Carbon Reporting within the Renewable Transport Fuel Obligation – Methodology

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E4tech

This paper has been produced by [E4tech] for and in consultation with the Department for Transport. It has undergone a peer review process involving a project Advisory Group and other stakeholders. It sets out the principles behind the advice which led to the Requirements and Guidance for Carbon and Sustainability Reporting contained in the consultation document Carbon and Sustainability Reporting within the Renewable Transport Fuel Obligation.

This paper was written at the same time as the detailed RTFO scheme design was being developed. Although details of the scheme design may have changed since the writers of this paper were briefed, such changes do not affect the validity of the contents of this paper.

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1.   Introduction

This document represents advice to the Department for Transport on how carbon reporting could operate under the Renewable Transport Fuel Obligation. It defines our recommended methodology for calculating carbon intensity[1] under the RTFO. This Methodology forms the foundation of the broader process of Carbon Reporting (see Figure 1) which it is expected "Obligated Companies"[1] will carry out every month in order to be awarded Renewable Transport Fuel Certificates (RTFCs) for the fuels they supply into the UK market.

Report result to the RTFO administrator

Apply Technical Guidance to calculate carbon intensity

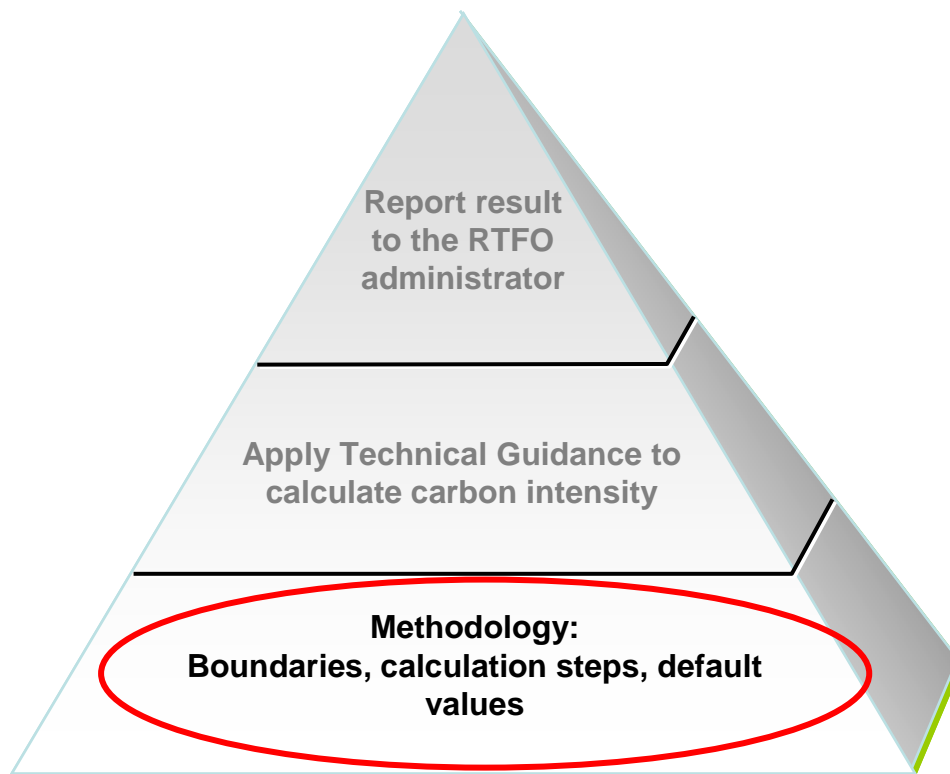**Methodology: Boundaries, calculation steps, default values**

Figure 1 – The Carbon Reporting process

To encourage suppliers to source sustainable biofuels the Government proposes that the Administrator of the RTFO scheme should require fuel suppliers to submit reports on the net GHG saving of the biofuels they supply in order to receive RTFCs. However under the Energy Act 2004 and the draft RTFO order the Administrator will make the final decision on what, if any, reporting requirements to introduce. The Government proposes that the Administrator will publish transport fuel supplier performance in this area. Pressure from the public, shareholders or Non Governmental Organisations may create an incentive for companies to produce or purchase the least carbon intensive fuels. In the future, the Government may link the number of RTFCs awarded to the carbon intensity of a fuel to provide an economic

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[1] As defined under the RTFO.

incentive for the uptake of the least carbon intensive fuels. The methodology should therefore differentiate between biofuels on a well-to-wheels basis.

The Government also proposes that the Administrator should monitor the impact of the policy on GHG emissions, through an as accurate as possible measurement of the GHG savings resulting from the introduction of biofuels into the market. It is important to note that the Methodology treats these two objectives in this hierarchical order. The implication being that, when a trade-off must be made between creating a Carbon Reporting system which can accurately differentiate between two biofuels, and a system which accurately assesses the full effects of the RTFO, the former is favoured. This is because it is possible to assess factors which might affect the total level of GHG savings through ex post studies.

These objectives for Carbon Reporting will require a Methodology which:

- Encourages and facilitates reporting that accurately represents the actual fuel chains companies are using.
- Is simple to use
- Is capable of assessing the GHG emissions from different fuel chains with a range of characteristics.

In addition to Carbon Reporting the Government also proposes that the Administrator will encourage the supply of biofuels which meet broader sustainability criteria (e.g. biodiversity, soil quality, water use etc) by establishing a parallel "Sustainability Reporting" requirement. The methodology for Sustainability Reporting has been developed separately; however, the Government proposes that the Administrator should integrate these processes for the launch of the RTFO.

This document defines our recommendation to the Government regarding the Methodology for calculating the carbon intensity of a biofuel, firstly, by outlining the approach adopted on a number of methodological issues (Section 2). This requires specification of the boundaries of the carbon intensity calculation, the use of reference systems, the way co-products are treated and the principles for setting default values for the data needed to calculate the carbon intensity of biofuels. This methodological information has been included to enable stakeholders to understand the key principles and assumptions which underlie the Methodology, and to enable the RTFO Administrator to add any new fuel chains to the Methodology on a consistent basis.

Secondly, the proposed Methodology, including all appropriate default values, is set out in Section 3 for a number of fuel chains. The Methodology currently covers each of the following fuel chains:

- Ethanol from: wheat, corn, sugar beet and sugar cane
- Ethyl tertiary butyl ether (ETBE) from: the above sources of ethanol.
- Biodiesel from: oilseed rape, soy, palm, used cooking oil and tallow.

- Biomethane from: MSW and manure.

2.   Methodological Issues

2.1. *Boundaries*

In order to meet the objectives of Carbon Reporting (see Section 1) we recommend that the initial boundary definition for calculating the carbon intensity of a biofuel should include: **all direct and indirect emissions, or avoided emissions, that are a result of the production of a biofuel** (see Figure 2). This implies the consideration of reference systems to account for emissions or avoided emissions resulting from their displacement as a result of biofuels production activities. For example, co-products of biofuels production such as glycerine may substitute other products in the market leading to avoided emissions.

Practical considerations related to the magnitude of emissions and the nature of reference systems lead to constraints in the boundary definition and emissions considered. These are set out below.

2.1.1. Minor sources of GHG emissions

The first constraint relates to the fact that there are several sources of GHG emissions which only make a small contribution to the carbon intensity of a fuel chain, and for which the marginal benefit of including a number of them in the calculation does not justify the additional cost[2]. Typically these sources individually contribute less than one percent of the overall carbon intensity of a fuel chain.

However, care needs to be taken not to define this boundary condition in terms of "percentage contribution" alone. Biofuel fuel chains typically have a very large number of sources which contribute only a small proportion individually, but which, in aggregate, can contribute in the region of 10 to 20 percent of total chain emissions. A sensible approach is to focus on particular sources of GHG emissions which always make a small absolute contribution to the chain emissions. On this basis, there are three sources in particular which we recommend should be excluded:

- Emissions associated with the manufacture or maintenance of machinery or equipment used in the biofuel fuel chain.
- Emissions of three GHGs included in the Kyoto Protocol – perfluorocarbons, hydrofluorocarbons and sulphur hexafluoride – that are of little relevance to biofuel fuel chains. The only potential source of these GHGs is air conditioning in vehicles (e.g. tractors used in crop production) and is likely to be very small.

