market value |

**Co-products treated by allocation by market value**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Co-product 1: crude glycerine** | | | | Market value [£ / t gylcerine] | | | | |
| Quantity of crude glycerine produced | [t glycerine / t biodiesel] | *value* | x | *value* | = | *calculation* | 30 | |
| **Co-product 2: Potassium sulphate** | | | | Market value [£ / t potassium sulphate] | | | | |
| Quantity of potassium sulphate produced and sold as chemical | [t potassium suplhate / t biodiesel] | *value* | | *value* | = | *calculation* | 31 | |
| **Primary product: biodiesel** | | | | Market value [£ / t biodiesel] | | | | |
| Market value of biodiesel | | | | *value* | = | *calculation* | 32 | |
| **Total market value of products** | | | | | | | | |
| Total market value | [£ / t biodiesel] | | | | | *calculation* | 33 | |
| Allocation factor (%age of emissions attributable to biodiesel) | % | | | | | *calculation* | AF_3 | |
| **Totals** | | | | | | Total Emissions [$kgCO_{2e}$/t biodiesel] | | |
| Module total | | | | | (26 + 27 + 28 + 29) x AF_3 = | *calculation* | 34 | |
| Contribution to fuel chain | | | | | 34 = | *calculation* | Stage_7 | |

## Stage 8 - Liquid fuel transport and storage

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | Transport from biodiesel plant to refinery / blending facility | | | | | | | |
| Transport distance | [km] | *value* | dist_4 | | | | | |
| Fuel consumption | [MJ/t-km] | *value* | FC_4 | | | | | |
| **Totals** | | | | | | Total Emissions [$kgCO_{2e}$/t biodiesel] | | |
| Module total | [MJ/t biodiesel] | *value* | x | *value* | = | *calculation* | 35 | |
| Contribution to fuel chain | | | | | 35 = | *calculation* | Stage_8 | |

### Default value tables

| **Stage/Input** | **Units** | **Feedstock country of origin** | |
|---|---|---|---|
| | | **Malaysia** | **Indonesia** |
| **Stage 1 – Crop Production** | | | |
| Yield of FFB | [t/ha.a] | 19.0 | 17.7 |
| N fertiliser | [kg N/ha.a] | 100 | 95 |
| Type of N fertiliser | | SOA | Urea |
| P fertiliser | [kg $P_2O_5$/ha.a] | 45 | 30 |

| **Stage/Input** | **Units** | **Feedstock country of origin** | |
|---|---|---|---|
| | | **Malaysia** | **Indonesia** |
| Type of P fertiliser | | Rock | Rock |
| K fertiliser | [kg $K_2O$/ha.a] | 205 | 75 |
| Mg fertiliser (MgO) | [kg MgO /ha.a] | 33 | 33 |
| NPK fertiliser | [kg $P_2O_5$ /ha.a] | 50 | 50 |
| Pesticide | [kg/ha.a] | 3 | 3 |
| Replant and production | [litres/ha.a] | 30 | 30 |
| Harvest and collection | [litres/ha.a] | 30 | 0 |
| **Stage 2 – Feedstock Transport** | | | |
| Transport distance | [km] | 17 | 17 |
| Fuel consumption | [MJ/t-km] | 1.8 | 1.8 |
| Fuel type | | Diesel | Diesel |
| **Stage 3 – Conversion** | | | |
| Palm oil mill yield | [t CPO/t FFB] | 0.2 | 0.2 |
| Mill effluent emissions (POME) | [kg/t CPO] | 2500 | 2500 |
| POME emissions coefficient | [kg CO2e / kg] | 0.2472 | 0.2472 |
| Co-products | Description | Treatment | |
| Co-product 1 | Palm kernel | Allocation by market value | |

| **Stage/Input** | **Units** | **Feedstock country of origin** | |
|---|---|---|---|
| | | **Malaysia** | **Indonesia** |
| Quantity of palm kernel | [t palm kernel/t CPO] | 0.3 | 0.3 |
| Market value of palm kernel | [RM/t palm kernel] | 992 | 992 |
| Primary product: CPO | | | |
| Market value of CPO | [RM/t palm olein] | 1525 | 1524 |
| Allocation factor | % | 84 | 84 |
| **Stage 4 – Feedstock Transport** | | | |
| Transport distance | [km] | 250 | 400 |
| Fuel consumption | [MJ/t-km] | 1.8 | 1.8 |
| Fuel type | | Diesel | Diesel |
| **Stage 5 – Conversion** | | | |
| Refinery yield | [t palm olein/t CPO] | 0.8 | 0.8 |
| Heavy fuel oil | [MJ/t palm olein] | 1366 | 1366 |
| Electricity imported | [MJ/t palm olein] | 121 | 121 |
| Co-products | Description | Treatment | |
| Co-product 1 | Palm stearin | Allocation by market value | |
| Quantity of palm stearin | [t palm stearin/t | 0.2 | 0.2 |

| **Stage/Input** | **Units** | **Feedstock country of origin** | |
|---|---|---|---|
| | | **Malaysia** | **Indonesia** |
| | palm olein] | | |
| Market value of palm stearin | [USD/t palm stearin] | 389 | 389 |
| Primary product: palm olein | | | |
| Market value of palm olein | [USD/t palm olein] | 438 | 438 |
| Allocation factor | % | 85 | 85 |
| **Stage 6 – Feedstock Transport** | | | |
| Transport distance | [km] | 15000 | 15000 |
| Fuel consumption | [MJ/t-km] | 0.2 | 0.2 |
| Fuel type | | HFO | HFO |
| **Stage 7 – Conversion** | | | |
| Biodiesel Yield | [t biodiesel / t palm oil] | 0.95 | 0.95 |
| Natural gas | [MJ/t biodiesel] | 1690 | 1690 |
| Electricity imported | [MJ/t biodiesel] | 335 | 335 |
| Methanol | kg/t biodiesel | 113 | 113 |
| Potassium hydroxide | kg/t biodiesel | 26 | 26 |
| Co-products | | | |

| **Stage/Input** | **Units** | **Feedstock country of origin** | |
|---|---|---|---|
| | | **Malaysia** | **Indonesia** |
| Co-product 1 | Crude glycerine | Allocation by market value | |
| Quantity of crude glycerine | [t glycerine/t biodiesel] | 0.1 | 0.1 |
| Market value of glycerine | [£/t glycerine] | 345 | 345 |
| Co-product 2: | Potassium sulphate | Allocation by market value | |
| Quantity of potassium sulphate | [t potassium sulphate/t biodiesel] | 0.04 | 0.04 |
| Market value of potassium sulphate | [£/t potassium sulphate] | 75 | 75 |
| Primary product: biodiesel | | | |
| Market value of biodiesel | [£/t biodiesel] | 340 | 340 |
| Allocation factor | % | 90 | 90 |
| **Stage 8 – Liquid fuel transport and storage** | | | |
| Transport distance | [km] | 0 | 0 |
| Fuel consumption | [MJ/t-km] | 0 | 0 |

# Used cooking oil and tallow to ME biodiesel

**Fuel chain summary**

| | **Carbon intensity [kg CO2/t biodiesel]** |
|---|---|
| 1 – Feedstock Transport | 8 |
| 2 – Conversion | 471 |
| 3 – Liquid fuel transport | 0 |
| TOTAL | 479 |

**Selected default options**

| **Stage** | **Module** | **Input** | **Options** |
|---|---|---|---|
| 1 | Feedstock transport | Transport mode fuel efficiency | Truck (by geographic region), Rail (by geographic region), Shipping |
| 2 | Conversion | Fuel emissions factor | Coal, Natural gas, Heavy fuel oil, Biomass |
| 3 | Liquid fuel transport | Transport mode fuel efficiency | Truck (by geographic region), Rail (by geographic region), Shipping |

