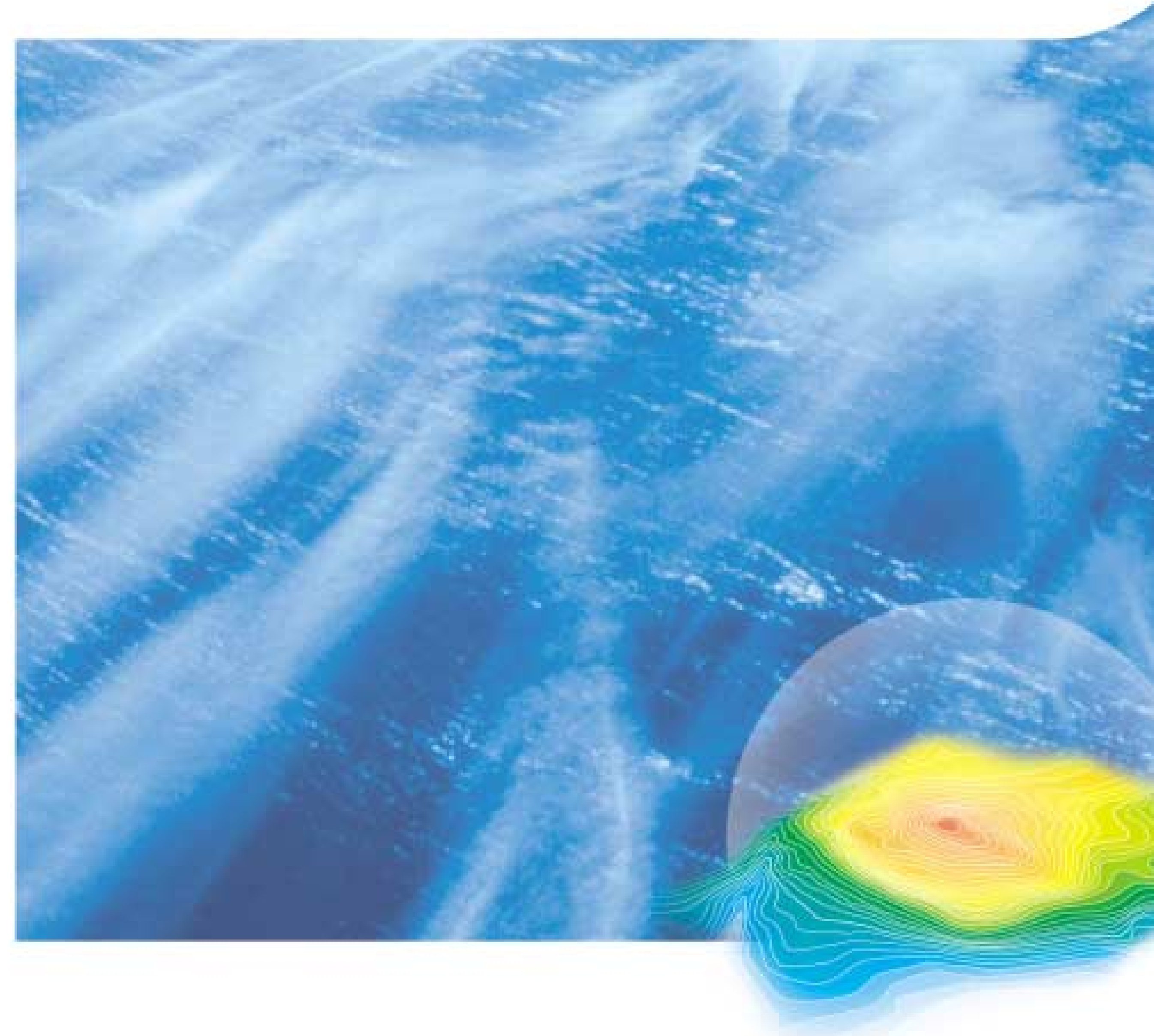
SUSTAINABLE ENERGY IRELAND



Liquid Biofuels Strategy Study for Ireland

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Liquid Biofuels Strategy Study for Ireland

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Sustainable Energy Ireland

Sustainable Energy Ireland (SEI) is Ireland's national energy agency. Established on May 1st 2002 under the Sustainable Energy Act 2002, SEI has a mission to promote and assist the development of sustainable energy. This encompasses environmentally and economically sustainable production, supply and use of energy, in support of Government policy, across all sectors of the economy. Its remit relates mainly to improving energy efficiency, advancing the development and competitive deployment of renewable sources of energy and combined heat and power, and reducing the environmental impact of energy production and use, particularly in respect of greenhouse gas emissions.

SEI is charged with implementing significant aspects of the Green Paper on Sustainable Energy and the National Climate Change Strategy as provided for in the National Development Plan.

SEI manages programmes aimed at:

- assisting deployment of superior energy technologies in each sector as required;
- raising awareness and providing information, advice and publicity on best practice;
- stimulating research, development and demonstration;
- stimulating preparation of necessary standards and codes;
- publishing statistics and projections on sustainable energy and achievement of targets.

SEI is responsible for advising Government on policies and measures on sustainable energy; implementing programmes agreed by Government and stimulating sustainable energy policies and actions by public bodies, the business sector, local communities and individual consumers.

Executive summary

The EC Biofuels directive 2003/30/EC demands from the member states that a share ("Reference Percentage") of 2 % on energy basis in 2005 and 5.75 % in 2010 of the fossil fuels sold on their transportation markets should be replaced by biofuels. To assist the Irish government in the formulation of goals and strategies as required by this Directive, Sustainable Energy Ireland has commissioned a consortium of Ecofys, Teagasc, and the Fraunhofer Institute to quantify the impacts of the establishment of an Irish biofuel industry and to identify the most strategic routes towards the implementation of the EC transport biofuel directive.

Biofuel resources availability

Ireland is able to produce about 12 PJ of biofuels, being about equal to the 2010 target. However, that would imply that part of the current feed crops is to be used for energy purposes. This normally induces additional feed import. If such induced import is to be avoided, a realistic estimate of the Irish biofuel resources availability (being 2.8 PJ) comprises about 79 % of the 2005 and 23 % of the 2010 target.

Significantly larger amounts of advanced biofuels (12 PJ) could be produced from lignocellulose residues, if these become available in the medium (post 2010) and long term.

Technical and legal limits to introducing biofuels

Meeting the 2005 Reference Percentage is possible under current fuel standards and directives with all biofuels considered. However, these standards and directives do not give sufficient space for meeting the 2010 Reference Percentage of the biofuel directive. One can only meet this directive by applying:

- **(Partly) using biofuels that do not meet the current gasoline directive regarding ethanol or the current diesel standard.**
- **Adapting the standards that maximize the ethanol and biodiesel percentages, before 2010.**
- Introducing new biofuels (other than ethanol and FAME) that meet the current gasoline and diesel directives and standards

Benefit for the environment

The best estimate of the well-to-wheel (WTW) greenhouse gas (GHG) emission for biodiesel from rape-seed is about 50% of that of conventional diesel. Bio-methyl ester from RVO emits about 16% of the diesel WTW GHG emission. Bioethanol from sugarbeet emits about 45 % as compared to gasoline, and from wheat this is about 33% of the gasoline emission.

Delivered biofuel cost

Because of different heating values, costs of biofuels and fossil fuels are best compared on the basis of their energy content. Biodiesel from rape seed at the refilling station[*] costs about 25 €/GJ (0.80 €/l), which is about 2.5 times higher than the cost of fossil diesel. Biodiesel produced from tallow or RVO costs

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[*] This cost includes cost for blending, and costs and margin for fuel distribution and retail, but excludes excise duty and VAT.

about 17 €/GJ (0.56 €/l). Ethanol (from wheat) can be delivered at about 27 €/GJ (0.58 €/l), as compared to 11 €/GJ (0.33 €/l) for gasoline

In the long term, Fischer Tropsch diesel is expected to be produced for a cost that is roughly 30% higher than current fossil diesel costs. Long-term estimates for ligno-cellulosic biomass indicate cost levels of about 16 €/GJ (0.33 €/l).

In order to get equal litre prices for the consumer at the pump for RME an excise duty exemption is required of about 47 ct/l (being higher than the actual excise, 37 ct/l). In the case of RVO based biodiesel, the required excise exemption would be about 22 ct/l. In the case of ethanol from wheat, the excise exemption needed would be about 25 ct/l (as compared to an excise of 44 ct/l).

Greenhouse gas emission reduction costs about 340 €/tonne CO_2-eq. when using biodiesel. With RVO based biodiesel this is about 100 €/tonne. In the case of bioethanol, this is 300 - 450 €/tonne.

Import of biomass and biofuels

The countries of the EU-15, as well as the EU-25, show large surplus potentials of biodiesel or bioethanol, compared to the targets of the biofuel Directive for 2005. For 2010, the countries of the EU-15, as well as the EU-25, show surplus potentials only when there is a focus on bioethanol.

The export potentials from other world regions (in particular from Brazil, China and Thailand) are very large compared to the size of the Irish (and EU) market. The costs (including transport to the EU) can be significantly lower than EU biofuels' production costs.

Macro-economic impacts

Although employment involved will generally be higher, the introduction of (5.75%) biofuels will contribute less to the Irish GDP than the current use of fossil fuels. The main reasons for this are the difference in cost price and the fact that, in order to achieve the 5.75%, Ireland will need a significant amount of (direct and/or indirect) import.

Importing ethanol from Brazil may be more attractive for the Irish treasury than using Irish wheat, that is currently used for feed production, for local bioethanol production.