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[2] For example, the initial cost of gathering data on these emission sources and the ongoing cost to the RTFO Administrator of ensuring that information relating to these sources is up-to-date.

- Emissions associated with the production of chemicals used in conversion plants that would contribute less than 1 percent of total fuel chain emissions.

These sources of emissions are typically excluded from other biofuel well-to-wheel studies e.g. JEC (2007).

Therefore, it is recommended that the follow sources of emissions are excluded from the Methodology (see Figure 2):

- GHG emissions associated with the manufacture or maintenance of machinery or equipment used in the production of feedstocks, in their conversion to biofuels or in their transport.
- Emissions of the three GHGs: perfluorocarbons, hydrofluorocarbons and sulphur hexafluoride.
- Emissions associated with the production of chemicals used in conversion plants that would contribute less than 1 percent of total fuel chain emissions.

2.1.2. Reference systems

Reference systems can be included as part of the boundary of the biofuel carbon intensity calculation to account for emissions or avoided emissions resulting from systems displaced as a result of biofuel production activities.

The following reference systems need to be considered in defining the boundaries of the carbon intensity calculation:

- Alternative land use reference systems: used to determine biofuels emissions net of emissions or avoided emissions that would have occurred due to an alternative use of the land. This includes the impact of displacing biomass production from that land to another area, e.g. sugarcane replaces soy that is displaced to another area.
- Previous land use reference system: used to determine biofuels emissions net of emissions or avoided emissions that would have occurred due to land use change, e.g. forest or grass land is converted to energy crops
- Residue and waste use reference system: used to determine biofuels emissions net of emissions or avoided emissions that would have occurred due to an alternative use or disposal system for the residue or waste, e.g. waste is landfilled instead used for biofuel.

There are two other situations where reference systems are considered in relation to biofuel production activities.

- The boundaries of the biofuel carbon intensity calculation could be extended to include emissions or avoided emissions from products substituted by co-products of biofuel production activities. However, system extension is not systematically applied to determine the GHG

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implications of co-products because it is not always practical or appropriate. Therefore, co-production substitution reference systems are not systematically included within the boundaries of the biofuel carbon intensity calculation. The treatment of co-products is discussed in a separate section below (section 2.2).

- Fossil fuel reference systems are used to calculate the net GHG emissions resulting from the displacement of fossil fuels by biofuels in transport applications. This calculation is strictly outside the boundary of the biofuel carbon intensity calculation, but is required to establish the net GHG impact of the RTFO policy. Fossil fuel reference systems are discussed in a separate section below (section 2.3).

Alternative land use reference systems

The land on which the biofuels crop is grown could have an alternative use (e.g. food or feed production). The alternative use would have emissions or emissions savings associated with it. Displacing the alternative use could also lead to impacts elsewhere e.g. deforestation.

An alternative land use reference system would need to be selected from a range of possible alternatives (e.g. for oilseed rape in the UK the reference system could be set-aside land, wheat production, oilseed rape production for food, or a number of other arable or break crops). Similarly, if any biomass production that is displaced migrates to another location, the impact could vary widely depending on the land type to which it is displaced, and that land's previous use. If the reference systems were set by the RTFO Administrator:

- They would be inaccurate for a significant proportion of cases, as there will always be a range of alternative land uses and potential biomass production displacement effects.
- It would be very difficult to collect evidence to provide the basis for selecting the most appropriate reference system, since it is very difficult to collect accurate information on what might have happened if something else had not. For example, land-use surveys do not report the alternative to the actual crop grown.
- The most suitable reference system could change frequently (e.g. in the case of UK crop production this could be annually[3]). This would be costly for the RTFO Administrator and it would create uncertainty for the industry.

An alternative to the RTFO Administrator setting the reference system is to allow industry to use actual data in place of a "default" reference system. However, it is impossible to verify a claim that a specified alternative activity would have taken place had the biofuel had not been produced. For example, it would not be possible for a farmer to provide evidence which proves that they would have grown wheat (for food) if they had not grown oilseed rape for

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[3] An example of this in practice is that in the first study by CONCAWE, EUCAR & JRC (2003) no reference system was used for arable production, while in the second study (2006) a reference system was used.

biofuels. Furthermore, the implications of the biofuel production instead of the alternative are difficult to assess, e.g. where and how is the alternative product produced if there is still need for it?

Therefore, we recommend that alternative land use reference systems be excluded from this Methodology. A better way to deal with reference systems is through ex post analysis by the RTFO Administrator. This could be done using regional land use data and scenarios based on comparative reference systems, and would overcome inaccuracy in reporting without the complications of having to include a reference system in the carbon intensity calculation Methodology.

An exception to this is land use change which could result in significant direct GHG emissions, e.g. conversion of forests and managed or wild grasslands. This is addressed below.

It is, therefore, recommended that a second constraint be placed on the initial boundary definition (see Figure 2):

- This Methodology excludes reference scenarios for alternative land use.

Furthermore, it is recommended that:

- The RTFO Administrator should carry out analysis to determine more accurately the policy's net effect on GHG emissions – in particular this should include investigation of the GHG impacts which result from the displacement of alternative land uses by biofuels.

Previous land use reference systems

Conversion of land (e.g. managed or wild grassland, forest) to biofuel production could, in many cases, result in GHG emissions large enough to cancel out the potential benefit of the biofuels. In addition, there could be other significant negative environmental impacts, on biodiversity in particular.

Because of its importance, it is proposed that land use change be included within the carbon intensity calculation methodology. Industry would be required to report on whether or not land use change has occurred and the nature of any change for every batch of biofuel supplied.

Reporting on land use change would occur under Sustainability Reporting because of its broader environmental implications. Fuel suppliers will be required to report on how the land used to produce a biofuel was being used in November 2005 – based on the categories given in Table 1.

Table 1 – Land use type definitions

Land use	Description
Cropland	This category includes cropped land, including rice fields, and agro-forestry systems where the vegetation structure falls below the thresholds used for the Forest Land category. Including set-aside – provided it has not been set aside for more than 5 years.
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 forest) without agricultural use	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.

The Intergovernmental Panel on Climate Change has developed an approach to calculating the GHG emissions resulting from land use changes based on a relatively limited set of qualitative information (IPCC, 2006). Default values have been calculated which will enable fuel suppliers to determine the GHG impact of a land use change by selecting the appropriate default value based on:

- The country in which the land use change occurred
- The land use in 2005 (grassland or forest land)
- The type of biofuel crop (annual or perennial)

A detailed description of how these default values have been calculated is included in Annex 2.

Where no information on land use change is provided, the methodology could automatically penalise the carbon intensity of a biofuel with a default impact of land use change – based on the type of fuel, the feedstock and the origin of the feedstock (e.g. biodiesel produced from soy grown in Brazil). Such default values would require a detailed historical knowledge of what the land uses were for all land used to produce biofuels. The expected geographic scope of imported biofuels (and biofuel feedstocks) means it is unlikely that sufficiently detailed default values could be developed. At best, it might be possible to achieve default values for land use change at the state level within countries such as Brazil and Malaysia. However, this level of detail would almost certainly discriminate against biofuels produced within these areas which did not cause detrimental land use change and for which land use change information was not available or not reported. Therefore, we recommend that

default values not be applied to fuels for which no land use change information is provided. It should be noted that this will mean there is little incentive for companies to report on land use change (since if they do it will only make the carbon intensity of their fuels worse).