## Default fuel chain

### Stage 1 - Feedstock Transport

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Description | From central aggregation point to biodiesel plant. Note - includes credit for alternative waste treatment | | | | | | |
| **Alternative waste treatment** | | | | | | Emissions ($kgCO_{2e}$/t feedstock) | |
| Credit | [kg $CO_{2e}$/t feedstock] | value | x | value | = | calculation | 1 |
| **Transport** | | | | | | | |
| Transport distance | [km] | value | dist_1 | | | | |
| Fuel consumption | [MJ/t-km] | value | FC_1 | | | | |
| **Totals** | | | | Emissions factor [kgCO2e/MJ] | | Emissions ($kgCO_{2e}$/t feedstock) | |
| Module total | [MJ/t feedstock] | value | x | value | = | calculation | 2 |
| Contribution to fuel chain | | | | | 2 ÷ z1 x AF = | calculation | Stage_1 |

### Stage 2 - Conversion

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Description | Biodiesel plant | | | | | | |
| **Basic data** | | | | | | | |
| Plant yield | [t biodiesel / t UCO or tallow] | value | (z1) | | | | |
| **Conversion Inputs** | | | | Emissions factor [kgCO2e/MJ] | | Emissions ($kgCO_{2e}$/t biodiesel) | |
| Natural gas | [MJ/t biodiesel] | value | x | value | = | calculation | 3 |
| Electricity imported | [MJ/t biodiesel] | value | x | value | = | calculation | 4 |
| | | | | Emissions factor (kgCO2e/kg) | | | |
| Methanol | kg/t biodiesel | value | x | value | = | calculation | 5 |
| Potassium hydroxide | kg/t biodiesel | value | x | value | = | calculation | 6 |

| **Co-products** | **Description** | **Treatment** |
|---|---|---|
| Co-product 1: | Crude glycerine sold as chemical | Allocation - by market value |
| Co-product 2: | Potassium sulphate | Allocation - by market value |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Co-products treated by allocation by market value** | | | | | | | | |
| **Co-product 1: crude glycerine** | | | | | Market value [£ / t glycerine] | | | |
| Quantity of crude glycerine produced | [t glycerine / t biodiesel] | *value* | x | | *value* | = | *calculation* | 7 |
| **Co-product 2: Potassium sulphate** | | | | | Market value [£ / t potassium sulphate] | | | |
| Quantity of potassium sulphate produced and sold as chemical | [t potassium suplhate / t biodiesel] | *value* | | | *value* | = | *calculation* | 8 |
| **Primary product: biodiesel** | | | | | Market value [£ / t biodiesel] | | | |
| Market value of biodiesel | | | | | *value* | = | *calculation* | 9 |
| **Total market value of products** | | | | | | | | |
| Total market value | [£ / t biodiesel] | | | | | | *calculation* | 10 |
| Allocation factor (%age of emissions attributable to biodiesel) | % | | | | | | *calculation* | AF |
| **Totals** | | | | | | | Total Emissions [$kgCO_{2e}$/t biodiesel] | |
| Module total | | | | | | (3 + 4 + 5 + 6) x AF = | *calculation* | 11 |
| Contribution to fuel chain | | | | | | 11 = | *calculation* | Stage_2 |

## Stage 3 - Liquid fuel transport and storage

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | From biodiesel plant to refinery / blending facility | | | | | | | |
| Transport distance | [km] | *value* | dist_2 | | | | | |
| Fuel consumption | [MJ/t-km] | *value* | FC_2 | | | | | |
| **Totals** | | | | | Emissions factor [kgCO2e/MJ] | | Total Emissions [$kgCO_{2e}$/t biodiesel] | |
| Module total | [MJ/t biodiesel] | *value* | x | | *value* | = | *calculation* | 12 |
| Contribution to fuel chain | | | | | | 12 = | *calculation* | Stage_3 |

### Default value tables

| **Stage/Input** | **Units** | **Value** |
|---|---|---|
| **Stage 1 – Feedstock Transport** | | |
| Credit for alternative waste treatment | [kg $CO_2$e/t feedstock] | 0 |
| Transport distance | [km] | 50 |
| Fuel consumption | [MJ/t-km] | 1.53 |
| Fuel type | | Diesel |

| | | |
|---|---|---|
| **Stage 2 – Conversion** | | |
| Yield | [t biodiesel/t UCO or tallow] | 0.875 |
| Natural gas | [MJ/t biodiesel] | 1690 |
| Electricity imported | [MJ/t biodiesel] | 335 |
| Methanol | kg/t biodiesel | 113 |
| Potassium hydroxide | kg/t biodiesel | 26 |
| Co-product 1 | Crude glycerine | Allocation by market value |
| Quantity of crude glycerine | [t glycerine/t biodiesel] | 0.1 |
| Market value of glycerine | [£/t glycerine] | 345 |
| Co-product 2: | Potassium sulphate | Allocation by market value |
| Quantity of potassium sulphate | [t potassium sulphate/t biodiesel] | 0.04 |
| Market value of potassium sulphate | [£/t potassium sulphate] | 75 |
| Primary product: biodiesel | | |
| Market value of biodiesel | [£/t biodiesel] | 340 |
| Allocation factor | % | 90 |
| **Stage 3 – Liquid fuel transport and storage** | | |
| Transport distance | [km] | 0 |

| | | |
|---|---|---|
| Fuel consumption | [MJ/t-km] | 0 |

# Oilseed rape to HVO biodiesel

**Fuel chain summary**

| | **Carbon intensity [kg CO2/t biodiesel]** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Module** | **Australia** | **Canada** | **Finland** | **France** | **Germany** | **Poland** | **Ukraine** | **United Kingdom** |
| 1 - Crop production | 2510 | 2406 | 2471 | 2066 | 2075 | 1915 | 2633 | 2525 |
| 2 - Drying and storage | 0 | 84 | 87 | 80 | 92 | 97 | 88 | 92 |
| 3 - Feedstock transport | 29 | 142 | 38 | 113 | 113 | 113 | 0 | 38 |
| 4 - Feedstock transport | 900 | 0 | 0 | 0 | 0 | 0 | 116 | 0 |
| 5 - Conversion (crushing) | -562 | -636 | -628 | -653 | -605 | -586 | -608 | -608 |
| 6 - Feedstock transport | 419 | 144 | 0 | 43 | 37 | 16 | 10 | 43 |
| 7 - Conversion (hydrogenation) | 488 | 488 | 488 | 488 | 488 | 488 | 488 | 488 |
| 8 - Liquid fuel transport and storage | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| TOTAL | 3772 | 3299 | 3119 | 2825 | 2840 | 2664 | 2842 | 3221 |

**Selected default options**

| Stage | Module | Input | Options |
|---|---|---|---|
| 1 | Crop production | Nitrogen fertiliser emissions factor | Ammonium nitrate (AN), Ammonium sulphate (AS),Urea, Calcium nitrate (CN), Urea ammonium nitrate liquid (UAN), NPK (Urea / TSP / MOP) |
| 1 | Crop production | Phosphorus fertiliser emissions factor | Triple superphosphate (TSP), Rock phosphate, Mono ammonium phosphate (MAP) |
| 2 | Drying and storage | Fuel emissions factor | Diesel,<br>Heavy fuel oil,<br>Coal,<br>Natural gas |
| 3 | Feedstock transport | Transport mode fuel efficiency | Truck (by geographic region),<br>Rail (by geographic region),<br>Shipping |
| 4 | Feedstock transport | Transport mode fuel efficiency | Truck (by geographic region),<br>Rail (by geographic region),<br>Shipping |
| 5 | Conversion (crushing) | Fuel emissions factor | Coal,<br>Natural gas,<br>Heavy fuel oil,<br>Biomass |

| Stage | Module | Input | Options |
|---|---|---|---|
| 6 | Feedstock transport | Transport mode fuel efficiency | Truck (by geographic region),<br>Rail (by geographic region),<br>Shipping |
| 7 | Conversion (esterification) | Fuel emissions factor | Coal,<br>Natural gas,<br>Heavy fuel oil,<br>Biomass |
| 8 | Liquid fuel transport | Transport mode fuel efficiency | Truck (by geographic region),<br>Rail (by geographic region),<br>Shipping |

**Default fuel chain**

Stages 1 to 5 are identical to the fuel chain given for palm oil to ME biodiesel.