Policy incentives, and evaluation

Most EU countries currently choose excise duty exemption as the central policy instrument for the implementation of the biofuel directive. It is relatively easy to implement. Disadvantages to this instrument are the fact that it generally gives no long-term guarantee, which is a disincentive for investments and innovation. Another disadvantage is that the cost to the government is relatively high.

An alternative is an obligation in combination with a certificate system. The sellers of transport fuel are then obliged to redeem a certain amount of biofuel certificates at the end of the year. An advantage of this system is that one has the guarantee that the target will be obtained using the market mechanism as a driver. Furthermore, it is a flexible system, which could incorporate other elements, such as information about the sustainability of (imported) biofuels, in the longer term. Other interesting policy alternatives may be a levy/subsidy system or a tendering system.

Contents

1 Introduction

1.1 Ireland and the European biofuels context

Directive 2003/30/EC (see Annex A) demands from all EU Member States that a minimum proportion of transport biofuels or other renewable fuels should be sold on their markets. The EC gives Reference Percentages of 2 % by 31 December 2005 and 5.75 % by 31 December 2010. These reference percentages are on the basis of energy content* of all gasoline and diesel for transport purposes.

All member states are required to set national indicative targets, and to report on the measures taken to promote biofuels, the amount of national resources allocated for the production of these biofuels, and on the actual biofuel sales. To assist the Irish government in the formulation of goals and strategies as required by this Directive, Sustainable Energy Ireland has commissioned a consortium of Ecofys, Teagasc, and the Fraunhofer Institute to quantify the impacts of the establishment of an Irish biofuel industry and to identify the most strategic routes towards the implementation of the EC transport biofuel directive.

1.2 Biofuels

Many types of transport biofuels exist: ethanol from sugar and starch crops, biodiesel from oil, pure bio oil, and fuels produced from wood or grasses by advanced technologies. All have very different properties **Figure 1-1** contains an overview of a few main routes for the production of transport biofuels.

Some of these fuels can be delivered to a central point or gas stations by existing infrastructure, while others need new tanker trucks or pipelines. Most biofuels are suitable for current internal combustion engine vehicles (ICEVs) as well as future fuel cell vehicles (FCVs) using on-board reforming. In some cases the fuel can be used without any change to the engine, but in most cases adaptations (fuel system materials, calibration) are necessary [1]. Refuelling and on-board storage (especially for hydrogen) may involve technologies that are not yet commercially available.

* On a Lower Heating Value (LHV) basis

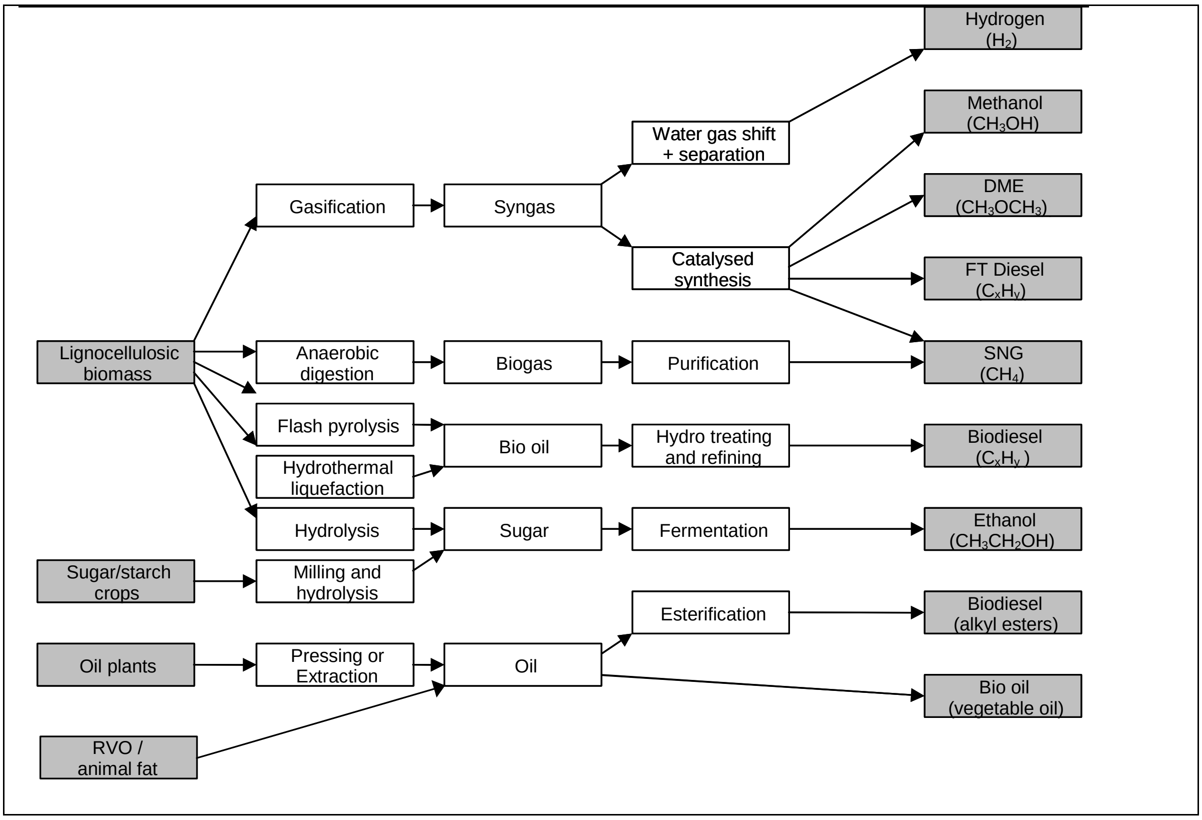


Figure 1-1. Overview of conversion routes to biofuels [2; 3] [Φ]

Some transport biofuels are already in use. Extensive experience with alcohol (ethanol) use for transportation exists in Brazil, the USA, and some other countries. In Brazil, cheaply available cane sugar has allowed a large and competitive ethanol fuel market to supply 11.3 % of the total primary energy consumption [4]. A National Alcohol Programme was created in 1975 (ProAlcool) to reduce oil imports, to protect the sugarcane plantation industry, to increase the utilization of domestic renewable-energy resources, to develop the alcohol capital goods sector and process technology for the production and utilization of industrial alcohols, and to achieve greater socio-economic and regional equality through the expansion of cultivable lands for alcohol production and the generation of employment [4-6]. Ethanol is produced from maize (corn) in the USA and, on a much smaller scale, from wheat and sugar beets in Europe [7]. Biodiesel (methyl ester) is produced from rape-seed in Europe (especially Germany and France) and from soybeans in the USA.

The EU production and use of biofuels has increased rapidly over the past 10 years: biodiesel ten-fold and ethanol almost five-fold.

1.3 Selection of biofuels to be analysed

The focus in this study is on the short-term implementation of mainstream biofuels. Mainstream means that the biofuels or blends do not require any adaptations to the common transportation fleet, and that they can be bought at ordinary refilling stations. These fuels will have to meet official standards and directives (see Chapter 4). Biofuels that cannot be certified as a mainstream fuel, such as pure plant oil,

[Φ] See reference section of the document are therefore not included in this report. Several biofuels that may be used within official standards and directives mentioned, are technically fully proven and can be implemented on a commercial scale at this moment are selected for this study (see **Table 1-1**).

Table 1-1. Biofuels selected for this study.

Short-term	
Gasoline replacement	**Diesel replacement**
Ethanol from wheat	Biodiesel from rape-seed
Ethanol from sugar beet	Biodiesel from recoverable vegetable oil
Ethanol from biomass residues	Biodiesel from tallow
Long term	
Ethanol from lignocellulosic biomass	Fischer-Tropsch diesel from lignocellulosic biomass

The abovementioned short-term biofuels can be implemented directly. However, there is also a range of very promising biofuels, that may be implemented in the medium (e.g. towards 2010) to long term. Two examples of these fuels that can (partly) replace gasoline or diesel will also be discussed.

1.4 Neat fuel comparison basis

In this study, the main focus will be on the introduction of biofuel via blends with fossil fuels. The main advantage of blends, as compared to pure biofuels, is that existing transportation fuel specifications can be met, allowing the fuel to be used in all cars without the need for vehicle adaptations. This would facilitate a relatively fast transition towards biofuels.

To illustrate the differences between biofuels and fossil fuels, we use the "neat fuel comparison basis" in the analyses in this report. This means that, as shown in **Figure 1-2**, we concentrate only on that part of the blend that is affected by the introduction of biofuels.