However, the RTFO Administrator should use its powers to disclose information publicly to provide an incentive for companies to report on land use change. In particular, the RTFO Administrator could conduct ex post analysis to review the potential GHG emissions which might have occurred as a result of the biofuels for which companies have not reported any data on land use change. The RTFO Administrator could achieve this by:

- Determining the country of origin for all biofuels feedstocks which have no land use change information reported,
- Establishing the risk of biofuels having caused land use changes in these countries (e.g. based on the extent of land use change in these countries, the growth in biofuel feedstock production and the influence of other factors such as expanding food production).
- Estimating the area and types of land use change which might have been caused by biofuels.
- Converting this to a GHG impact (grams CO_2e / MJ), based on the default values derived from the IPCC guidelines.

If the RTFO were to evolve to a scheme which linked the award of Renewable Transport Fuel Certificates to carbon intensity, reporting on land use change would have to be mandatory to create the incentive to report. The implications of such a scheme in relation to technical barriers to trade would have to be carefully considered.

Finally, we recommend that Government can take further steps to avoid undesirable land use change resulting from the RTFO by pursing bilateral and multilateral agreements to improve environmental regulation and, in particular its enforcement, in high risk regions.

It is, therefore, recommended that (see Figure 2):

- Carbon intensity is calculated with and without land use change – using information collected under Sustainability Reporting based in IPCC guidelines.
- The impacts of the RTFO on land use change should be monitored, ex post, in all countries which export biofuels to the UK.

Waste management reference systems

Using wastes as feedstock for biofuels displaces other waste management practices (e.g. landfill, composting etc). This change in practice could result in a net increase or decrease in the emissions of GHGs.

For example, waste management practices may have previously resulted in significant quantities of methane being released into the atmosphere (e.g. digestion of manure in open ponds). Converting this methane into a transport fuel instead, would therefore achieve a significant reduction in GHG emissions.

While it is difficult to set an accurate reference system for waste pathways, on a project by project basis it should be possible to identify the most appropriate reference scenario. Most plants would be diverting a waste stream away from an existing waste management practice such as landfill, incineration, composting etc.

Therefore, we recommend that biofuel producers who use wastes as a feedstock should be able to claim a credit for "alternative waste treatment", as long as supporting evidence can be provided. "Wastes" currently refers to used cooking oil, tallow, organic municipal solid waste, wet manure and dry manure. Because of the difficulty in defining what an accurate reference system would be, the default assumption should be that there is no net increase or decrease in GHG emissions as a result of a change in waste management practices.

It is important to note that the RTFO Administrator will need to monitor the evolution of waste management legislation and practice to determine whether or not the "alternative waste treatments" are in fact likely to have occurred.

Therefore, it is recommended that:

- Biofuel producers who use wastes as a feedstock be allowed to claim a credit for "alternative waste treatment".
- As a default, this credit will be set to zero.

Residue reference systems

Biofuel crops often have residues associated with them – for example, straw from wheat. The use of these residues can have a significant impact on the net GHG savings of a biofuel. If, for example, the wheat straw from a biofuel crop is sold to an electricity generator who co-fires the straw with coal, the net GHG savings achieved would be significantly higher than if the residue was left to decay on the field.

Residues are treated as co-products within the methodology. The reference system for biofuel crop residues is to assume that they are left on the field and that this has no net impact on GHG emissions[4]. The only exception is for the palm oil chain, where an assumption is made that part of the residues (the fibre and the shell) are burnt at the palm oil mill to produce heat and power.

Residues from primary biomass production, such as straw, are not considered as biofuel feedstocks in the chains currently covered by the methodology.

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[4] It is assumed that, within a full crop rotation cycle, there is no net benefit associated with the nutrient value of the crop residues.

> Therefore, it is recommended that:
>
> - Residues are treated as co-products within the methodology
> - The reference system for biofuel crop residues is to assume that they are left on the field and that this has no net impact on GHG emissions

Summary

Figure 2 below summarises the boundaries which are proposed for monthly carbon intensity calculations. It also highlights where the boundaries can be extended for annual carbon reporting, and where ex post analysis could be used by the RTFO Administrator to ensure that the net GHG impacts of the RTFO are understood.
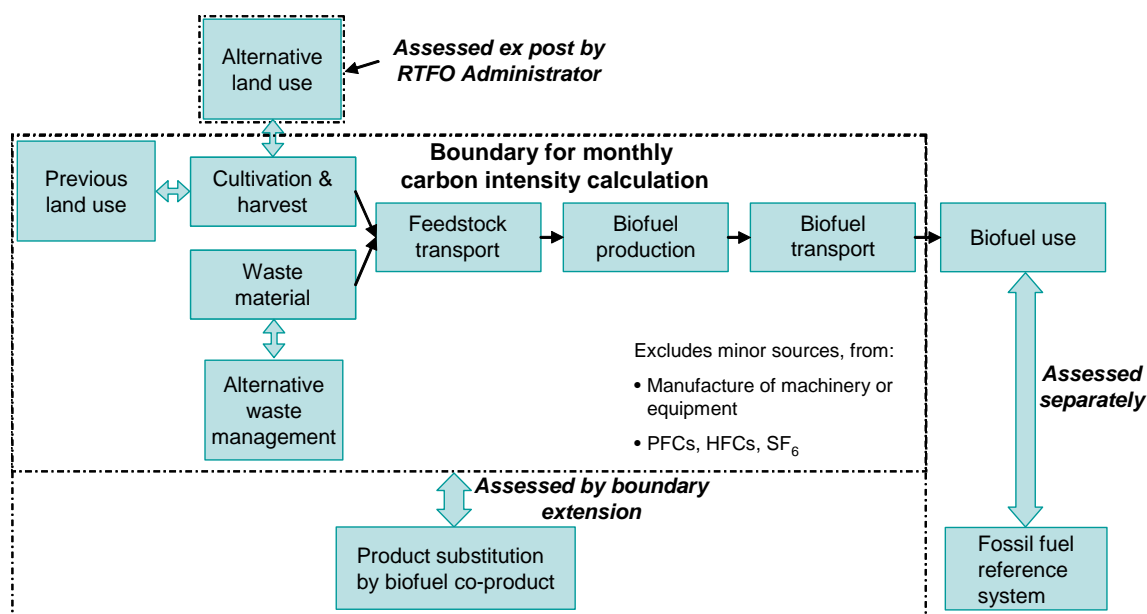

Figure 2 – Boundaries for the carbon intensity calculation

ETBE substituting MTBE

The substation of MTBE by ETBE which has been produced using renewable ethanol must be treated as a special case. MTBE is currently blended with gasoline as a fuel oxygenate. MTBE is a more carbon intensive fuel than gasoline – because the methanol used to produce MTBE is manufactured in a very energy intensive process. This means that ETBE which substitutes MTBE out of the fuel mix will result in a higher GHG saving than it was simply substituting gasoline. This benefit must be taken account of within the system boundaries. Following the approach taken by JEC (2007) the methodology will give ETBE a credit equal to the GHG emissions which would have occurred during the production of the methanol in an equivalent amount of MTBE. Because ETBE has a lower energy content per litre than MTBE, slightly more gasoline will actually be used to compensate – a penalty is given for the amount of gasoline which must be added.

2.2. Co-products

In addition to producing biofuels all of the fuel chains considered by this Methodology produce other products. These include, inter alia: animal feeds, chemicals, electricity and heat. Many of these substitute other products with different (often higher) carbon intensities – for example, rapeseed meal can substitute soy meal for animal feed, while "excess" electricity or heat produced at a biofuel plant could substitute energy produced from fossil fuelled sources.