## Stage 6 - Feedstock Transport

| Description | From extraction facility to hydrogenation plant | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Emissions factor [kgCO2e/MJ] | | | |
| Transport distance | [km] | value | dist_3 | | | | | |
| Fuel consumption | [MJ/t-km] | value | FC_3 | | | | | |
| **Totals** | | | | | | | Emissions ($kgCO_{2e}$/t rapeseed oil) | |
| Module total | [MJ / t rapeseed oil] | value | | x | value | = | calculation | 19 |
| Contribution to fuel chain | | | | | | 19 ÷ z2 = | calculation | Stage_6 |

## Stage 7 - Conversion

| Description | Hydrogenation plant | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Basic data** | | | | | | | | |
| Plant yield | [t HVO biodiesel / t rapeseed oil] | value | (z2) | | | | | |
| **Conversion Inputs** | | | | | Emissions factor [kgCO2e / MJ] | | Emissions [$kgCO_{2e}$/t HVO diesel] | |
| Natural gas | [MJ/t HVO biodiesel] | value | | x | value | = | calculation | 20 |
| Electricity | [MJ/t HVO biodiesel] | value | | x | value | = | calculation | 21 |
| **Totals** | | | | | | | Total Emissions [$kgCO_{2e}$/t HVO biodiesel] | |
| Module total | | | | | | 20 + 21 = | calculation | 22 |
| Contribution to fuel chain | | | | | | 22 = | calculation | Stage_7 |

## Stage 8 - Liquid fuel transport and storage

| Description | From HVO biodiesel plant to refinery / blending facility | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Transport distance | [km] | value | dist_4 | | | | | |
| Fuel consumption | [MJ/t-km] | value | FC_4 | | | | | |
| **Totals** | | | | | Emissions factor [kgCO2e/MJ] | | Total Emissions [$kgCO_{2e}$/t HVO biodiesel] | |
| Module total | [MJ/t HVO biodiesel] | value | | x | value | = | calculation | 23 |
| Contribution to fuel chain | | | | | | 23 = | calculation | Stage_8 |

**Default value tables**

| **Stage/Input** | **Units** | **Feedstock country of origin** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Australia** | **Canada** | **Finland** | **France** | **Germany** | **Poland** | **Ukraine** | **United Kingdom** |
| **Stage 1 – Crop production** | | | | | | | | | |
| Yield @ traded moisture content | [t/ha.a] | 1.19 | 1.46 | 1.30 | 3.18 | 3.44 | 2.38 | 1.12 | 3.03 |
| Traded moisture content | % | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| N fertiliser | [kg N /ha.a] | 61 | 75 | 67 | 155 | 170 | 102 | 60 | 185 |
| Type of N fertiliser | | AN | AN | AN | AN | AN | AN | AN | AN |
| P fertiliser | [kg $P_2O_5$/ha.a] | 16 | 20 | 18 | 45 | 45 | 35 | 15 | 45 |
| Type of P fertiliser | | TSP | TSP | TSP | TSP | TSP | TSP | TSP | TSP |

| **Stage/Input** | **Units** | **Feedstock country of origin** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Australia** | **Canada** | **Finland** | **France** | **Germany** | **Poland** | **Ukraine** | **United Kingdom** |
| K fertiliser | [kg $K_2O$/ha.a] | 12 | 15 | 13 | 80 | 90 | 44 | 12 | 48 |
| Lime | [kg CaO/ha.a] | 18.9 | 18.9 | 18.9 | 18.9 | 18.9 | 18.9 | 18.9 | 18.9 |
| Pesticides | [kg/ha.a] | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 |
| Diesel fuel consumption | [litres/ha.a] | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 |
| **Stage 2 – Drying and storage** | | | | | | | | | |
| Moisture removed | % by weight | 0 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Fuel for heating | [MJ/t OSR] | 0 | 318 | 318 | 318 | 318 | 318 | 318 | 318 |
| Electricity | [MJ/t OSR] | 0 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| **Stage 3 – Feedstock Transport** | | | | | | | | | |
| Transport distance | [km] | 300 | 3000 | 100 | 300 | 300 | 300 | 1700 | 100 |

| Stage/Input | Units | Feedstock country of origin | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Australia** | **Canada** | **Finland** | **France** | **Germany** | **Poland** | **Ukraine** | **United Kingdom** |
| Fuel consumption | [MJ/t-km] | 0.38 | 0.19 | 1.53 | 1.53 | 1.53 | 1.53 | 0.19 | 1.53 |
| Fuel type | | Diesel | Diesel | Diesel | Diesel | Diesel | Diesel | Diesel | Diesel |
| **Stage 4 – Feedstock Transport** | | | | | | | | | |
| Transport distance | [km] | 18000 | 0 | 0 | 0 | 0 | 0 | 2300 | 0 |
| Fuel consumption | [MJ/t-km] | 0.2 | N/A | N/A | N/A | N/A | N/A | 0.2 | N/A |
| Fuel type | | HFO | N/A | N/A | N/A | N/A | N/A | HFO | N/A |
| **Stage 5 – Conversion** | | | | | | | | | |
| Plant yield | [t rapeseed oil/t oilseed rape] | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 |
| Natural gas | [MJ/t rapeseed oil] | 1986 | 1986 | 1986 | 1986 | 1986 | 1986 | 1986 | 1986 |
| Electricity imported | [MJ/t rapeseed | 337 | 337 | 337 | 337 | 337 | 337 | 337 | 337 |

| **Stage/Input** | **Units** | **Feedstock country of origin** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Australia** | **Canada** | **Finland** | **France** | **Germany** | **Poland** | **Ukraine** | **United Kingdom** |
| | oil] | | | | | | | | |
| Co-product 1: Rape meal – sold as animal feed | | Substitutes US soy meal (soybeans crushed in EU) | | | | | | | |
| Quantity of rape meal | [t rape meal/t rapeseed oil] | 1.32 | 1.32 | 1.32 | 1.32 | 1.32 | 1.32 | 1.32 | 1.32 |
| Credit for co-product 1 | [$kgCO_2e$/t rape meal] | -504 | -504 | -504 | -504 | -504 | -504 | -504 | -504 |
| **Stage 6 – Feedstock Transport** | | | | | | | | | |
| Transport distance | [km] | 1900 | 6700 | 0 | 2000 | 1700 | 760 | 500 | 2000 |
| Fuel consumption | [MJ/t-km] | 0.2 | 0.2 | 0 | 0.2 | 0.2 | 0.2 | 0.19 | 0 |
| Fuel type | | HFO | HFO | HFO | HFO | HFO | HFO | Diesel | HFO |
| **Stage 7 – Conversion** | | | | | | | | | |

| **Stage/Input** | **Units** | **Feedstock country of origin** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Australia** | **Canada** | **Finland** | **France** | **Germany** | **Poland** | **Ukraine** | **United Kingdom** |
| Plant yield | [t biodiesel/t rapeseed oil] | 0.813 | 0.813 | 0.813 | 0.813 | 0.813 | 0.813 | 0.813 | 0.813 |
| Natural gas | [MJ/t biodiesel] | 7660 | 7660 | 7660 | 7660 | 7660 | 7660 | 7660 | 7660 |
| Electricity imported | [MJ/t biodiesel] | 159 | 159 | 159 | 159 | 159 | 159 | 159 | 159 |
| **Stage 8 – Liquid fuel transport and storage** | | | | | | | | | |
| Transport distance | [km] | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 |
| Fuel consumption | [MJ/t-km] | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Fuel Type | | HFO | HFO | HFO | HFO | HFO | HFO | HFO | HFO |

# Soy to HVO biodiesel

**Fuel chain summary**

| | **Carbon intensity [kg CO2/t biodiesel]** | | |
|---|---|---|---|
| | **Argentina** | **Brazil** | **USA** |
| 1 – Crop production | 2372 | 2677 | 3107 |
| 2 – Drying and storage | 95 | 88 | 79 |
| 3 – Feedstock transport | 371 | 1689 | 91 |
| 4 – Conversion (crushing) | -1429 | -1528 | -1278 |
| 5 – Feedstock transport | 0 | 0 | 31 |
| 6 – Feedstock transport | 311 | 247 | 183 |
| 7 – Conversion (hydrogenation) | 488 | 488 | 488 |
| 8 – Liquid fuel transport | 35 | 35 | 35 |
| **TOTAL** | 2243 | 3696 | 2736 |