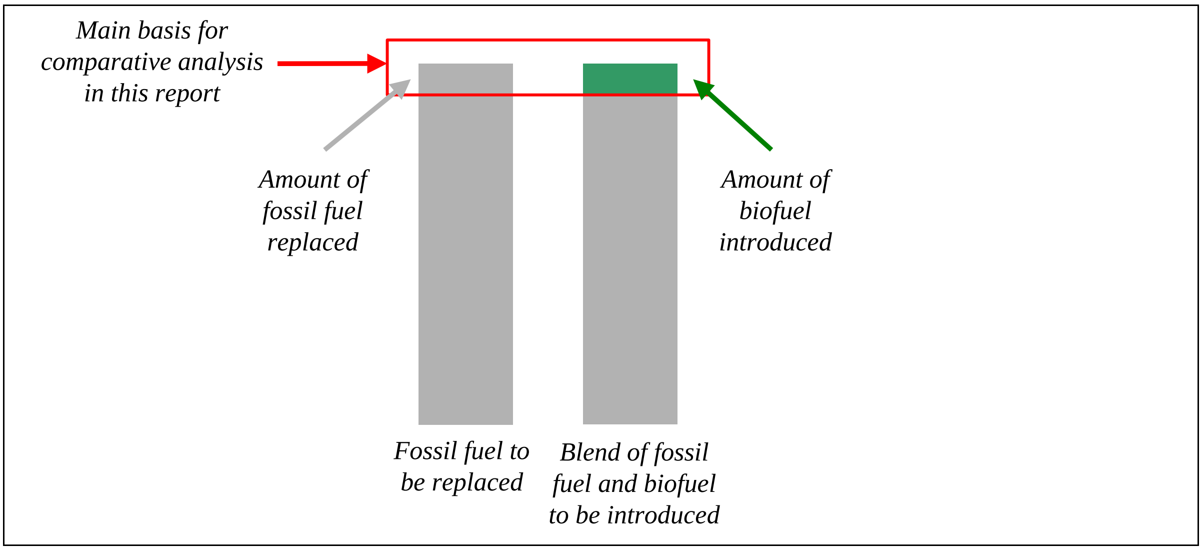


Figure 1-2. Schematic representation of the "neat fuel comparison basis" for the comparison between a 100% fossil fuel and a fossil fuel / biofuel blend

The introduction of a certain amount of biofuel in a blend, means that a corresponding amount of fossil fuel is replaced. We concentrate the analysis on the part within the red square in **Figure 1-2**, i.e. the part of the fossil fuel that is actually replaced versus the biofuel that is actually introduced.

2 Irish Transportation Fuel Context

2.1 Current and future use of transport fuels

Thirty nine percent of Ireland's final energy consumption is in transportation, with 26 % of total national CO_2 emissions originating from this sector [8]. There has been a strong growth during the nineties of an average 6 % per year for gasoline and 9 % per year for diesel. The reason is twofold: The total amount of vehicles on Irish roads rose by 60 % to 1.68 million, and average engine sizes increased over the same period. Other factors affecting the huge growth in transport energy usage are: the increase in average annual mileage per car and congestion, leading to inefficient driving patterns.

Figure 2-1 shows both the Irish historical gasoline and diesel use [11], and the projected future use until 2010. In 2002 the transport fuel consumption was 189 PJ; 44 % of this was diesel, 37.9 % gasoline, and the rest mainly kerosene for planes. The projection assumes an annual growth rate between 2002 and 2005 of 4% and between 2005 and 2010 of 3.3 % in accordance with the GDP growth [10]. Historically, there has been a continuing change from gasoline to diesel of 0.5% per year [8].

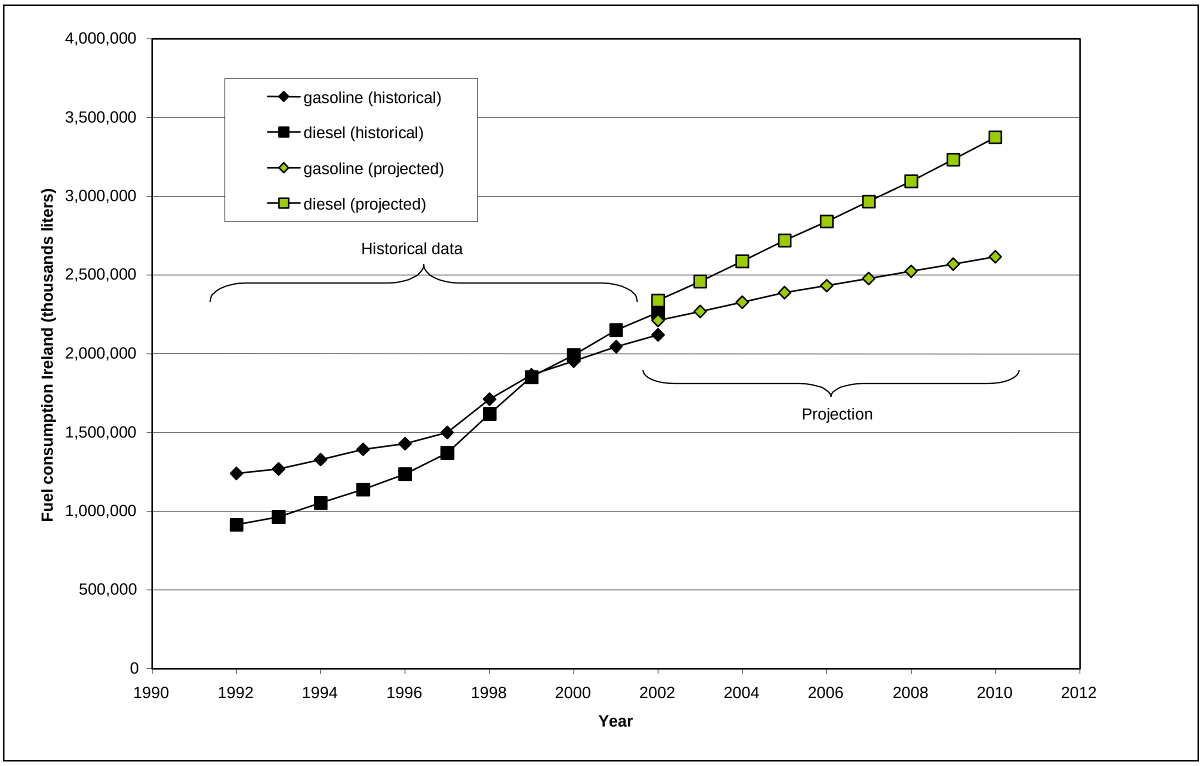


Figure 2-1. Historical excised gasoline (leaded and unleaded) and diesel consumption [9], and projection until 2010 [8; 10].

In energy values the current energy use in surface transport is 82 PJ diesel and 71 PJ gasoline. Most of this energy is used for road transport. The majority of the diesel use is in freight and public services, while the greatest gasoline use is in private cars (see **Figure 2-2**).

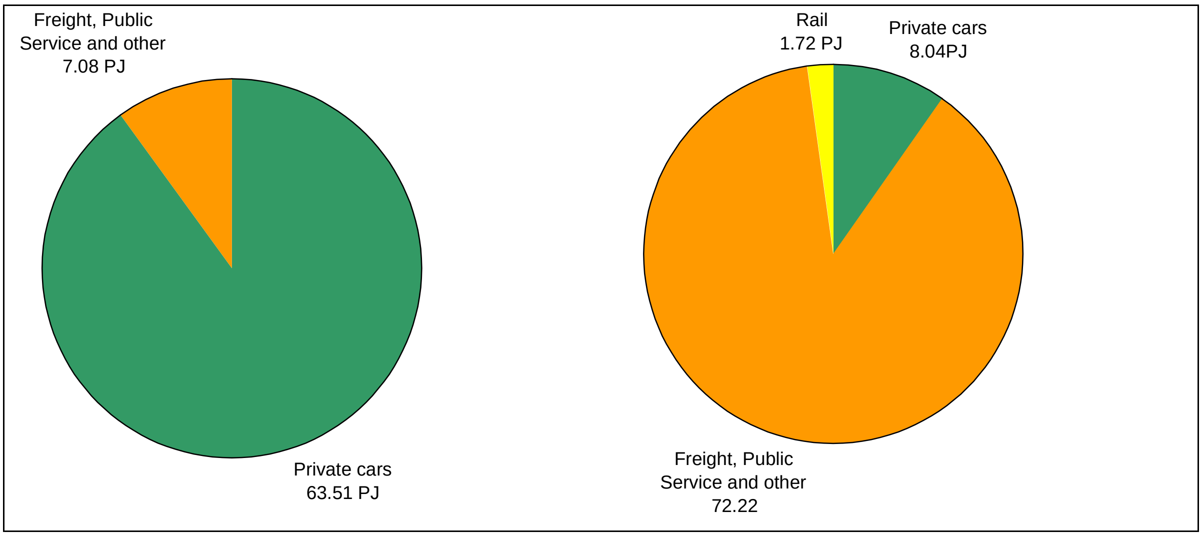


Figure 2-2. Gasoline (left) and diesel (right) use in surface transport by sector. Fuel use in barges is negligible.

The projected fuel use of 2.4 billion litres gasoline and 2.7 billion litres diesel in 2005 translates to 74 and 97 PJ respectively. The 2 % target therefore requires 1.5 PJ gasoline and 1.9 PJ diesel to be replaced by biofuels. **Table 2-1** summarises the fuel consumption in the reference years, and the biofuels targets for Ireland in order to meet the reference percentages. The actual volumes of biofuels depend on their energy content. If gasoline is to be replaced by ethanol and diesel by biodiesel, the amounts required are 70 and 59 million litres in 2005 and 221 and 211 million litres in 2010 respectively.

Table 2-1. Gasoline and diesel use for road transport in the reference years and the required amounts of biofuels to meet the reference percentages.

		Energy consumption (PJ)	EC reference	Biofuels required (PJ)
2005	gasoline	74	2 %	1.5
	diesel	97		1.9
	total	172		3.4
2010	gasoline	82	5.75 %	4.7
	diesel	120		6.9
	total	202		12

2.2 Niche markets

It may be advantageous from a policy point of view to introduce biofuels only into certain niche markets. Therefore in this section we will investigate whether such niche markets of sufficient size may exist in Ireland. An ideal niche market would have the following characteristics:

- Can fill in a large part of the biofuels target
- Have a limited amount of actors
- Is homogeneous
- Has separate refilling stations

Ireland consumes a relatively small amount of transportation fuel relative to other European countries. Currently, fuel consumption data is statistically available divided into type of fuel and broad sector, as shown in the Table below.

Table 2-2. Fuel use by sector (energy basis).