There are a number of ways in which the effect of co-products on GHG emissions can be taken into account within a biofuel fuel chain. A simple approach is to allocate a portion of the emissions to the co-product based on physical (e.g. mass, energy content, exergy content) or economic properties of the products. If allocation by mass was used as in the example shown in Figure 3, for a biofuel plant that emitted 4 tonnes CO_2e and produced 1 tonne of biofuel and 1 tonne of co-product, each product stream would be "allocated" 2 tonnes of CO_2.
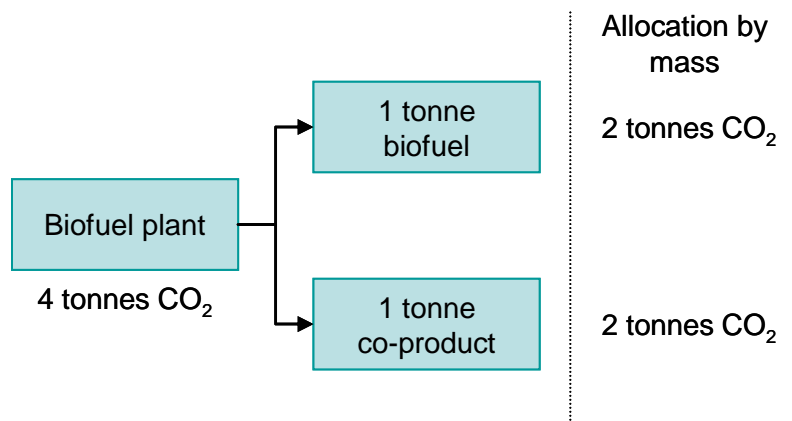

Figure 3 – Allocation by mass

Allocation, however, does not always accurately represent the GHG impact of co-products. The benefit of a co-product should depend on what that co-product actually substitutes. For example, "excess" electricity from a biofuel plant in one country might be substituting hydro electricity with a carbon intensity lower than electricity generated from biomass. In another country the electricity from the biofuel plant could be offsetting generation from a coal-fired power plant. In the first instance the net impact of the substitution would be a slight increase in GHG emissions, while in the second instance, it would be a significant saving.

Extending the boundaries of the carbon intensity calculation and treating the substituted product as part of the biofuel system can be more representative of the GHG impacts. In this way, the biofuel can be credited with the GHG emissions which have been displaced from a substituted alternative product. For example, if the substituted product had a carbon intensity of the 1.5 kg

$CO_2e / t_{product}$ the biofuel would receive an equivalent credit for every tonne of product that is displaced.

While this approach is more accurate than the allocation approach, it is not always appropriate. Figure 4 shows a fuel chain in which wheat is grown to produce ethanol from grain. In addition, the straw is used in a separate CHP plant to produce electricity for export to the grid. Under the substitution approach the ethanol would receive a credit for the exported electricity, based on the difference between the carbon intensity of the electricity generated and the (marginal) carbon intensity of the grid. This creates the potential for double counting when the electricity is sold under a policy regime which recognises (explicitly or implicitly) and rewards low carbon intensity electricity, for example the UK Renewable (Electricity) Obligation. In these situations it will be necessary to fall back on the allocation approach to achieve a result which is sensible and does not create the potential for double counting.
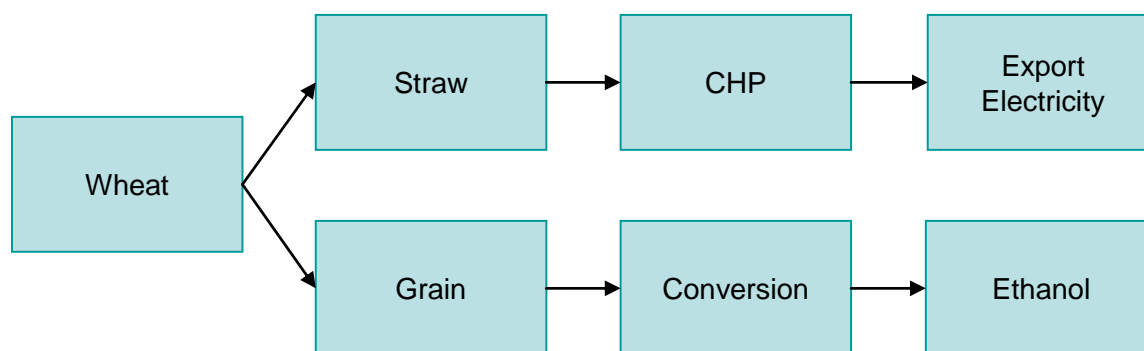
Figure 4 – Electricity co-product of an ethanol production chain.

This methodology will have to address the co-products (actual and potential) from many different fuel chains. In some cases it will not be possible to identify what product is substituted by a particular co-product, while in other situations it could be very difficult to assess the carbon intensity of the substituted product. For these reasons, the methodology allows for the possibility of using allocation by market value as a fall back option for addressing co-products. If the RTFO Administrator is convinced that the information required to address a particular co-product through substitution is not available, then they can specify that allocation by market value will be used for that co-product. The market values used to carry out the allocation procedure should be set by the RTFO Administrator, and they should be based on three year rolling averages (updated annually).

Combing approaches to co-products

It should be noted that, within one conversion plant (e.g. a biofuel plant or an oilseed crushing plant):

- The substitution approach can be used alongside either of the allocation approaches.
- Allocation by market value and allocation by energy content cannot be used simultaneously.

- If allocation by market value is required, it must be used for all co-products, including energy co-products..

Therefore, it is recommended that the approach to address co-products should be flexible and, that the most appropriate approach (i.e. that which most accurately estimates the net GHG impact) should be decided for each individual co-product. In practice, this is means that:

- Substitution will be the first choice approach, and
- Allocation will be preferred when co-products are used for heat or electricity generation or are converted into another biofuel.
- Allocation by market value will be allowed when it is not possible to define a sensible substitution approach.

(see Annex 1 for a detailed list of approaches recommended by co-product)

2.3. Fossil fuel reference systems

A fossil fuel reference system is necessary to convert the carbon intensity of a biofuel to a GHG saving. The **direct** GHG savings resulting from the use of a biofuel depend on:

- The carbon intensity of the biofuel
- The carbon intensity of the displaced fossil fuel,
- The energy efficiency of the vehicles using the fossil fuel and the energy efficiency of the vehicles using the biofuel / fossil fuel blend.

The **indirect** GHG savings resulting from a biofuel take into account additional factors (e.g. alternative land use and previous land use where information has not been reported by companies). These factors will be periodically assessed (ex post) by the RTFO Administrator and reported as part of the overall impact of the RTFO.

The most recent report by JEC (2007) is considered to be the most appropriate source for all of this information. This study has been subject to wide ranging peer review and is generally agreed to be the best available lifecycle analysis study on transport fuels in European conditions.

2.3.1. Carbon intensity of fossil fuels

Table 2 – Carbon intensity of fossil fuels in Europe (JEC, 2007).

Carbon intensity	g CO_2e / MJ_{fuel}
Gasoline	84.8*
Diesel	86.4*
Natural gas	62.0
MTBE	84.3*

* These carbon intensities are 1 g CO_2e / MJ_{fuel} less than the values reported in Appendix 2 of JEC (2007) because emissions beyond the refinery (i.e. distribution to refuelling stations) are ignored.

The carbon intensities given for fossil fuels shown in Table 2 were calculated using the CONCAWE EU refining model. A marginal analysis was carried out to compare the expected situation in 2010 if no biofuels were supplied (the "business-as-usual" case) and if biofuels did displace demand for gasoline and diesel. The carbon intensities of the fossil fuels were obtained by dividing the GHG emissions savings by the displaced volume of fossil fuels.

This approach is preferred to a simplistic allocation method because of the multiple products produced by refineries as well as the complex interactions and synergies within a refinery and between different refineries within a region.

Assumptions made to enabling model the above scenarios included:

- In the base case, oil refineries were required to substantially meet 2010 demand with minimum adaptation of the refining configuration.
- Demands for other oil products were fixed to the values expected in 2010.
- Crude oil supply was fixed, with the exception of a balancing crude (heavy Middle Eastern is considered as the marginal crude).
- Gasoline and diesel maximum sulphur content were assumed to be 10 ppm. All other fuel specifications were assumed to remain at the currently legislated levels.