**Selected default options**

| **Stage** | **Module** | **Input** | **Options** |
|---|---|---|---|

| Stage | Module | Input | Options |
|---|---|---|---|
| 1 | Crop production | Nitrogen fertiliser emissions factor | Ammonium nitrate (AN), Ammonium sulphate (AS),Urea, Calcium nitrate (CN), Urea ammonium nitrate liquid (UAN), NPK (Urea / TSP / MOP) |
| 1 | Crop production | Phosphorus fertiliser emissions factor | Triple superphosphate (TSP), Rock phosphate, Mono ammonium phosphate (MAP) |
| 2 | Drying and storage | Fuel emissions factor | Diesel,<br>Heavy fuel oil,<br>Coal,<br>Natural gas |
| 3 | Feedstock transport | Transport mode fuel efficiency | Truck (by geographic region),<br>Rail (by geographic region),<br>Shipping |
| 4 | Conversion (crushing) | Fuel emissions factor | Coal,<br>Natural gas,<br>Heavy fuel oil,<br>Biomass |
| 5 | Feedstock transport | Transport mode fuel efficiency | Truck (by geographic region),<br>Rail (by geographic region),<br>Shipping |
| 6 | Feedstock transport | Transport mode fuel efficiency | Truck (by geographic region),<br>Rail (by geographic region),<br>Shipping |

| Stage | Module | Input | Options |
|---|---|---|---|
| 6 | Conversion (esterification) | Fuel emissions factor | Coal,<br>Natural gas,<br>Heavy fuel oil,<br>Biomass |
| 7 | Liquid fuel transport | Transport mode fuel efficiency | Truck (by geographic region), Rail (by geographic region), Shipping |

**Default fuel chain**

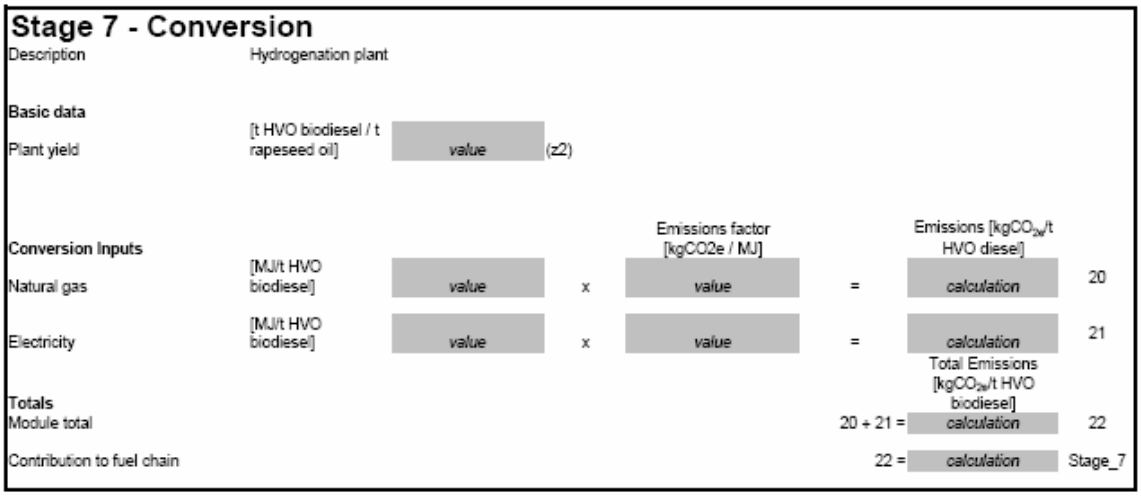
Stages 1 to 5 are identical to the fuel chain given for palm oil to ME biodiesel.

**Stage 5 - Feedstock Transport**

| Description | From crusher to port (Mode 1) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Emissions factor [kgCO2e/MJ] | | | |
| Transport distance | [km] | value | dist_2 | | | | | |
| Fuel consumption | [MJ/t-km] | value | FC_2 | | | | | |
| Totals | | | | | | | Emissions (kgCO2e/t soy oil) | |
| Module total | [MJ/t soy oil] | value | | x | value | = | calculation | 18 |
| | | | | | | | Total Emissions [$kgCO_{2e}$/t HVO biodiesel] | |
| Contribution to fuel chain | | | | | | 18 ÷ z2 = | calculation | Stage_5 |

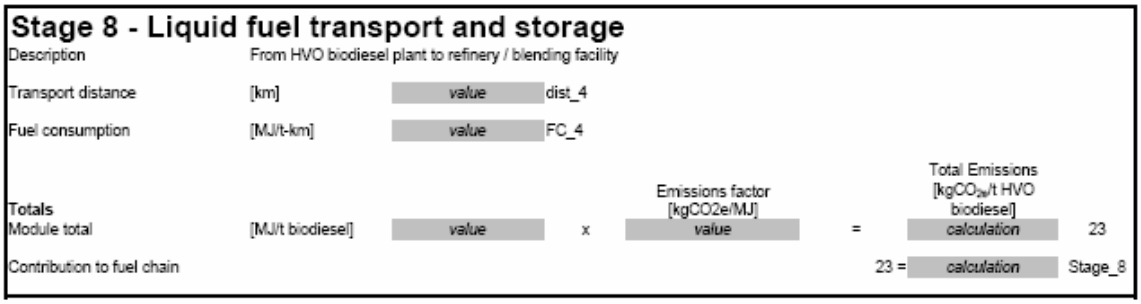
**Stage 6 - Feedstock Transport**

| Description | From port to HVO biodiesel plant (Mode 2) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Emissions factor [kgCO2e/MJ] | | | |
| Transport distance | [km] | value | dist_3 | | | | | |
| Fuel consumption | [MJ/t-km] | value | FC_3 | | | | | |
| Totals | | | | | | | Emissions (kgCO2e/t soy oil) | |
| Module total | [MJ/t soy oil] | value | | x | value | = | calculation | 19 |
| | | | | | | | Total Emissions [$kgCO_{2e}$/t HVO biodiesel] | |
| Contribution to fuel chain | | | | | | 19 ÷ z2 = | calculation | Stage_6 |



**Stage 7 - Conversion**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | Hydrogenation plant | | | | | | | |
| **Basic data** | | | | | | | | |
| Plant yield | [t HVO biodiesel / t rapeseed oil] | value | (z2) | | | | | |
| **Conversion Inputs** | | | | | Emissions factor [kgCO2e / MJ] | | Emissions [$kgCO_{2e}$/t HVO diesel] | |
| Natural gas | [MJ/t HVO biodiesel] | value | x | value | = | calculation | | 20 |
| Electricity | [MJ/t HVO biodiesel] | value | x | value | = | calculation | | 21 |
| **Totals** | | | | | | | Total Emissions [$kgCO_{2e}$/t HVO biodiesel] | |
| Module total | | | | | 20 + 21 = | calculation | | 22 |
| Contribution to fuel chain | | | | | 22 = | calculation | | Stage_7 |



**Stage 8 - Liquid fuel transport and storage**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | From HVO biodiesel plant to refinery / blending facility | | | | | | | |
| Transport distance | [km] | value | dist_4 | | | | | |
| Fuel consumption | [MJ/t-km] | value | FC_4 | | | | | |
| **Totals** | | | | | Emissions factor [kgCO2e/MJ] | | Total Emissions [$kgCO_{2e}$/t HVO biodiesel] | |
| Module total | [MJ/t biodiesel] | value | x | value | = | calculation | | 23 |
| Contribution to fuel chain | | | | | 23 = | calculation | | Stage_8 |