Sector	Fuel	Energy Consumption (PJ)	Share in total (%)
Air	Gasoline	0.08	0.04%
Air	Kerosene	33	18%
Road (Private Car)	Gasoline	64	34%
Road (Private Car)	LPG	0.2	0.11%
Road (Private Car)	Diesel	8.0	4.3%
Road (Freight, Public Service & Other)	Gasoline	7.1	3.8%
Road (Freight, Public Service & Other)	Diesel	72	39%
Rail	Diesel	1.7	0.92%
Rail	Electricity	0.08	0.04%
Inland Navigation	Fueloil	0.7	0.38%
Inland Navigation	Diesel	0.04	0.02%

Looking at diesel alone, the table shows that the key consumption area is road transport: Private cars represent 4.3 % and the remaining road transport, i.e. freight, public service and other, represents 39 % of total transport fuel consumption, with rail and inland navigation making a negligible contribution.

The forecasts identified in **Table 2-1** show that for Ireland meeting the EU reference values by substitution of either diesel or gasoline, the sum of biodiesel and ethanol use would need to represent 3.4 PJ in 2005 and 12 PJ in 2010. The table above illustrates that the private car section of the market could cover this in 2005, but only if pure biodiesel or a high blend of ethanol in gasoline would be used by the vast majority of private cars driven on diesel. Because of the large amount of stakeholders involved here, this is not likely to happen.

Other road diesel users need further analysis. There is limited information available that breaks down the figures further, however fuel consumption data is available on the two largest bus companies in Ireland, the agricultural sector, and the railways.

In 2003, Ireland's two largest bus companies, Dublin Bus and Bus Éireen consumed 1.1 PJ and 0.94 PJ diesel respectively [12]. In total this makes 2.1 PJ, which would be just sufficient to meet the EU reference point for diesel in 2005 but would be insufficient in 2010. Discussions would be necessary with these bus companies to understand if a switch to the use of pure biodiesel is feasible in terms of the engines, refuelling infrastructure and costs. However, using this data as an estimate of the entire bus sector, it appears that the bus sector alone would be insufficient to meet the EU reference point in 2010, which for diesel in Ireland equates to roughly 6.9 PJ.

Irish farmers and contractors use about 13 - 15 PJ fuel oil (diesel) for farm operations, mainly in tractors and machinery. Agricultural road vehicles consume 2.2 PJ of mainly gasoline [13]. This sector has a lot of actors and would be difficult to address as one niche.

The diesel use in rail transport is 1.7 PJ (see **Table 2-2**). Diesel trains may be an interesting niche, because they have a limited amount of distribution points. Details on whether the engines would be suitable for running on pure biodiesel, or the costs for conversion are not known. This niche market is not large enough to meet the 2005 reference point for diesel only.

There is no readily available consumption information for other road diesel categories that might include potential niche markets e.g. trucks. Furthermore, some of the sector fuel consumption reported by the Department of Communications, Marine and Natural Resources was derived from a sector analysis carried out in 1990, which officials recognise may be in need of updating [14].

In conclusion, there is a lack of data on which to estimate whether niche markets exist that can fulfil the full Irish biofuel directive target. However, we expect that it is unlikely that a sufficiently large homogeneous niche market will be found, since the largest niche market found, the national bus companies, are insufficient to fill even the full 2005 target.

3 Availability of Biofuel Resources in Ireland

3.1 Crop production, yields and costs

Production areas

The total area currently used for arable crops in Ireland is 0.4 Mha, which is 9 % of the total area devoted to agriculture. The remaining 91 % is used as grassland or for rough grazing. Four arable crops are produced in significant quantities: cereals (300 kha), sugar beet (32 kha), potatoes (14 kha) and forage maize (15-20 kha).

Cereal grain production in Ireland has been around 2 Mtonne/yr over the ten years from 1992 to 2002 [15]. In 2003 production was 2.1 Mtonne/yr, broken down as shown in **Table 3-1** [16].

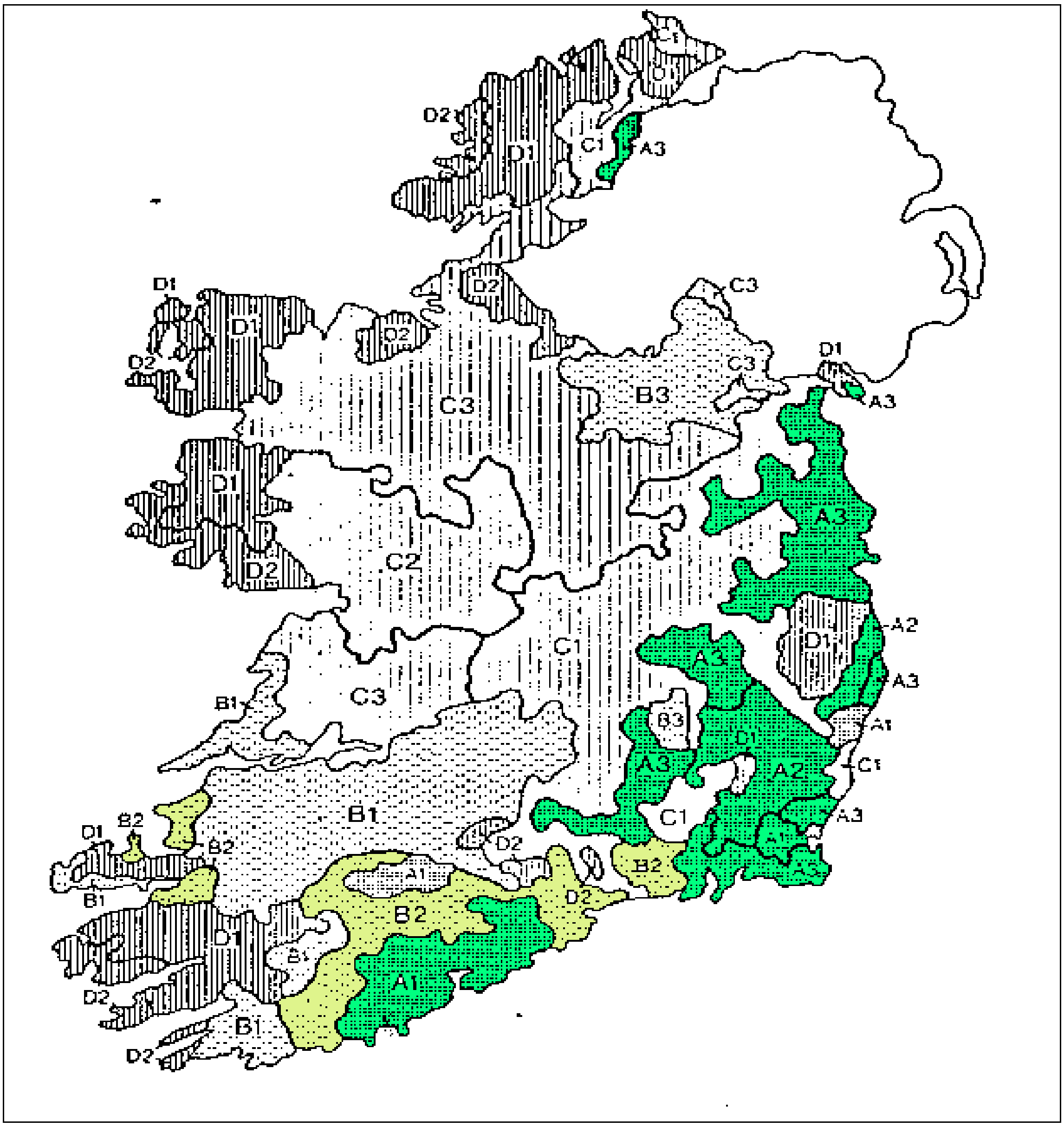
Table 3-1. Cereal area, production and yield, 2003.

Crop	Area (kha)	Yield (tonne/ha)	Production (ktonne)
Wheat	95.7	8.3	794
Barley	183.1	6.5	1198
Oats	21.0	7.4	155

The beet area has been falling slowly, under the influence of a static sugar quota and increasing sugar yields. The potato area has been falling more rapidly, due to a static ware (table ware) market, a reduction of losses, little expansion in processing and an end to the use of potatoes for animal feed as small growers ceased production.

Rape-seed production has always been small in Ireland. In the early nineties it was about 6000 ha, and it has now fallen to little more than 2000 ha (see **Table 3-3**).

Some of the land currently used as grassland has the potential to be converted to arable use. **Figure 3-1** shows the distribution of land suitable for arable production (land use types A1, A2, A3 and B2). This land is mainly in the south-east of the country and amounts to roughly 1 Mha. In the distant past the tilled area was much bigger than at present. However, the tilled area has remained fairly stable for the past half-century, and a big increase at this stage would have to overcome obstacles including a large investment in tillage machinery and some re-training of farmers. So in the short-term any estimation of the land available for arable biofuel crops should assume no more than a very small increase in total arable area.



A1: Arable, dairying, dry stock
A2: Arable, sheep, dry stock
A3 Arable, dry stock
C1: Dry stock, arable, dairying (low)
C2: Dry stock

B1: Dairying (high), dry stock (average)
B2: Dairying, dry stock (low), arable (high)
B3: Dairying, dry stock
D1: Hill sheep (high), hill cattle (low)
D2: Hill cattle (high), hill sheep (low)

Figure 3-1. Agricultural land-use types in Ireland [17]. The land use types A1, A2, A3 and B2 (coloured green) are suitable for arable production.