2.3.2. Energy efficiency of vehicles

Table 3 – Energy efficiency of vehicles using fossil fuels and fossil fuel / biofuels blends in Europe (JEC, 2007).

Fuel	Engine type	MJ / 100 km
Gasoline	DISI	208.8
Gasoline / Ethanol 5% blend	DISI	208.8
Gasoline + ETBE	DISI	208.8
Diesel	DICI	183.1
Diesel / Biodiesel 5% blend	DICI	183.1
CNG	PISI (dedicated engine)	222.8
Biomethane (neat)	PISI (dedicated engine)	222.8*

* JEC (2007) does not calculate a tank to wheel figures specifically for biomethane, however, it is assumed that, if biomethane enters the UK market it will be required to meet fuel standards equivalent to CNG and will, therefore, be chemically very similar to CNG.

The tank to wheel fuel and carbon efficiencies shown above were calculated for theoretical 2010 vehicles using the US National Renewable Energy Laboratory's (NREL) ADVISOR model, adapted to European conditions. The reference driving cycle was the NEDC road driving cycle which is currently used for measuring passenger car emissions and fuel consumption in Europe.

A common vehicle model was assumed, representing a typical European compact size 5-seater sedan, (e.g. VW Golf). All vehicles were designed to comply with a minimum set of performance criteria including: time lag to reach various speeds, gradability, top speed, acceleration and range. All vehicles were required to comply with the relevant EURO IV emissions standards.

The JEC study also assumed that the energy efficiency of vehicles using blended fuels (e.g. 95%/5% diesel/biodiesel) would be the same as when using the base fuel (e.g. diesel). This assumption has been the subject of debate, with some industry players suggesting that the use of biofuel / fossil fuel blends increases energy efficiency (relative to using neat fossil fuels). There is insufficient evidence available in the literature to confirm these claims.

The energy efficiencies shown in Table 3 are based on theoretical rather than actual vehicles and on marginal vehicle technologies (i.e. those which will be entering the market in 2010) rather than "average" efficiencies. However, collecting accurate data which represented average market conditions and allowed for comparison between "equivalent" vehicles (on the basis of the conditions outlined above) would be very difficult.

2.3.3. Calculating well to wheel GHG savings
The GHG savings for a particular biofuel can be calculated using the following formula:

$$\text{GHG saving} = \frac{CI_{biofuel} \times EE_{biofuel} - CI_{fossil\_fuel} \times EE_{fossil\_fuel}}{CI_{fossil\_fuel} \times EE_{fossil\_fuel}} \times 100$$

Where	
$CI_{biofuel}$ = carbon intensity of the biofuel (grams CO_2e / MJ)	CI_{fossil_fuel} = carbon intensity of the fossil fuel displaced by the biofuel (grams CO_2e / MJ)
$EE_{biofuel}$ = energy efficiency of the vehicle whilst operating on a biofuel / fossil fuel blend (MJ / km)	EE_{fossil_fuel} = energy efficiency of the vehicle whilst operating on neat fossil fuel blend (MJ / km)

The assumption (discussed in Section 2.3.2) that a vehicle's energy efficiency is the same regardless of whether it is running on a fossil fuel / biofuel blend or on a neat a fossil fuel implies that 1 MJ of biofuel displaces 1 MJ of fossil fuel. Whilst this is the case, the formula above can be simplified to remove the energy efficiencies – i.e.

$$\text{GHG saving} = \frac{CI_{biofuel} - CI_{fossil\_fuel}}{CI_{fossil\_fuel}} \times 100$$

Calculating well to wheel GHG savings for ETBE displacing MTBE

The only exception to the above approach is when the biofuel being considered is ETBE <u>substituting MTBE (as discussed in Section 2.1.2)</u>. In this case the following formula is used to calculate the GHG saving:

$$\text{GHG saving} = 1 - \frac{CI_{ETBE} \times EE_{ETBE}}{CI_{MTBE} \times EE_{MTBE}} \times (-100)$$

Or, taking into account the assumption that the energy efficiency of a vehicle using ETBE and MTBE would be the same, the formula simplifies to:

$$\text{GHG saving} = 1 - \frac{CI_{ETBE}}{CI_{MTBE}} \times (-100)$$

2.4. Default values

Default values are an essential part of this Methodology – they enable the carbon intensity of a batch of biofuel to be reported, without requiring the company supplying it to collect every single piece of data required to make the calculation. An inherent risk with the use of default values is that the carbon intensity results which are reported do not accurately reflect reality.

The way in which default values are set will have implications on the effectiveness of the RTFO in incentivising the introduction of the least carbon intensive biofuels and on the companies' costs of complying with Carbon Reporting. If Carbon Reporting is to achieve the objective of encouraging the supply of fuels with lower carbon intensities, then it will be necessary to design a default value system which enables and encourages the reporting of qualitative and quantitative information. Section 2.4.1 sets out proposals for how the default values system will *enable* accurate reporting and Section 2.4.2 sets out how it will *encourage* accurate reporting.

2.4.1. Enabling reporting

The simplest default value system would define one carbon intensity number for each different biofuel type (ethanol, biodiesel, biomethane, ETBE). Such a system would obviously make it impossible to accurately differentiate between biofuel types, given the possible variations within supply chains for each type. Therefore, the objectives of Carbon Reporting, as stated in Section 1, would not be achieved.

It is clearly desirable to create a default value system which enables the maximum amount of differentiation between different biofuel types. It is also necessary for the default value system to recognise that companies will have varying levels of information available about each biofuel they supply under the RTFO. In some cases all that might be known about a biofuel is its fuel type (e.g. biodiesel) and that it is of renewable origin, while other biofuels might be accompanied by detailed quantitative information (actual data) on key sources of GHG emission in its fuel chain. Care needs to be taken, therefore, to ensure that *flexibility is inherent in the default value system*.

The following three features of the proposed default value system will enable flexibility and accurate reporting.

Default values will be set for all data points

Default values will be set for every single piece of data needed to calculate the carbon intensity of a fuel chain. This means that the carbon intensity of a biofuel could be estimated without the need to provide any information on the chain. However, any data point for which a default value is provided could be substituted by actual data. Where two or more data points are strongly correlated, it should not be permissible to submit actual data for just one of

these inputs. For example, nitrogen fertiliser use could not be reduced below the default value without changing the default value for crop yield.

Selected defaults

For certain data inputs it is possible to create default values which a company could select between on the basis of qualitative information on their fuel chain. These situations exist:

- Where an input has two or more possible configurations that have significant differences in GHG emissions, and
- Where these different configurations can be characterised qualitatively.

Examples of such situations include:

- The energy supply configuration of a biofuel conversion plant – for example, a plant could use a boiler to provide process heat and draw electricity from the national grid, alternatively the plant could use various CHP configurations to generate both the heat and electricity requirements of the plant. Each of these configurations has different energy efficiencies, in addition, some may produce heat and electricity in excess of what is required at the plant, and these may be sold as co-products.
- The fuel used in the biofuel conversion plant – for example, this could be coal, fuel oil, natural gas, straw or another form of biomass. Each of these sources of energy has different emission coefficients (i.e. kg CO_2e / MJ_{fuel}).
- The mode of transport used to move the biofuel or the feedstock – a number of different transport modes, with different energy intensities and carbon intensities could be used. For example, small trucks, large trucks, coastal shipping, international shipping, rail, pipeline, barges etc.

Levels of default value

The default value system can be made more flexible by establishing default values which correspond to the different levels of information companies are likely to have about a fuel. These different levels are summarised in Table 4.