## Default value tables

| **Stage/Input** | **Units** | **Feedstock country of origin** | | |
|---|---|---|---|---|
| | | **Argentina** | **Brazil** | **USA** |
| **Stage 1 – Crop Production** | | | | |
| Yield @ traded moisture content | [t/ha.a] | 2.54 | 2.54 | 2.60 |
| Moisture content | % | 13 | 13 | 13 |
| N fertiliser | [kg N/ha.a] | 10 | 10 | 24 |
| Type of N fertiliser | | Urea | Urea | AN |
| P fertiliser | [kg $P_2O_5$/ha.a] | 5 | 50 | 100 |

| **Stage/Input** | **Units** | **Feedstock country of origin** | | |
|---|---|---|---|---|
| | | **Argentina** | **Brazil** | **USA** |
| Type of P fertiliser | | MAP | MAP | TSP |
| K fertiliser | [kg $K_2O$/ha.a] | 3 | 60 | 55 |
| Pesticides | [kg/ha.a] | 1.31 | 1.31 | 1.31 |
| Electricity | [kWh/ha.a] | 11.00 | 11.00 | 11.00 |
| Diesel fuel consumption | [litres/ha.a] | 75.6 | 75.6 | 75.6 |
| **Stage 2 – Drying and storage** | | | | |
| Moisture removed | % | 2 | 2 | 2 |
| Fuel for heating | [MJ/t soy] | 138 | 138 | 138 |
| Fuel type | | Diesel | Diesel | Natural gas |
| Electricity | [MJ/t soy] | 15 | 15 | 15 |
| **Stage 3 – Feedstock Transport** | | | | |
| Transport distance | [km] | 330 | 1500 | 100 |
| Fuel consumption | [MJ/t-km] | 1.8 | 1.8 | 1.46 |
| Fuel type | | Diesel | Die | Dies |

| **Stage/Input** | **Units** | **Feedstock country of origin** | | |
|---|---|---|---|---|
| | | **Argentina** | **Brazil** | **USA** |
| | | | sel | el |
| **Stage 4 – Conversion** | | | | |
| Yield | [t soy oil/t soy] | 0.17 | 0.17 | 0.17 |
| Natural gas | [MJ/t soy oil] | 5447 | 5447 | 5447 |
| Electricity imported | [MJ/t soy oil] | 1476 | 1476 | 1476 |
| Co-products | Description | Treatment | | |
| Co-product 1: | Soymeal sold as animal feed | Substitutes for EU wheat | | |
| Quantity of soy meal produced & sold as animal feed | [t soy meal/t soy oil] | 4.32 | 4.32 | 4.32 |
| Credit | [kg$CO_2$e/t soy meal] | -373 | -373 | -373 |
| **Stage 5 – Feedstock Transport** | | | | |
| Transport distance | [km] | 0 | 0 | 1500 |
| Fuel consumption | [MJ/t-km] | 0 | 0 | 0.19 |
| Fuel type | | None | None | Diesel |
| **Stage 6 – Feedstock Transport** | | | | |

| **Stage/Input** | **Units** | **Feedstock country of origin** | | |
|---|---|---|---|---|
| | | **Argentina** | **Brazil** | **USA** |
| Transport distance | [km] | 14500 | 11500 | 8500 |
| Fuel consumption | [MJ/t-km] | 0.2 | 0.2 | 0.2 |
| Fuel type | | HFO | HFO | HFO |
| **Stage 7 – Conversion** | | | | |
| Plant yield | [t biodiesel/t soy oil] | 0.813 | 0.813 | 0.813 |
| Natural gas | [MJ/t biodiesel] | 7660 | 7660 | 7660 |
| Electricity imported | [MJ/t biodiesel] | 159 | 159 | 159 |
| **Stage 8 – Liquid fuel transport and storage** | | | | |
| Transport distance | [km] | 2000 | 2000 | 2000 |
| Fuel consumption | [MJ/t-km] | 0.2 | 0.2 | 0.2 |
| Fuel Type | | HFO | HFO | HFO |

# Palm to HVO biodiesel

**Fuel chain summary**

| | Carbon intensity [kg CO2/t biodiesel] | |
|---|---|---|
| | **Indonesia** | **Malaysia** |
| 1 – Crop Production | 312 | 358 |
| 2 – Feedstock transport | 14 | 14 |
| 3 – Conversion (palm oil extraction) | 675 | 675 |
| 4 – Feedstock transport | 82 | 51 |
| 5 – Conversion (palm oil refining) | 152 | 142 |
| 6 – Feedstock transport | 354 | 354 |
| 7 – Conversion (esterification) | 488 | 488 |
| 8 – Liquid fuel transport | 35 | 35 |
| **TOTAL** | 2112 | 2117 |

**Selected default options**

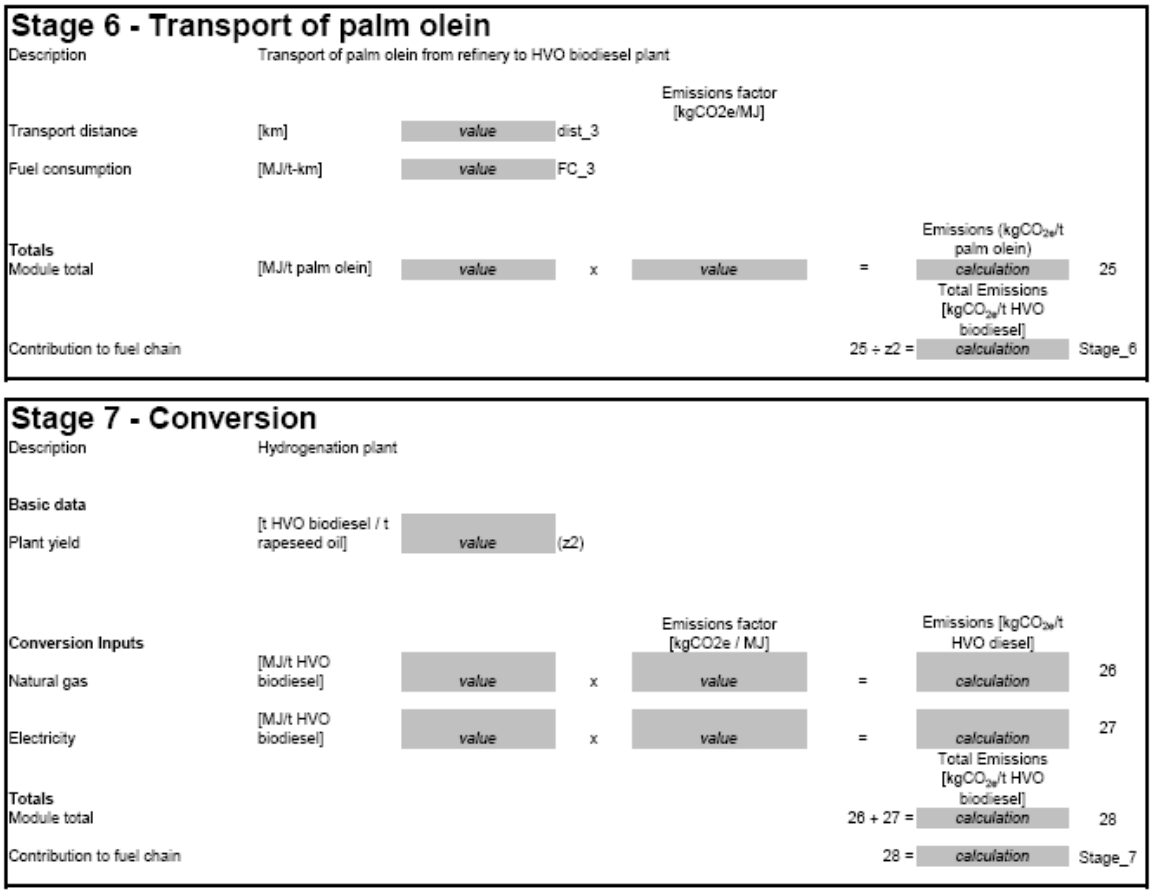
| **Stage** | **Module** | **Input** | **Options** |
|---|---|---|---|
| 1 | Crop production | Nitrogen fertiliser emissions factor | Ammonium nitrate (AN), Ammonium sulphate (AS),Urea, |

| Stage | Module | Input | Options |
|---|---|---|---|
| | | | Calcium nitrate (CN), Urea ammonium nitrate liquid (UAN), NPK (Urea / TSP / MOP) |
| 1 | Crop production | Phosphorus fertiliser emissions factor | Triple superphosphate (TSP), Rock phosphate, Mono ammonium phosphate (MAP) |
| 2 | Feedstock transport | Transport mode fuel efficiency | Truck (by geographic region),<br>Rail (by geographic region),<br>Shipping |
| 4 | Feedstock transport | Transport mode fuel efficiency | Truck (by geographic region),<br>Rail (by geographic region),<br>Shipping |
| 5 | Conversion (palm oil refining) | Fuel emissions factor | Coal,<br>Natural gas,<br>Heavy fuel oil,<br>Biomass |
| 6 | Feedstock transport | Transport mode fuel efficiency | Truck (by geographic region),<br>Rail (by geographic region),<br>Shipping |
| 7 | Conversion (esterification) | Fuel emissions factor | Coal,<br>Natural gas,<br>Heavy fuel oil,<br>Biomass |
| 8 | Liquid fuel transport | Transport mode fuel efficiency | Truck (by geographic region),<br>Rail (by geographic |

| Stage | Module | Input | Options |
|---|---|---|---|
| | | | region),<br>Shipping |

**Default fuel chain**

Stages 1 to 5 are identical to the fuel chain given for palm oil to ME biodiesel.