There are few agronomic limits to an expansion of the cereal area. Contracts to grow beet for sugar production include a clause limiting production to every third year in the rotation. Rape-seed production is not recommended more often than one year in five, and it should not be grown within two years of sugar beet. Also in the EU allocation of quotas following the Blair House Agreement, Ireland was granted only 4500 ha of rape-seed (see Annex D). Following the recent CAP review, it seems likely that the limit on eligible land no longer applies, and that a new Irish set-aside quota will be negotiated [18]. In this report, it is assumed that there will be no regulatory limit on rape-seed production.

One could exclude about 100 kha of arable land from sugar beet production on the basis of remoteness from the two sugar processing factories that would be the most likely sites for any sucrose-based biofuel process. If one also assumes no increase in the rape-seed area (about 2 kha rotated on 10 kha of arable land), the theoretical maximum area of beet that could be grown is about 95 kha. On the other hand, the theoretical maximum area of rape that could be grown is about 80 kha (i.e. one-fifth of the tilled area). This derivation is summarized in **Table 3-2**.

In practice the area of either crop that could be grown is considerably less than these figures. Small holdings and farms with inadequate resources would not be suitable for these crops, and many part-time farmers would not be interested. Reasonable targets for the medium term might be about 40-50 kha of beet and 10-15 kha of rape-seed.

Besides the 0.4 Mha currently in arable use, the remaining arable land of 0.6 Mha may be tilled as well beyond 2010. This would, however, require considerable adaptations in the agricultural sector.

Table 3-2. Potential areas for beet or rape-seed for the short and middle term, that could be realised within the area currently in arable use and current rotation. The *total area for agriculture* and the *area currently in arable use* are factual, the other numbers are estimations.

Total agriculture		*4.5 Mha*	
Total arable land		1 Mha (page 12 in pdf draft - also attached)	
Total current arable in use		*0.4 Mha*	
	Cereals		*300 kha*
	sugar beet		*32 kha*
	potatoes		*14 kha*
	forage maize		*15-20 kha*
	rapeseed		*2 kha*
Deployable for sugar beet production			
	Restriction because of remoteness		100 kha
	Rotation		1 out 3 years
	Beet potential		**(400 - 100 - 10) / 3 ~ 95 kha**
	Realistic		40 - 50 kha
Deployable for rape-seed production			
	Rotation		1 out 5 years
	Rape-seed potential		**400 / 5 = 80 kha**
	Realistic		10 - 15 kha

Crop yields

There has been a slight increase in overall crop yields masked by big annual fluctuations in the yields of the main crops over the past 10 years (**Figure 3-2** and **Figure 3-3**). Winter wheat yields have been among the highest in Europe. Other cereal yields are also reasonably high, but the large proportion of spring crops limits overall yields. Sugar beet yields are limited by the relatively cool summers and are lower than those of the prime beet-growing areas of France, the Netherlands and Germany. Potato yields are also relatively low; apart from climatic limitations, the ware market preference for high-dry-matter varieties has ruled out the use of the highest yielding varieties.

Rape-seed yields have been reasonable (**Table 3-3**, **Figure 3-2**); the apparent fall in yield in the past decade has been mainly due to a swing from winter- to spring-sown crops. Arable farmers have the competence and technology to grow the crop successfully, and many would welcome a break crop from cereals in the rotation. The major deterrent has been the lack of profitability in comparison with cereal crops. Area aid payments for oil-seed crops have been reduced more quickly than those on cereals, and the price available for seed has not increased sufficiently to compensate.

Set-aside land

The Irish set-aside area has been a minimum of 10 % of the arable area (30 kha) for several years up to and including 2004, but this figure will change to 5 % (15 kha) in 2005. By its nature set-aside is in small fragmented areas and the land is often below average quality. In most cases it is maintained in permanent pasture that is topped in summer and grazed in autumn. The use of set-aside for biofuel production will be dictated by profitability in the first instance, but is also likely to be confined to larger growers, in particular those with no animal enterprise. To date the only non-food use of set-aside has been a small area of oil-seed rape. The potential of 15 kha of biofuels is unlikely ever to be achieved; a realistic target is probably about 5 kha.

Table 3-3. Production and yield of oil-seed rape [15].

Year	Rape-seed area (kha)	Yield (tonne/ha)	Production (ktonne)
1990	5.4	3.6	20.0
1995	4.1	3.3	13.0
2000	2.7	3.2	8.6
2002	2.2	3.1	6.7

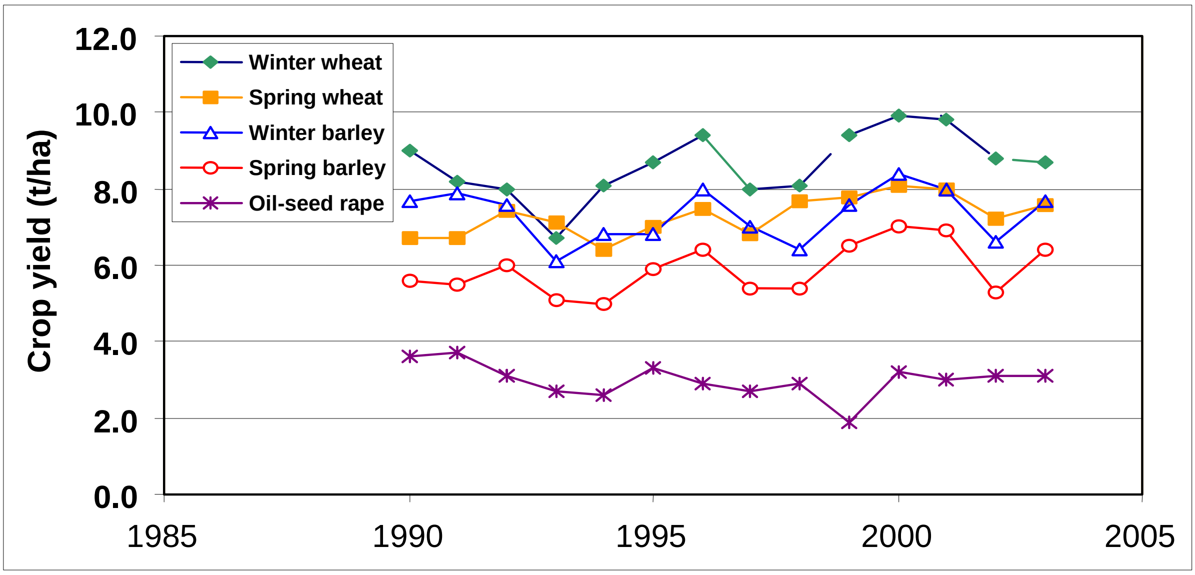


Figure 3-2. Yields of cereals and oil-seed rape, 1990-2003.

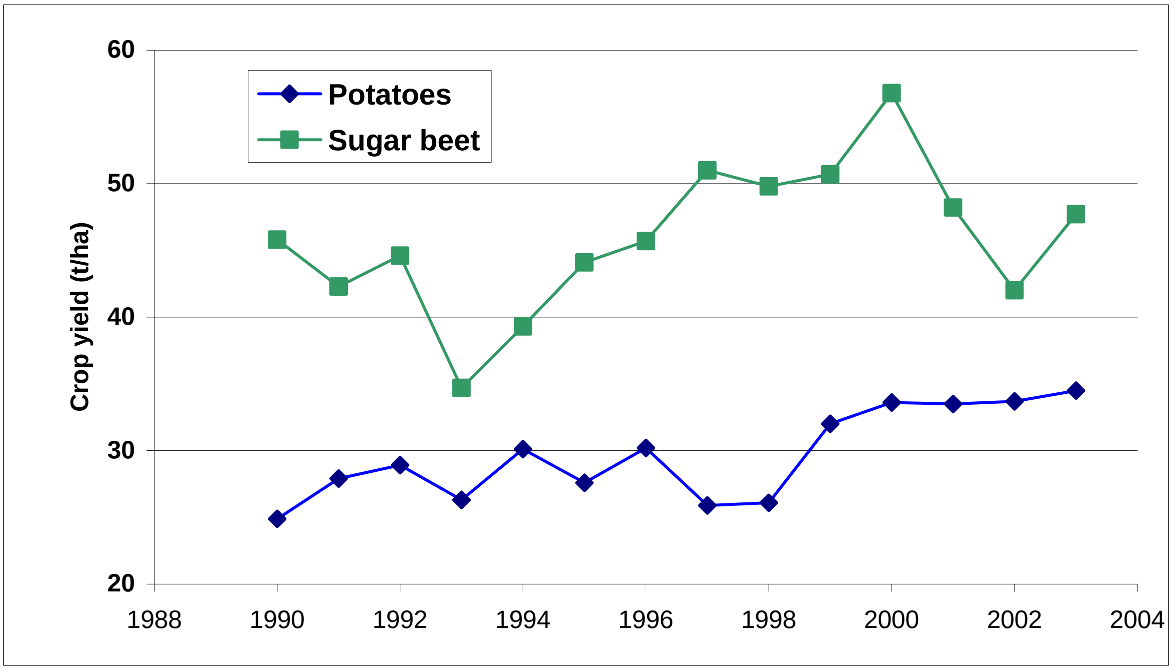


Figure 3-3. Yields of sugar beet and potatoes, 1990-2003.

Crop production costs

Estimates of the variable costs of producing the main crops are shown in **Table 3-4** [19]. Contractor charges were used in the estimation of machinery costs; with sensible machinery management many farmers would expect to achieve costs lower than these.

Table 3-4. Estimated variable production costs of the main arable crops.

Crop	W. wheat	W. barley	S. barley	W. rape	S. rape	Beet	Potatoes
Material costs €/ha	516	449	311	415	252	621	2820
Machinery hire €/ha	337	309	295	396	314	509	3614
Miscellaneous €/ha	61	53	39	39	17	232	0
Total €/ha	913	812	645	850	582	1363	6434
Assumed yield tonne/ha	9.3	7.7	6.4	4.0	2.7	49.1	34
Prod. cost €/tonne	98.2	105.5	100.8	212.5	215.6	27.8	189

Contractor charges are used to estimate machinery costs. Assumed yields are the mean national yields for the 5-year period 1999-2003, with the exception of rape where separate winter and spring crop yields are not available.