Table 4 – Four different levels of default value

Level	Description
Input-level defaults	Each individual piece of data needed to calculate the carbon intensity of any biofuel has a default value. These default values vary by fuel, feedstock and origin
Selected defaults	For certain data points, default values will exist which can be selected between on the basis of a qualitative description.
Fuel chain defaults	
Feedstock and origin defaults	A range of default values based on a known fuel type, feedstock and origin – e.g. ethanol from UK wheat.
Feedstock defaults	A range of default values based on a known fuel type and feedstock – e.g. ethanol from wheat.

Level	Description
Fuel defaults	A range of default values based on a known fuel type only – e.g. ethanol.

In summary, it is recommended that:

- Default values should exist for every single input needed to calculate the carbon intensity of each fuel chain under consideration.
- Qualitative evidence should be allowed as a mechanism for more accurately representing a fuel chain through use of selected defaults.
- Fuel chain default values should exist at the levels set out in Table 4.

2.4.2. Encouraging reporting

A key mechanism for encouraging more accurate reporting and reducing the risk of underestimating the carbon intensity of biofuels is to set default values "conservatively" – that is, to set values at a magnitude which represents the worst common practice. For example, if wheat yields in the UK are, on average, around 8 tonne per hectare, but are frequently as low as 6 t/ha, then the latter could be selected as the default value. This principle can be applied to the input-level default values and also to fuel chain default values.

Conservative or typical?

There are clearly risks associated with setting default values at a level which is too conservative:

- Reporting of actual data and the uptake of fuels with a low carbon intensity would be encouraged, but the compliance costs for industry would potentially be high.
- The biofuels' carbon intensity would be overestimated if purely based on default values, making them appear to achieve lower GHG savings than they actually do. This could lead to a lack of public support for biofuels policies because the GHG savings are not thought to be worthwhile.
- The industry might be reluctant to use the Methodology and may attempt to develop alternative schemes.

If, however, default values were not conservative enough:

- There would be little or no incentive for companies to report actual data and the supply of fuels with a low carbon intensity would not be encouraged
- The biofuels' carbon intensity would be underestimated, possibly making them appear to achieve better GHG savings than they do.
- There would be considerable uncertainty about the actual carbon savings of the policy.
- There would be a risk to both the industry and the Government that biofuels would lose credibility as an environmentally friendly fuel if a third

party (e.g. an environmental NGO) demonstrates that the Methodology overestimated GHG savings.

Both of the situations described above are extremes, however, if default values are set conservatively then the policy objective of including carbon reporting within the RTFO (to maximise GHG savings) is more likely to be achieved. In addition, it would be easier to manage the public perception risks if default values were too high – the apparent overestimation could be more easily explained and would have more resonance with the public than the reverse.

There are two important principles to add to this view.

For some data inputs it would be relatively easy for companies to report actual data – for example, a biofuel producer should be able to report on the yield, the energy efficiency and the fuel mix used at its plants. However, some data is scientifically and practically more difficult to collect – for example, N_2O emissions from soils are notoriously difficult to measure because emissions vary between fields on the basis of soil type, daily climate, cultivation techniques, the rates and timing of fertiliser application and the crop which is grown (JEC, 2007). Therefore, it would be appropriate to set input-level default values for which it is "difficult" to report actual data at a magnitude representative of typical practice rather than at a conservative magnitude.

Most biofuel chains have approximately five major sources of GHG emissions, with the remainder made up of a large number (e.g. 15 – 20) of sources which contribute less than 5% individually (see Table 5). If a company wanted to report actual data on their fuel chain rather than relying on input-level default values they would optimise their efforts on the basis of impact (in terms of reducing the carbon intensity for their fuel chain) and cost of reporting. The sensitivity of the overall fuel chain result to an input which only contributes 5 percent is low – if it were technically possibly to halve this source of emissions, it would still only decrease the carbon intensity of the entire fuel chain by 2.5 percent.

Table 5 – Breakdown of sources of GHG emissions from oilseed rape to biodiesel chain (adapted from Mortimer and Elsayed, 2006)

Contribution	Sources
Greater than 10%	N_2O emissions from soils (Crop production) N fertiliser (Crop production) Methanol (Conversion - esterification)
5 – 10%	Natural Gas (Conversion - esterification) Natural Gas (Conversion - crushing)
2.5 – 4.9%	Diesel Fuel (Crop production) Pot. Hydroxide (Conversion - esterification) Electricity (Conversion - crushing) Electricity (Conversion - esterification)

Contribution	Sources
Less than 2.5%	Diesel Fuel (Feedstock transport)
	Fuel Oil (Drying and storage)
	P fertiliser (Crop production)
	Nitrogen (Conversion - crushing)
	K fertiliser (Crop production)
	Compressed Air (Conversion - crushing)
	Steam (Liquid fuel transport & storage)
	Pesticides (Crop production)
	Electricity (Drying and storage)
	Sulphuric Acid (Conversion - esterification)
	Electricity (Drying and storage)
	Seeds (Crop production)
	Nitrogen (Conversion - esterification)
	Hexane (Conversion - crushing)
	Caustic Soda (Conversion - crushing)
	Citric Acid (Conversion - crushing)
	Electricity (Liquid fuel transport & storage)

In practice, there would be little interest in reporting actual data on the sources of emission which represent 5 percent or less of total fuel chain emissions. Setting these input-level default values at a conservative magnitude causes the carbon intensity of the fuel chain to be overestimated (exposing Carbon Reporting to the risks discussed above) without creating sufficient incentive for companies to report actual data. Therefore input-level default values for sources of GHG emissions that contribute less than 5 percent of the total emissions from a default fuel chain should be set at a magnitude representative of typical practice rather than at a conservative magnitude.

It is therefore recommended that:

- The magnitude of input-level default values is determined by the ease of reporting actual data and their contribution to overall fuel chain carbon intensity (as shown in Figure 5).
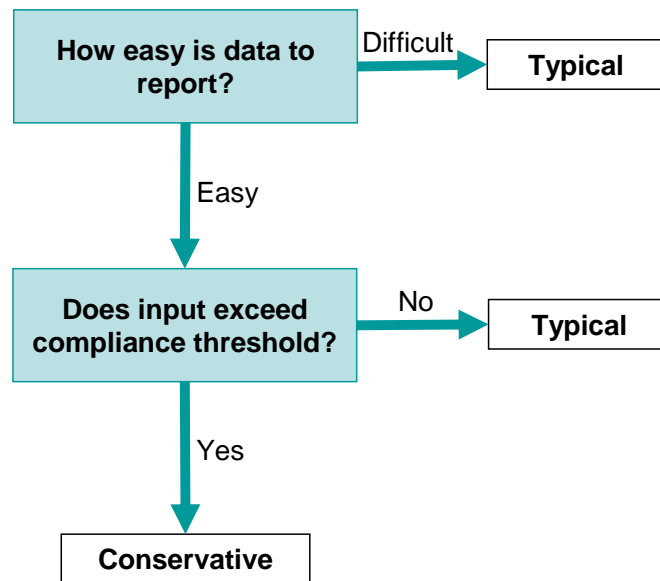
Figure 5 – Approach to selecting appropriate magnitude for input level default values

Fuel chain default values

Feedstock & origin, feedstock and fuel default values will be established on the basis of the relevant input-level default values. The magnitude selected at the input-level will be maintained for these higher level default values. This is expected to define defaults which are conservative.

The process for setting these higher-level default values is as follows:

- Feedstock and origin default values will be set using input-level default values and default fuel chains.
- Feedstock default values will be set equal to the feedstock and origin default value from the country which has the highest carbon intensity (provided the fuel from this feedstock and origin is likely to make up 5% of the market or more).
- Fuel default values will be set equal to the feedstock default value from the feedstock which has the highest carbon intensity (again provided the fuel from this feedstock and origin is likely to make up 5% of the market or more).

Allowing industry time to adapt

Both existing and planned biofuel companies have established (or are establishing) their production processes and the supply chains on the basis of what is currently the most economically rational approach. At the present time there is no economic incentive to design processes or establish supply chains in a way which minimises the carbon intensity of the biofuels that are produced (with the exception of the cost of energy). The introduction of Carbon Reporting opens up the opportunity to create such an incentive – be it driven by public, shareholder or Government pressure.