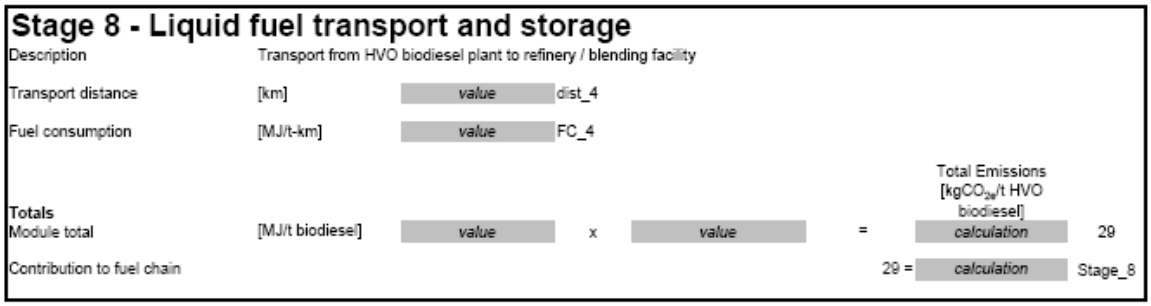


**Stage 6 - Transport of palm olein**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | Transport of palm olein from refinery to HVO biodiesel plant | | | | | | | |
| | | | | Emissions factor [kgCO2e/MJ] | | | | |
| Transport distance | [km] | value | dist_3 | | | | | |
| Fuel consumption | [MJ/t-km] | value | FC_3 | | | | | |
| Totals | | | | | | Emissions ($kgCO_{2e}$/t palm olein) | | |
| Module total | [MJ/t palm olein] | value | x | value | = | calculation | 25 | |
| | | | | | | Total Emissions [$kgCO_{2e}$/t HVO biodiesel] | | |
| Contribution to fuel chain | | | | | 25 ÷ z2 = | calculation | Stage_6 | |

**Stage 7 - Conversion**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | Hydrogenation plant | | | | | | | |
| Basic data | | | | | | | | |
| Plant yield | [t HVO biodiesel / t rapeseed oil] | value | (z2) | | | | | |
| | | | | Emissions factor [kgCO2e / MJ] | | Emissions [$kgCO_{2e}$/t HVO diesel] | | |
| Conversion Inputs | | | | | | | | |
| Natural gas | [MJ/t HVO biodiesel] | value | x | value | = | calculation | 26 | |
| Electricity | [MJ/t HVO biodiesel] | value | x | value | = | calculation | 27 | |
| | | | | | | Total Emissions [$kgCO_{2e}$/t HVO biodiesel] | | |
| Totals | | | | | | | | |
| Module total | | | | | 26 + 27 = | calculation | 28 | |
| Contribution to fuel chain | | | | | 28 = | calculation | Stage_7 | |




**Default value tables**

| **Stage/Input** | **Units** | **Feedstock country of origin** | |
|---|---|---|---|
| | | **Malaysia** | **Indonesia** |
| **Stage 1 – Crop Production** | | | |
| Yield of FFB | [t/ha.a] | 19.0 | 17.7 |
| N fertiliser | [kg N/ha.a] | 100 | 95 |
| Type of N fertiliser | | SOA | Urea |
| P fertiliser | [kg $P_2O_5$/ha.a] | 45 | 30 |
| Type of P fertiliser | | Rock | Rock |
| K fertiliser | [kg $K_2O$/ha.a] | 205 | 75 |
| Mg fertiliser (MgO) | [kg MgO /ha.a] | 33 | 33 |
| NPK fertiliser | [kg $P_2O_5$ /ha.a] | 50 | 50 |
| Pesticide | [kg/ha.a] | 3 | 3 |

| **Stage/Input** | **Units** | **Feedstock country of origin** | |
|---|---|---|---|
| | | **Malaysia** | **Indonesia** |
| Replant and production | [litres/ha.a] | 30 | 30 |
| Harvest and collection | [litres/ha.a] | 40 | 40 |
| **Stage 2 – Feedstock Transport** | | | |
| Transport distance | [km] | 17 | 17 |
| Fuel consumption | [MJ/t-km] | 1.8 | 1.8 |
| Fuel type | | Diesel | Diesel |
| **Stage 3 – Conversion** | | | |
| Palm oil mill yield | [t CPO/t FFB] | 0.2 | 0.2 |
| Mill effluent emissions (POME) | [kg/t CPO] | 2500 | 2500 |
| POME emissions coefficient | [kg CO2e / kg] | 0.2472 | 0.2472 |
| Co-products | Description | Treatment | |
| Co-product 1 | Palm kernel | Allocation by market value | |
| Quantity of palm kernel | [t palm kernel/t CPO] | 0.3 | 0.3 |
| Market value of palm kernel | [RM/t palm kernel] | 992 | 992 |
| Primary product: CPO | | | |
| Market value of CPO | [RM/t palm olein] | 1525 | 1524 |

| **Stage/Input** | **Units** | **Feedstock country of origin** | |
|---|---|---|---|
| | | **Malaysia** | **Indonesia** |
| Allocation factor | % | 84 | 84 |
| **Stage 4 – Feedstock Transport** | | | |
| Transport distance | [km] | 250 | 400 |
| Fuel consumption | [MJ/t-km] | 1.89 | 1.89 |
| Fuel type | | Diesel | Diesel |
| **Stage 5 – Conversion** | | | |
| Refinery yield | [t palm olein/t CPO] | 0.8 | 0.8 |
| Natural gas | [MJ/t palm olein] | 1366 | 1366 |
| Electricity imported | [MJ/t palm olein] | 121 | 121 |
| Co-products | Description | Treatment | |
| Co-product 1 | Palm stearin | Allocation by market value | |
| Quantity of palm stearin | [t palm stearin/t palm olein] | 0.2 | 0.2 |
| Market value of palm stearin | [USD/t palm stearin] | 389 | 389 |
| Primary product: palm olein | | | |
| Market value of palm olein | [USD/t palm olein] | 438 | 438 |
| Allocation factor | % | 85 | 85 |

| **Stage/Input** | **Units** | **Feedstock country of origin** | |
|---|---|---|---|
| | | **Malaysia** | **Indonesia** |
| **Stage 6 – Feedstock Transport** | | | |
| Transport distance | [km] | 16500 | 16500 |
| Fuel consumption | [MJ/t-km] | 0.2 | 0.2 |
| Fuel type | | HFO | HFO |
| **Stage 7 – Conversion** | | | |
| Plant yield | [t biodiesel/t rapeseed oil] | 0.813 | 0.813 |
| Natural gas | [MJ/t biodiesel] | 7660 | 7660 |
| Electricity imported | [MJ/t biodiesel] | 159 | 159 |
| **Stage 8 – Liquid fuel transport and storage** | | | |
| Transport distance | [km] | 2000 | 2000 |
| Fuel consumption | [MJ/t-km] | 0.2 | 0.2 |
| Fuel Type | | HFO | HFO |

# Ethanol to ETBE

ETBE can be produced in two ways:

- Using isobutene in a refinery, in which case it is most likely to be substituting MTBE from the fuel mix, or
- Using isobutene imported from a dedicated isobutene plant, in which case it is most likely to be substitution gasoline from the fuel mix.