Estimates of overhead costs of farms where arable crops are the main enterprise, are given in **Table 3-5** [20]. The margin for the farmer follows from the difference between market price plus area aid and variable plus overhead costs.

Table 3-5. Overhead costs per ha on mainly arable farms [20].

Size unadjusted (ha)	67	
Size adjusted[1)] (ha)	61	
Overhead costs		
Land rental (€)		5528
Car/elec/phone		2067
Hired labour		4042
Interest charges		1707
Machinery operating		6207
Buildings maintenance		621
Land improvement maintenance		633
Other		2817
Total		23622
Overheads per adjusted ha	387.2	

1) Adjustments are intended to remove unproductive areas of the farm

Markets

The main characteristics of the Irish cereals market are described by the Cereals Association of Ireland [21]:

1. A demand for about 1.3-1.4 Mtonne of feed grains for native animal feeding. A fall in animal numbers is predicted as a result of the mid-term CAP Review and measures to control nitrate leaching and greenhouse gas emissions. On the other hand, other factors may lead to an increase in the proportion of cereals in animal rations:

   - The increasing cost of silage relative to grain.
   - The need to increase ration energy content to reduce the slaughter age.

   Overall, the most likely outcome is little change in this demand.

2. A demand for about 240 ktonne of malting barley for the domestic brewing industry
3. Fluctuating exports of feed grain to Northern Ireland and malting barley to continental markets.
4. An import of about 200 ktonne of milling wheat for the flour industry.
5. A domestic seed requirement for about 50 ktonne.
6. A self-sufficiency of about 100% in barley and 60% in wheat (**Table 3-6**).

In effect, any substantial demand for Irish cereal grains for an energetic use would be met by a small increase in the total arable area, or by competing for that grain with the animal feed market , which in turn would lead to an elimination of feed grain exports or an expansion of imports.

The average moisture content of grain at harvest is about 20%. Traditionally up to 80% of grain is sold from the combine and dried and stored at merchant premises before being formulated into animal rations. There is adequate merchant drying capacity for all but the wettest years. About 0.2 Mtonne goes into "coarse" rations following rolling at moistures up to 20%. Much of the grain for this purpose is treated with organic acids at merchant intake as an alternative to drying.

Table 3-6. The grain market in 2001/2 and 2002/3 [16].

Crop	Year	Production (ktonne)	Import (ktonne)	Export (ktonne)	Domestic use (ktonne)	Self-sufficiency %
Wheat	2001/2	769	575	177	1164	66
	2002/3	867	770	175	1466	59
Barley	2001/2	1277	64	215	1185	108
	2002/3	963	115	89	998	96

Sugar beet is grown solely for sugar extraction. The current contract price for A Quota beet is about 50 €/tonne; for B Quota there is a levy of about 10 €/tonne. In years of high yields when growers' production exceeds their B-quota the surplus is used as animal feed.

Potatoes are grown almost exclusively for sale as food. About 40 ktonne of a total production of 480 ktonne are processed as crisps or chips. Only a small proportion of the crop is grown on contract and prices are extremely variable.

Until recently, all oil-seed rape was exported to the UK for oil extraction. Two small cold-pressing plants with a combined capacity of 2 ktonne/year have now commenced operation in Ireland. Recent prices have been about 200 €/tonne from the combine.

Likely price and availability of biofuel crops

A farmer's income from crop production follows from the difference between the excess of variable production costs and the sum of the following incomes:

- Price received for crop
- Price received for residues (e.g. straw)
- Area Aid payments
- Possible carbon premium of 45 €/ha for biofuel crops on "eligible" land.

Area Aid payments for 2004/5 are € 383 per ha for cereals, oilseeds, hemp, flax and linseed (but excluding sugar beet and potatoes) grown on eligible land. The same payment applies to set-aside land, which may be left fallow or used to produce any of a list of industrial crops including cereals, oil-seed crops, sugar beet (not for sugar production) and potatoes (Annex C).

While the contribution of cereal straw to profitability has been significant in the past, in recent years straw prices have fallen to a level that barely covers baling and collection costs. With falling animal numbers, a stagnant or declining mushroom industry and in the absence of any new market, an increase in cereal straw price in the near future is unlikely. Rape straw has had no market to date and is ploughed back in situ.

For a farmer to decide to grow an industrial crop on set-aside, the main criterion is that the return from the crop exceeds the variable production costs after a small allowance (~30 €/ha) is made for the cost of maintaining fallow set-aside. The desirability of a break crop in the rotation and increased weed control problems after fallow set-aside are also important considerations. To date, virtually the only crop grown on Irish set-aside has been a small amount of rape-seed.

On eligible land, cropping decisions are based mainly on a comparison of variable production costs (as in **Table 3-5**) with expected market prices, with cereals as the reference point. Other considerations are straw prices, rotation constraints and the 45 €/ha carbon premium for biofuel crops.

Teagasc specialists suggest that the Irish grain market is inelastic and that large quantities could be procured at prices slightly (~ 5 €/tonne) higher than the market price for feed grains. An increase in cereals demand could be met initially by a reduction of feed grain exports, or a small increase in the arable area. A major increase would probably be met by imports. Grain prices are expected to be about 100 €/tonne for feed barley ex combine (108 €onne$_{dry}$) rising slowly in storage, possibly to about 125 €/tonne by the following June. Wheat prices are expected to be similar but about 5 €/tonne higher.The availability of the carbon premium may reduce the price of biofuel cereals by about 5 €/tonne

At this level of cereal prices, a price for rape-seed of about 220 - 250 €/tonne would be required for significant numbers to switch to rape production. Demand for sugar beet contracts is always high. Beet prices for non-sugar use would probably need to be at about B-Quota price to be attractive to growers.

3.2 By-products and residues

Cereal straw

There are very few direct measurements of straw production. As estimates of grain/straw ratio, a summary of German research suggests the following [22]:

Winter wheat	1:0.8
Spring wheat	1:0.9
Winter barley	1:0.9
Spring barley	1:1.0
Oats	1:1.2

These results refer to measurements made about 1995. In the interim, advances in breeding may have increased grain yields without a corresponding increase in straw yield. The results also reflect the amount of straw that would be possible to recover with a combine harvester, rather than the actual amount harvested in practice.

The only Irish trials in which straw and grain yields were measured were at Oak Park in 1997 - 2000. Those trials included winter wheat, spring wheat and spring barley at two levels of nutrient and pesticide use, i.e. normal commercial practice and reduced input levels. In the case of N fertiliser the input reduction was 20-30%.

The average harvested straw and grain yields in these trials over the four-year period were as in **Table 3-7**. The straw/grain ratios are well below the German estimates. In the trials, as in normal farming practice, the cutting height was chosen to facilitate the grain harvest and much straw was left as high stubble. If the straw had a higher value, the cutting height would be reduced and more straw would be harvested. Nevertheless, the trials are probably an accurate reflection of current normal farming practice.

Table 3-7. Grain and straw yields, Oak Park 1997-2000.

Crop	Input level	Grain yield (tonne/ha @ 15% m.c.)	Straw yield (tonne/ha @ 15% m.c.)	Straw/grain ratio
W. wheat	Normal	11.2	6.1	0.55
	Reduced	10.6	5.8	0.55
S. barley	Normal	7.4	4.1	0.55
	Reduced	6.7	3.4	0.51
W. barley	Normal	9.5	5.3	0.56
	Reduced	8.3	4.5	0.54
W. oats	Normal	8.2	7.1	0.86
	Reduced	7.4	6.4	0.86

Based on these results, a straw/grain ratio of 0.55 was used to estimate the national straw harvest. Applied to a grain yield of 1992 ktonne (the 2003 wheat + barley grain harvest) would give a straw production estimate of 1096 ktonne. This is somewhat lower than the estimate of 1300 ktonne in the SEI Study [23].

To date straw goes to three uses:

- Mushroom compost production takes about 100 ktonne. This outlet is not increasing and the industry is struggling to remain competitive.
- An amount estimated at 50-100 kt is ploughed back in situ; this may increase rapidly if the cereals market remains depressed.
- Animal bedding and feeding takes most of the remainder.

In recent years supply has exceeded demand and the price has fallen to levels little above the cost of baling and collection. No additional market other than energy can be foreseen; apart from ethanol, it could be burned in baled, chopped or pelleted form to produce heat or electricity. For energy use, wheat straw would be most readily available, followed by barley.

In attempting to estimate the volume of straw that might be accessible for energy use, the SEI report suggests between 80 and 325 ktonne [23]. Given the depressed state of the market in recent years, it is likely that amounts up to or exceeding 100 ktonne could be bought for 25 €/tonne in the field, i.e before baling and bale collection. The cost of these operations is estimated at about 15 €/tonne, giving a total of 40 €/tonne before road transport. Straw storage in dry conditions to provide a year-round supply could be a significant problem.

Rape-seed straw

German estimates of the above-ground straw/grain ratio for rape are from 2.9 to 4.2; with normal losses of leaf and stubble this is estimated to reduce to about 1.7 [22]. In Oak Park trials of 1998-2002, the area ration of harvested straw to grain was 1.26. With an area of no more than 2000ha at present, straw production amounts to about 7500t. Rape straw will only become of significance if a number of vegetable oil projects like the existing two get under way, and especially if a biodiesel project using some rape-seed oil is realised.