From the industry's point of view, therefore, there is a strong argument that they should be given time to understand how Carbon Reporting might have an

impact on their business and to best assess their options. It is difficult to assess how much time would be required to adapt to the implications of Carbon Reporting. From the Government's point of view, it may be worthwhile considering options for allowing industry time to adapt, as such flexibility would reduce the risks to early players in the industry and would increase the likelihood of the RTFO's objectives being achieved.

As discussed earlier it will be easier to report actual data for some inputs than others. The inputs which were defined as being difficult to report on in Section 2.4.2 were those which were scientifically or practically difficult to report. However, there is another subset of inputs which could be considered difficult to collect in the initial stages of Carbon Reporting. From the perspective of the obligated company or biofuel producer, the further upstream a GHG emitting activity takes place the more difficult it is likely to be to report on initially. This is due to a number of factors, including: the number of actors upstream (e.g. the wheat for one biofuel plant might come from thousands of different farms) and also the distance (both physical and in terms of the number of intermediaries) between the actors who are involved upstream. It is these upstream sources of GHG emissions which existing biofuel companies would find most difficult to influence in the short term.

One mechanism for giving the industry time to adapt to Carbon Reporting is to create a third "ease of reporting" category for certain upstream sources of GHG emission called "Difficult (Phase 1)". In the first phase of the RTFO the default values for these sources would then be set at a typical magnitude. In Phase two of the RTFO this set of default values would then be changed to a conservative magnitude – see Figure 6.
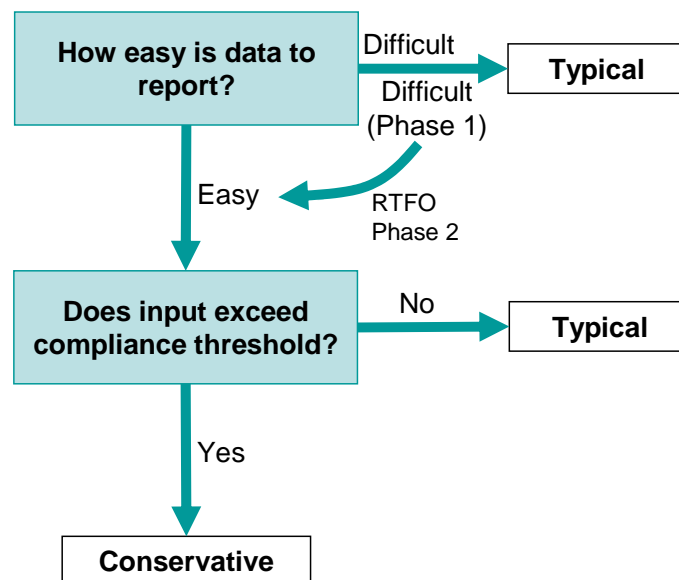

Figure 6 – Proposal for setting certain upstream default values at typical level for Phase 1.

> **It is therefore <u>recommended</u> that**
> - Industry be given time to adapt to the introduction of Carbon Reporting by initially setting the magnitude for a subset of default values (which are currently more difficult to report, but which should become easier to source actual data on over time) at a typical level, but changing this to a conservative level for the second phase of the RTFO.

2.4.3. Process for setting default values

The default values have been established by the following process:

1. A group of international experts were asked to define each of the ten fuel chains – that is, to set out the individual steps in the fuel chain, to list all of the sources of GHG emissions which fall within the boundaries defined in Section 2.1 (e.g. N fertiliser, natural gas use, transport etc) and to set out the calculation steps necessary to derive the carbon intensity for the fuel.

2. E4tech then reviewed these fuel chains to ensure that they were consistent and the steps to calculate the carbon intensity were correct. All the potential sources of emissions were also checeked against existing lifecycle analysis studies.

3. The expert group was then asked to collect data on each data point within the 10 fuel chains. The expert group was asked to provide the following information: best practice, typical practice and worst common practice values for each data point; comments on the accuracy of these values and how frequently the should be updated; distribution of practice within those ranges; and, ease with which data could be collected. The approach to setting the magnitude of default values (as described in Section 2.4.2) was explained to the expert group, but they were not asked to make recommendations on which values should be set at a conservative level and which should be set at a typical level.

4. E4tech then reviewed these values, in particular comparing them against values cited in the literature.

5. E4tech then defined whether the ease of reporting was "easy" or "difficult" – based on the information provided by the expert group. Recommendations were also made on how frequently values should be updated.

6. The appropriate magnitude for a default value was then selected from the values provided by the expert group (under (3)).

7. Finally, these values were reviewed by industry and other stakeholders.

2.5. N_2O emissions from soils

The N_2O emissions from soils that biofuel feedstocks are produced on are often one of the largest contributors to the carbon intensity of a biofuel. Because it is not envisaged that N_2O emissions will ever be measured directly it is appropriate to discuss how they will be calculated within the methodology.

The N_2O emissions from a particular field depend on soil type, daily climate, tillage practices, fertiliser rates and crop type. The most accurate approach to calculating the emissions from a particular field are to use a detailed soil chemistry model[5] which takes account of all of these factors. However, we do not considered it practical for the purposes of the RTFO to require companies to report all of the data needed to use such models.

An alternative is to use the approach developed by the IPCC (2006) which simply correlates N_2O emissions with nitrogen fertiliser rates. This approach is preferred for the RTFO methodology because it has the benefit of being simple and making N_2O emissions proportion to the driving factor which can most practically be influenced by the biofuel industry.

In the future, the RTFO administrator may wish to consider developing correlations between nitrogen fertiliser and N_2O emissions which vary by other factors such as crop type and country of origin.

In summary we recommend that the approach developed by the IPCC (2006) to N2O emissions with nitrogen fertisilser rates is adopted by the RTFO Administrator.

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[5] For example the DNDC model developed by researchers at the University of New Hampshire, or the DAYCENT model, which is a version of the CENTURY soil organic matter model developed at the Natural Resource Ecology Laboratory at Colorado State University.

3. Fuel chains

All biofuels are produced using a similar set of steps. Most require a crop to be grown, harvested and the seed to be dried to an appropriate moisture content before it is converted into a biofuel and transported to the point of use. A biofuel produced from waste follows similar steps; however, instead of being grown and harvested, it has to be collected.

- Because the sources of GHG emissions from each step in the biofuel chain are relatively similar it is possible to generalise these steps in to a set of "modules". These modules, shown in Figure 1, can be used as the basis for defining any fuel chain. Only the modules highlighted in blue below are needed for defining the ten fuel chains currently considered by this Methodology.
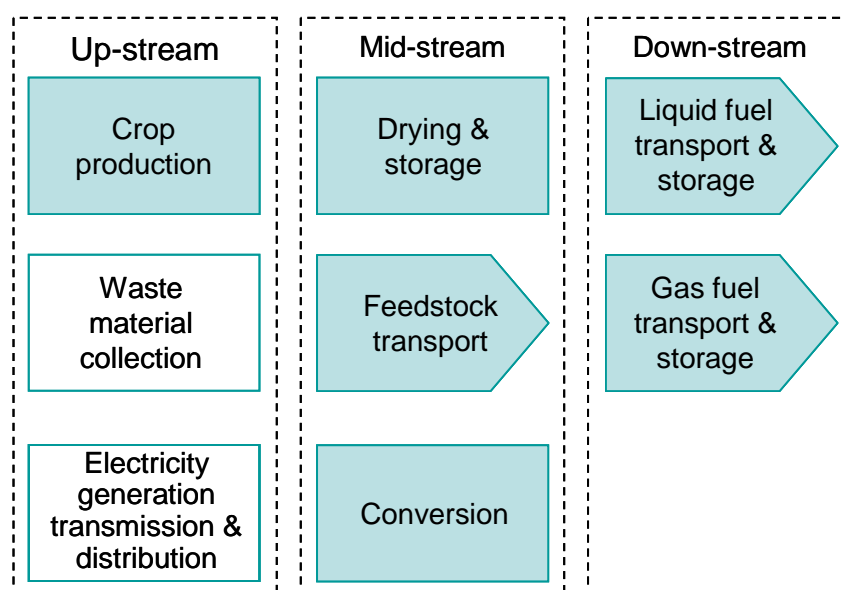
Up-stream	Mid-stream	Down-stream
Crop production	Drying & storage	Liquid fuel transport & storage
Waste material collection	Feedstock transport	Gas fuel transport & storage
Electricity generation transmission & distribution	Conversion	