In the first case, the benefits of substituting MTBE (which is more carbon intensive than gasoline) from the fuel mix must be taken into account. Fuel suppliers who are able to prove that refinery by-product isobutene has been used in the production of ETBE will be able to report default values which specifically take this into account. Consequently, there are two sets of default values and two different fuel chains within this section.

**Fuel chain summary**

ETBE produced using refinery by-product isobutene

| **Feedstock** | **Wheat** | | | | |
|---|---|---|---|---|---|
| **Origin** | **Canada** | **France** | **Germany** | **Ukraine** | **United Kingdom** |
| 1 - Conversion | 2636 | 2461 | 2387 | 2962 | 2404 |
| 2 - Liquid fuel transport & storage | 8 | 8 | 8 | 8 | 8 |
| TOTAL | 2644 | 2469 | 2395 | 2970 | 2412 |

| **Feedstock** | **Sugar beet** | **Molasses** | | |
|---|---|---|---|---|
| **Origin** | **UK** | **Pakistan** | **South Africa** | **UK** |
| 1 - Conversion | 2281 | 2655 | 2797 | 2151 |
| 2 - Liquid fuel transport & storage | 8 | 8 | 8 | 8 |
| TOTAL | 2289 | 2663 | 2805 | 2159 |

| **Feedstock** | **Sugar cane** | | | | **Corn** | |
|---|---|---|---|---|---|---|
| **Origin** | **Brazil** | **Mozambique** | **Pakistan** | **South** | **France** | **USA** |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | **Africa** | | |
| 1 - Conversion | 1964 | 2030 | 3062 | 3026 | 2267 | 2980 |
| 2 - Liquid fuel transport & storage | 8 | 8 | 8 | 8 | 8 | 8 |
| TOTAL | 1972 | 2038 | 3070 | 3034 | 2275 | 2988 |

**ETBE produced using isobutene from a dedicated plant**

| **Feedstock** | **Wheat** | | | | |
|---|---|---|---|---|---|
| **Origin** | **Canada** | **France** | **Germany** | **Ukraine** | **United Kingdom** |
| 1 - Conversion | 3124 | 2949 | 2875 | 3450 | 2892 |
| 2 - Liquid fuel transport & storage | 8 | 8 | 8 | 8 | 8 |
| TOTAL | 3132 | 2957 | 2883 | 3458 | 2900 |

| **Feedstock** | **Sugar beet** | **Molasses** | | |
|---|---|---|---|---|
| **Origin** | **UK** | **Pakistan** | **South Africa** | **UK** |
| 1 - Conversion | 2769 | 3143 | 3285 | 2639 |
| 2 - Liquid fuel transport & storage | 8 | 8 | 8 | 8 |
| TOTAL | 2777 | 3151 | 3293 | 2647 |

| **Feedstock** | **Sugar cane** | | | | **Corn** | |
|---|---|---|---|---|---|---|
| **Origin** | **Brazil** | **Mozambique** | **Pakistan** | **South Africa** | **France** | **USA** |
| 1 - Conversion | 2452 | 2518 | 3550 | 3514 | 2755 | 3468 |
| 2 - Liquid fuel transport & storage | 8 | 8 | 8 | 8 | 8 | 8 |

| | | | | | | |
|---|---|---|---|---|---|---|
| TOTAL | 2460 | 2526 | 3558 | 3522 | 2763 | 3476 |

**Selected default options (for both fuel chains)**

| Stage | Module | Input | Options |
|---|---|---|---|
| 1 | Conversion | Fuel emissions factor | Coal,<br>Natural gas,<br>Heavy fuel oil,<br>Biomass |
| 2 | Liquid fuel transport | Transport mode fuel efficiency | Truck (by geographic region),<br>Rail (by geographic region),<br>Shipping |

## Default fuel chain: ETBE produced using refinery by-product isobutene

### Stage 1 - Conversion

Description: ETBE conversion facility

NOTE 1: When the isobutene used to make ETBE is taken from a refinery, it is assumed it would have otherwise been used to produce MTBE and, therefore, some methanol is being displaced (while some extra gasoline is required) for which ETBE is given a GHG credit. Furthermore, it is assumed that producing ETBE requires no marginal increase in natural gas, electricity or isobutene relative to MTBE production. See Methodology document for a full explanation

| Inputs | | | | Ethanol carbon intensity [kg CO2e / t ethanol] | | Emissions [$kgCO_{2e}$/t ETBE] | |
|---|---|---|---|---|---|---|---|
| Ethanol | [t ethanol / t ETBE] | *value* | x | *value* | = | *calculation* | 1 |
| **Credit** for avoided methanol (minus additional gasoline required) | | | | | | | |
| Credit | | | | | | *calculation* | 2 |
| Debit for fossil carbon | | | | | | *calculation* | 3 |
| **Totals** | | | | | | Emissions [$kgCO_{2e}$/t ETBE] | |
| Module total | | | | | 1 + 2 + 3 = | *calculation* | 4 |
| Contribution to fuel chain | | | | | 4 = | *calculation* | Stage_1 |

### Stage 2 - Liquid fuel transport and storage

Description: From ETBE conversion facitity to duty point

| | | | |
|---|---|---|---|
| Transport distance | [km] | *value* | dist |
| Fuel consumption | [MJ/t-km] | *value* | FC |

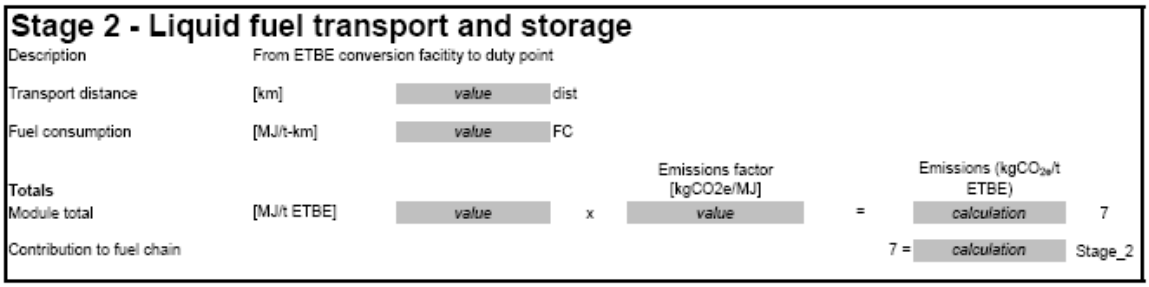
| Totals | | | | Emissions factor [kgCO2e/MJ] | | Emissions [$kgCO_{2e}$/t ETBE] | |
|---|---|---|---|---|---|---|---|
| Module total | [MJ/t ETBE] | *value* | x | *value* | = | *calculation* | 5 |
| Contribution to fuel chain | | | | | 5 = | *calculation* | Stage_2 |

## Default fuel chains: ETBE produced using isobutene from in a dedicated plant

### Stage 1 - Conversion

Description: ETBE conversion facility

| Inputs | | | | Ethanol carbon intensity [kg CO2e / t ethanol] | | Emissions ($kgCO_{2e}$/t ETBE) | |
|---|---|---|---|---|---|---|---|
| Ethanol | [t ethanol / t ETBE] | *value* | x | *value* | = | *calculation* | 1 |
| **Conversion Inputs** | | | | Emissions factor [kgCO2e/MJ] | | Emissions ($kgCO_{2e}$/t ETBE) | |
| Natural gas | [MJ/t ETBE] | *value* | x | *value* | = | *calculation* | 2 |
| Electricity imported | [MJ/t ETBE] | *value* | x | *value* | = | *calculation* | 3 |
| | | | | Emissions factor ($kgCO_{2e}$/t) | | | |
| Isobutene | [t / t ETBE] | *value* | x | *value* | = | *calculation* | 4 |
| Debit for fossil carbon | | | | | | *calculation* | 5 |
| **Totals** | | | | | | Emissions ($kgCO_{2e}$/t ETBE) | |
| Module total | | | | | 1 + 2 + 3 + 4 + 5 = | *calculation* | 6 |
| Contribution to fuel chain | | | | | 6 = | *calculation* | Stage_1 |