Recovered vegetable oil

Currently recoverable vegetable oil (RVO) is used for animal feed in Ireland, a practise which will become illegal from November 2004. This will free up a large amount of RVO that is already part of a collection process and can be used in biofuels. The SEI Study estimates that 19.8 ktonne of RVO was collectible in the whole of Ireland in 2003, and will reach 21.9 ktonne in 2010 [3]. Breaking this down by population (3.9 M south, 1.7 M north) gives 13.8 ktonne in the Republic and 6.0 ktonne in Northern Ireland. Assemblers estimate a loss of 10-15% during the cleaning process; a loss of 12.5% would reduce the above to 12.3 ktonne in the Republic, 5.3 ktonne in the north. The long-term forecast is that 25,400 tonnes may be available in 2020.

Movement across the border is easy, the RVO will move to whichever side has the best financial supports. At present, assuming de-excising in the south and with an excise reduction of 0.20 st•/litre in the north, the supports would be about equal. In this situation, the availability of larger quantities of tallow and potentially some rapeseed oil may make it easier to achieve the capacity needed for a biodiesel plant in the Republic.

Given that not all RVO would be made available by the collectors, a target for a biodiesel plant of 10-11 ktonne of RVO is probably a realistic estimate. This figure may increase slowly with the years as restrictions on alternative disposal methods get tighter and fast food consumption increases.

The price of this material has fluctuated in recent years since its use in animal feed came under threat. Most Irish RVO is exported to the UK, where its main use has been in animal feed. When it is banned from this use in Nov. 2004, in the absence of an Irish market it is likely to be taken up by biodiesel producers or electricity generators in the UK or other European countries. The current price in Ireland has increased to about 240 €/tonne, still much lower than that in most other EU countries where renewable energy prices are higher. Collectors do not pay for the RVO and in some cases collect a gate fee.

Prediction of future RVO prices in this situation is hazardous. Assemblers feel that a price of 260-320 €/tonne would be satisfactory for as long as competition does not force the collectors to pay for the RVO at their collection points.

It is important to remember that both tallow and RVO can be used as biodiesel or as fuel for heat and/or electricity production. Both of these markets are affected by different factors including global commodity prices and national customs, excise duties and other government incentives. These factors will influence choices made about using RVO and tallow as biofuels in Ireland.

Tallow

There is a growing interest in the use of animal fats in biodiesel production processes by several of the traditional producers who see a potential for this material in the future.

The amount of tallow produced in Ireland in 2003 was just over 78 ktonne, processed in the eight rendering plants in Ireland (raw material input of roughly 500 ktonne). From the predicted 10 % fall in animal numbers it can be expected that tallow production will be 71.7 ktonne in 2010 and 63.4 ktonne in 2020. The actual reduction in tallow production may be somewhat greater, as earlier slaughter will lead to smaller carcass sizes with less fat [3].

Almost half of the current production is risk material (SRM). Four of the rendering plants process non-risk material, roughly half of which is of high grade and half of which is lower grade. The ratio of risk to non-risk material can be subject to change depending on regulations affecting the raw material. Roughly

80% of Irish non-risk tallow production was exported in 2003 for use as animal feed, or in the pharmaceutical industry.

The risk material is currently used for process heat in rendering plants, and animal health controls are unlikely to allow its use for any form of transport fuel. So the material of interest is low-grade non-SRM material; The SEI report estimates the volume of this material at 21.9 ktonne in 2003, falling to 20.0 ktonne in 2010 and 17.6 ktonne in 2020. This is currently used in animal feed, which use is not under any immediate threat. Forthcoming European legislation on the use of animal by-products will restrict the use of tallow in animal feed. Forecasts published in the SEI December 2003 study estimated the amount of lower-grade tallow with no BSE risk that could be used for biofuels, assuming current tallow market conditions and fossil fuel prices. The amount available for biodiesel use could be estimated at about 17 ktonne at present falling to 15 ktonne in 2010 and 13 ktonne in 2020.

The price is again unpredictable; it is likely to increase from its current level of about 220 €/tonne, but lag slightly below that of RVO due to transport difficulties. A slowly increasing price of 250 - 300 €/tonne is suggested.

Sugar industry by-products

As a by-product of processing 1.6 Mtonne of beet, about 55 ktonne/annum of molasses is produced. Molasses is sold at about 80 €/tonne, and the current market is mainly animal feed. The sugar industry also produces about 110 ktonne of beet pulp at 27% moisture that sells at 33 €/tonne, i.e. 45 €/tonne of dry matter. This also goes to animal feed.

Wood residues

COFORD have estimated that residues from forestry and saw-milling will exceed the demand from the panel board industry by increasing amounts over the coming decade [24], see the table below.

Table 3-8. Estimate of wood residue surpluses, 2000-2015. Production in excess of current demand (ktonne)

Fuel source	2000/1	2005	2015
Pulpwood (60% m.c)	168	95	732
Sawmill residue (45% m.c.)	89	129	280
Forest residues (45% m.c.)	209	223	291

COFORD also estimate the delivered cost (0-40 km) of these materials as €21-35 for pulpwood, saw-milling residues 14 - 25 €/tonne and forest residues 21 - 56 €/tonne; the wide range of costs is mainly due to the range of alternative technologies that might be employed in tree harvesting.

The only alternative markets that can be envisaged for this material are other energy uses e.g. pellet production, CHP plants and co-firing in peat or coal burning power station. Some pellet and CHP developments are already under way.

3.3 Summary of the results

The various cropping areas currently in use, and the areas potentially available are summarised in Table 3.9. Reckoning with existing domestic uses of some feedstock, this results in realistic amounts of feedstock for biofuels.

Table 3-9. Summary of the area available for biofuel crops (kha), the resulting amounts of feedstock available (ktonne), and the assumed biofuels yield used for calculating the potential amount of biofuels in Ireland.

	Area (kha)			Potential (ktonne)			biofuels yield
	Current	Potential	Realistic	Potential	Realistic	National[1)]	(l/tonne)
Crops							
Cereals total	300	300	15[2)]	2455	565[3)]	140[2)]	356
forage maize	20	20		120			
Beet	32	95	50	4665	2455		90
Potato	14	14	14	476	476		90
Rapeseed	2	80	15	320	60		450
Residues							
Molasses				55	55	55	610
Beet pulp				110	110	110	90
RVO				11	11	11	1000
Tallow				15	15	15	900
Lignocellulose, beyond 2010							
Straw				1100	325		220[4)]
wood residues					1283		220[4)]

1) The national potential is defined as the realistic potential minus those areas on which currently already feed-crops are grown, and whose replacement would basically lead to additional import.
2) E.g. wheat on set-aside land.
3) The realistic amount of cereals available takes into account that there is a domestic use for wheat and barley.
4) 220 l/tonne equals a thermal conversion efficiency of 40 % biomass to Fischer Tropsch diesel, electricity is co-produced but not accounted for here.

The amount of feedstock that could potentially be made available for biofuels production within Ireland is very large. Multiplication by the biofuels yield per tonne of feedstock gives the potential amounts of biofuels, see **Figure 3-4**. The realistic total roughly equals the 2010 target. However, one has to realise that this implies that current feed crops are then to be used for energy purposes. This will then normally induce additional feed imports. On the other hand, as by-products of biofuels cropping (e.g. rape meal) will be used for animal feed, the extra import may be smaller than the amount of feed crops replaced.

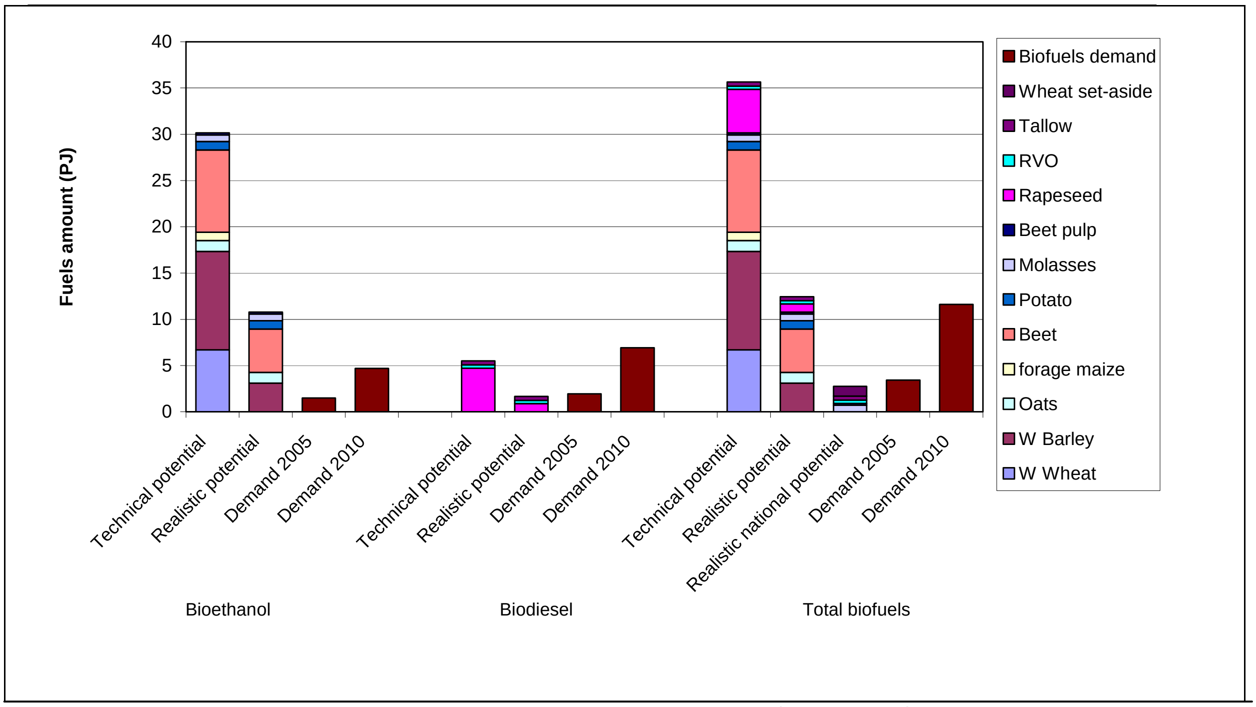


Figure 3-4. The potential bioethanol and biodiesel production from Irish feedstock expressed in energy content (PJ). "Demand 2005" and "Demand 2010" refer to the replacement of 2 % respectively 5.75 % of the total amount of gasoline and diesel with bioethanol respectively biodiesel.