Figure 7 – Module library

Generic GHG sources

The generic sources of GHG emissions identified within each of these modules are:

- *Crop production*: N_2O emissions from soil, fertiliser use, pesticide use, fuel for cultivation & harvesting, other inputs (including electricity for irrigation)
- *Drying and storage*: fuel for process heat, electricity
- *Feedstock transport*: fuel for transport
- *Conversion*: fuel for process heat, electricity, chemical use, co-products[6]
- *Liquid fuel transport and storage*: fuel for process heat[7], fuel for motive power (e.g. pumping) and fuel for transport

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[6] Generally a credit rather than a source.
[7] For example to keep fuels at the correct temperature

- *Gas fuel transport and storage*: fuel for motive power (e.g. compression and pumping).

The remaining modules may become necessary at some point in the future:

- *Waste material collection*: could be relevant when considering residues or waste that would not have otherwise been collected from its original source, for example, forestry pruning waste. However, collection of the waste feedstocks considered in the ten existing chains is not considered.
- *Electricity generation, transmission & distribution*: is only likely to be relevant to hydrogen production from electricity (via electrolysis), when a dedicated electricity generation system is used – for example, when an electrolysis plant is coupled to a wind farm.
- The *drying and storage* module could eventually be extended to include "sizing" (i.e. "drying, storage and sizing") of biomass when second generation biofuels begin to be available on the market. The more general term of "pre-processing" has not been used because it can easily be confused with steps within the conversion module which are generally referred to as pre-processing.

Defining a fuel chain

The process recommended for defining a fuel chain is as follows:

1. Identify all of the main processes which occur during biofuel production.

2. Match these processes with modules from the library and arrange in sequential order.

3. Ensure that:

   - The starting point is *crop production*, *waste material collection* or *feedstock transport*.

   - The chain includes at least one *conversion* module. More than one *conversion* module should be included if there are *conversion* processes which are typically carried out on separate sites (e.g. oil seeds are not typically crushed at the biodiesel plant).

   - *Feedstock transport* modules should be included between all other steps up until the conversion module which produces the final biofuel (blended or neat).

   - The end point is the duty-point – i.e. the point at which the fuel will be required to pay UK excise duty as a road fuel. In practice this means the final step in the chain should be either *liquid fuel transport & storage* or *gas fuel transport & storage*.

4. Where appropriate, the generic sources of GHG emissions within each module should then be tailored to the specific fuel chain – for example, within the *crop production* module "fertiliser use" should be expanded to cover all of the fertilisers used in that specific fuel chain (nitrogen, lime, potassium, phosphorus etc).

5. Any new sources of GHG emission should be added (e.g. for sugar cane to ethanol, manual harvest involves burning of the sugar cane which is not a generic data input category in the *crop production* module).

References

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.

JEC (2007), *Well-to-Wheels analysis of future automotive fuels and powertrains in the European context*. CONCAWE, EUCAR, ECJRC.

Annex 1

Summary of Co-product Approaches

Co-product	Fuel chains applicable to	End use	Substituted product	Approach
Straw / stover etc	Wheat to ethanol, corn to ethanol	Energy	E.g. natural gas, coal etc	Allocation by energy content
Palm fibre and shells	Palm to biodiesel	Energy	E.g. natural gas, coal etc	Allocation by energy content
Palm kernel olein	Palm to biodiesel	Wide range	Wide range	Allocation by market value
Palm kernel stearin	Palm to biodiesel	Wide range	Wide range	Allocation by market value
POME[8]	Palm to biodiesel	Fertiliser	Other fertilisers	Within system boundaries
DDGS[9] / WDGS[10]	Wheat to ethanol, corn to ethanol	Animal feed	Soy meal	Substitution
DDGS[11] / WDGS[12]	Wheat to ethanol, corn to ethanol	Energy	E.g. natural gas, coal etc	Allocation by energy content
Rape meal	Oilseed rape to biodiesel	Animal feed	Soy meal	Substitution
Rape meal	Oilseed rape to biodiesel	Energy	E.g. natural gas, coal etc	Allocation by energy content
Soy meal	Soy to biodiesel	Animal feed		Substitution (wheat)
Soy meal	Soy to biodiesel	Energy	E.g. natural gas, coal etc	Allocation by energy content
Palm stearin	Palm to biodiesel	Wide range	Wide range	Allocation by market value
Electricity	All	Export	E.g. natural gas, coal etc	Allocation by energy content
Heat	All	Export	E.g. natural gas, coal etc	Allocation by energy content
Chemicals (e.g. glycerine, potassium sulphate)	All	Wide range	Wide range	Allocation by market value

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[8] Palm oil mill effluent.
[9] Dried distillers grains with solubles.
[10] Wet distillers grains with solubles.
[11] Dried distillers grains with solubles.
[12] Wet distillers grains with solubles.

Annex 2 – Land use change calculations

Default values have been developed in order to understand the impact of land use change on carbon intensity (in kg CO_2e / hectare). These were derived using the IPCC "tier 1" methodology (IPCC, 2006) which gives a set of default values based primarily on climate zone, ecological zone and soil type. This Annex summarises the assumptions made when calculating each of these changes – it is not intended to be a stand alone description and should be read alongside the IPCC methodology.

Default values have been developed, by country, for changes from forest land and grassland to both annual and perennial biofuel crops. The categories of emissions included in the default values are:

- Change in carbon stocks in biomass
- Change in carbon stocks in dead organic matter
- Change in carbon stocks in soils

Assumptions

The following table indicates the climate zones which were assumed for the countries from which the UK is expected to import biofuel feedstocks.

Country	Climate zone	Ecological zone
Argentina	Warm temperate, dry	Temperate continental forest
Australia	Warm temperate, dry	Temperate oceanic forest
Brazil	Tropical, wet	Tropical rain forest
Canada	Cool temperate, dry	Temperate continental forest
France	Warm temperate, moist	Temperate continental forest
Germany	Cool temperate, moist	Temperate continental forest
Indonesia	Tropical, wet	Tropical rain forest
Malaysia	Tropical, wet	Tropical rain forest
Poland	Cool temperate, moist	Temperate continental forest
United Kingdom	Cool temperate, moist	Temperate oceanic forest
USA	Cool temperate, dry	Temperate continental forest

Other assumptions were:

1. For calculating changes in carbon stocks in biomass it is assumed:

   - Carbon stock immediately after land use conversion is zero

   - All biomass carbon (from a biofuel) is lost when annual crops are harvested, but none is lost for perennial crops.

2. For calculating changes in carbon stocks in dead organic matter it is assumed:

   - The amount of "dead wood/litter [carbon] stock" under the old land use category is equal to an average of the two IPCC default values given for each climate zone (for two forest types: broadleaf deciduous & needle-leaf evergreen).

- The amount of dead wood/litter carbon stock for the **new** land use category is zero.

3. For calculating change in carbon stocks in soils it is assumed:

- As a default, biofuels are grown on mineral soils, not organic soils

- The stock change factors for management regime and carbon input both before and after the land use change were assumed to be equal to 1. The stock change factor for land use system before the change was also assumed to be 1.