**Stage 2 - Liquid fuel transport and storage**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | From ETBE conversion facitity to duty point | | | | | | | |
| Transport distance | [km] | value | dist | | | | | |
| Fuel consumption | [MJ/t-km] | value | FC | | | | | |
| Totals | | | | Emissions factor [kgCO2e/MJ] | | Emissions ($kgCO_{2e}$/t ETBE) | | |
| Module total | [MJ/t ETBE] | value | x | value | = | calculation | 7 | |
| Contribution to fuel chain | | | | | 7 = | calculation | Stage_2 | |

**Default value tables (for both fuel chains)**

| **Stage/Input** | **Units** | **Refinery isobutene** | **Imported isobutene** |
|---|---|---|---|
| **Stage 1 – Conversion** | | | |
| Ethanol | [t ethanol/t ETBE] | 0.451 | 0.451 |
| Natural gas | [MJ/t ETBE] | 0 | 2264 |
| Electricity imported | [MJ/t ETBE] | 0 | 145 |
| Isobutene | [t / t ETBE] | 0 | 0.549 |
| Emissions coefficient for isobutene | [kg $CO_2e$ /t isobutene] | N/A | 500 |
| Credit | [$kgCO_2e$/t ETBE] | -54 | 0 |
| Debit for fossil carbon content of isobutene | [$kgCO_2e$/t ETBE] | 1726 | 1726 |
| **Stage 2 – Liquid fuel transport and storage** | | | |
| Transport distance | [km] | 450 | 400 |
| Fuel consumption | [MJ/t-km] | 0.2 | 0.2 |

# Manure and organic solid waste to bio-methane

**Fuel chain summary**

| | **Carbon intensity [g CO2/MJ biomethane]** |
|---|---|
| 1 – Feedstock transport | 6.43 |
| 2 – Conversion | 29.70 |
| 3 – Gaseous fuel transport and storage | 0.00 |
| Total | 36.13 |

**Selected default options**

| **Stage** | **Module** | **Input** | **Options** |
|---|---|---|---|
| 1 | Feedstock transport | Transport mode fuel efficiency | Truck (by geographic region),<br>Rail (by geographic region),<br>Shipping |
| 2 | Conversion | Fuel emissions factor | Coal,<br>Natural gas,<br>Heavy fuel oil,<br>Biomass |

## Default fuel chain

### Stage 1 - Feedstock Transport

| Description | From central aggregation point to digestion plant | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Emissions ($kgCO_{2e}$/t feedstock) | |
| **Alternative waste treatment** | | | | | | | | |
| Credit | [kg $CO_{2e}$/t feedstock] | *value* | x | *value* | = | | *calculation* | 1 |
| **Transport** | | | | | | | | |
| Transport distance | [km] | *value* | dist_1 | | | | | |
| Fuel consumption | [MJ/t-km] | *value* | FC_1 | | | | | |
| | | | | Emissions factor [kgCO2e/MJ] | | | Emissions ($kgCO_{2e}$/t feedstock) | |
| **Totals** | | | | | | | | |
| Module total | [MJ/t feedstock] | *value* | x | *value* | = | | *calculation* | 2 |
| | | | | | | | Total emissions ($gCO_{2e}$/MJ biomethane) | |
| Contribution to fuel chain | | | | | | 2 ÷ z1 = | *calculation* | Stage_1 |

### Stage 2 - Conversion

| Description | Digestion plant | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Plant yield | MJ biomethane / t waste | *value* | z1 | | | | | |
| **Basic data** | | | | | | | | |
| Mix of feedstock | | | | | | | | |
| Wet manure | % | *value* | | | | | | |
| Dry manure | % | *value* | | | | | | |
| OSW | % | *value* | | | | | | |
| | | | | Emissions factor [kgCO2e/MJ] | | | Emissions ($gCO_{2e}$/MJ biomethane) | |
| **Conversion Inputs** | | | | | | | | |
| Steam | MJ / MJ biomethane | *value* | | | | | | |
| Overall efficiency | % | *value* | | | | | | |
| Percent supplied from biogas | % | *value* | | | | | | |
| Natural gas (import) | MJ / MJ biomethane | *value* | x | *value* | = | | *calculation* | 3 |
| Electricity (import) | MJ / MJ biomethane | *value* | x | *value* | = | | *calculation* | 4 |
| Methane losses | MJ $CH_4$ lost / MJ biomethane | *value* | | | | | | |
| | | | | Emissions factor ($kgCO_{2e}$/$kgCH_4$) | | | | |
| | kg $CH_4$ lost / MJ biomethane | *value* | x | *value* | = | | *calculation* | 5 |
| | | | | Credit ($kgCO_{2e}$/kg) | | | | |
| **Co-products** | | | | | | | | |
| Fertiliser | MJ/MJ biomethane | *value* | x | *value* | = | | *calculation* | 6 |
| | | | | | | | Emissions ($gCO_{2e}$/MJ biomethane) | |
| **Totals** | | | | | | | | |
| Module total | | | | | | 3 + 4 + 5 + 6 = | *calculation* | 7 |
| Contribution to fuel chain | | | | | | 7 = | *calculation* | Stage_2 |

### Stage 3 - Gas fuel transport and storage

| Description | From biomethane plant to duty point | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Transport distance | [km] | *value* | dist_2 | | | | | |
| Fuel consumption | [MJ/t-km] | *value* | FC_2 | | | | | |
| | | | | Emissions factor [kgCO2e/MJ] | | | Emissions ($gCO_{2e}$/MJ biomethane) | |
| **Totals** | | | | | | | | |
| Module total | [MJ/MJ] | *value* | x | *value* | = | | *calculation* | 8 |
| Contribution to fuel chain | | | | | | 8 = | *calculation* | Stage_3 |

**Default value tables**

| Stage/Input | Units | Value |
|---|---|---|
| **Stage 1 – Feedstock Transport** | | |
| Credit | [kg $CO_2$e/t feedstock] | 0 |
| Transport distance | [km] | 40 |
| Fuel consumption | [MJ/t-km] | 8 |
| **Stage 2 – Conversion** | | |
| Yield | MJ biomethane/t waste | 4297 |
| Wet manure | % | 40 |
| Dry manure | % | 40 |
| OSW | % | 20 |
| Natural gas (import) | MJ/MJ biomethane | 0 |
| Electricity (import) | MJ/MJ biomethane | 0.077 |
| Methane losses | g CH4 lost/MJ biomethane | 0.887 |
| Emissions coefficient for methane | g CO2e / g CH4 | 23 |
| Co-products | Description | Treatment |
| Co-product 1 | Organic nitrogen fertiliser | Substitutes synthetic N fertiliser |

| | | |
|---|---|---|
| Fertiliser | MJ N/MJ biomethane | 0.02318 |
| Credit | $kgCO_2e$/MJ N | -0.034 |
| **Stage 3 – Gas fuel transport and storage** | | |
| Transport distance | [km] | 0.36 |
| Fuel consumption | [MJ/t-km] | 0 |

1 Note that, in this situation, default values for the other upstream stages are not required as these should have already been taken into account in the carbon intensity of the product which has been purchased.

2 It is easiest to do this on the basis of the quantity of co-product produced for every tonne of biofuel produced.

3 This analysis will need to be verifiable and should be based on public, peer reviewed studies or, for example carried out to a certain standard – e.g. ISO 14040.

4 In the case where products are not direct substitutes. For example, animal protein feeds might have different protein contents, in which case 1 tonne of the co-product might only substitute 0.8 tonnes of the marginal product.

5 Where possible “market value” should be based on a three year average market price for the product – this can be recalculated annually at the beginning of the RTFO year.

6 While yields (i.e. tonne output / tonne input) are not a “source” of GHG emissions, they are required to enable the fuel chain contribution total to be calculated within existing modules that are upstream of the added module.

7 Product at this point in the chain.