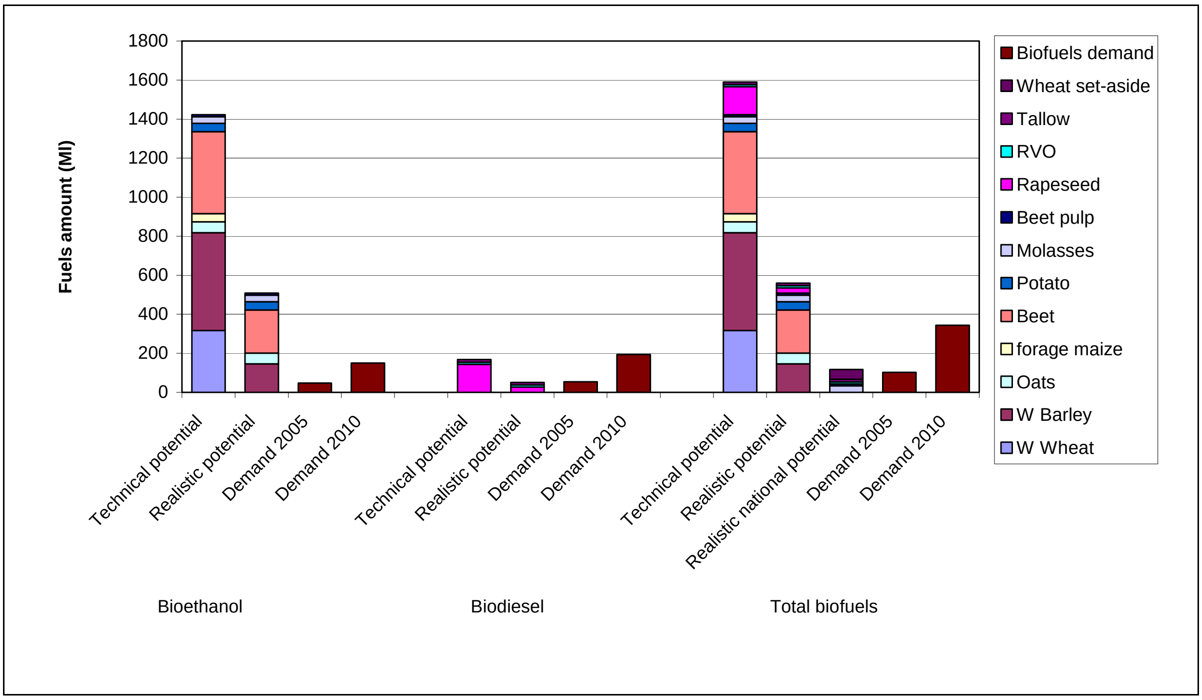


Figure 3-5. The potential bioethanol and biodiesel production from Irish feedstock expressed in volume (million litres). "Demand 2005" and "Demand 2010" refer to the replacement of 2 % respectively 5.75 % of the total amount of gasoline and diesel with bioethanol respectively biodiesel.

The real additional national potential can be considered as being limited to the available residues and the crops that can be produced on currently non-productive set-aside land. This realistic national potential comprises about 79 % of the 2005 and 23 % of the 2010 target. National means that one can use these feedstock for biofuels within Ireland without interfering with other uses. In other words, no streams are used that have a current use for food or feed, which would require necessary compensation by imports.

From the residues that could be converted to transport biofuels with current technology (i.e. RVO and tallow to diesel substitutes, molasses and beet pulp to ethanol) about half the 2005 reference target could be reached. The balance could be produced from crops already in production e.g. an additional 10 kha of sugar beet or a combination of 5 kha of rape-seed and 15 kha of cereals. This could be achieved with little disruption of existing crop rotations or markets.

Potentially large amounts of lignocellulose residues will become available for the production of advanced biofuels in the medium and long term. It has been assumed that the necessary technologies for the production of these biofuels will not yet be available at a sufficient large scale by 2010. However, the amounts of straw and wood residues could supply 12 PJ (280 Ml) of Fischer-Tropsch diesel, which is more than the demand for biomass-derived diesel in 2010, and equals the total 2010 target. Alternatively, a similar amount (on energy basis) of ethanol could be produced by hydrolysis fermentation. The potential for dedicated energy crops (post 2010) has not been assessed, but will increase this number.

4 Technical Issues Relevant for Biofuels Chains

4.1 Blending Ethanol with gasoline

Ethanol may be made available as a biofuel in different forms: As a neat ethanol (E95, actually 95 vol % ethanol with water), as E85 (85 vol % ethanol with gasoline) to be used in flexible fuels vehicles, as a blend smaller than 5 vol % in gasoline, or as its derivative ETBE.

Vapour pressure

The properties of ethanol are very different from those of gasoline. This means that the properties of an ethanol/gasoline blend will, in general, deviate more and more from those of gasoline with increasing ethanol content. The vapour pressure* is an example of a property that behaves differently. Although the vapour pressure of ethanol is much lower than that of gasoline, the vapour pressure of the blend peaks between 0 and 10 vol % ethanol.

Figure 4-1 and **Figure 4-2** demonstrate this effect schematically. The figures are only indicative since exact values are strongly determined by the exact composition of the base gasoline. Increases in the (RVP) of 6 - 8 kPa can already be expected with ethanol additions of only 3 vol % to base gasoline with normal volatility. The RVP only drops consistently below the gasoline RVP with blends of ethanol greater than 30 vol %.

The legal limit of the vapour pressure is 60 kPa (European Directive 98/70/EC and its amendment 2003/17/EC). Since gasoline is usually at, or close to, this maximum level, the vapour pressure of current European gasoline would be increased above the legal limit by addition of 2 % or 5.75 % (by energy†) of ethanol.

To be able to meet the vapour pressure requirement, the base gasoline composition would have to be modified. Reducing the butane content is a well-known solution in this case [25; 26]. Reducing the butane content of gasoline brings associated costs in refineries. In the case where this modified base gasoline would have to be produced alongside conventional gasoline, the cost would increase further, as would storage costs because a separate storage tank would be necessary. Estimates of this cost component will be included in the cost analysis.

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* The RVP is a measure of the vapour pressure of a liquid as measured by the ASTM D 323 procedure and is commonly applied to automotive fuels. For automotive fuels, the Reid Vapour Pressure (RVP) measured at 37.8 °C is used to define the fuel volatility [25].

† The targets in the biofuel directive are expressed on energy basis, most blending issues and legalities are on volume basis. Section 4.3 explains the relation between volume and energy fractions.

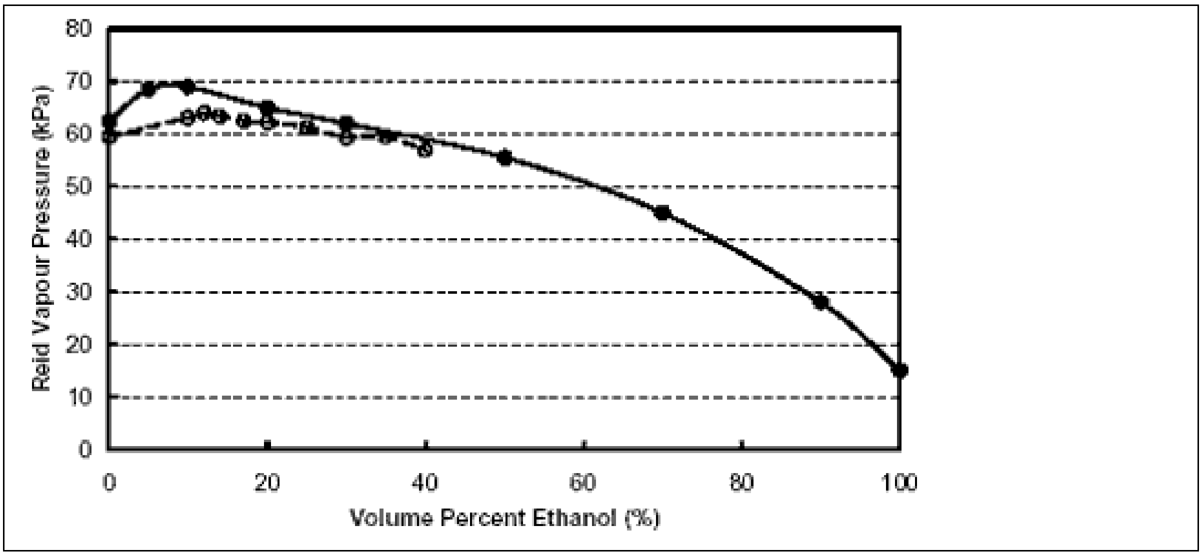


Figure 4-1. Example of the Reid Vapour Pressure with High Blend Ethanol; solid line --- [27], dashed line - -[28].

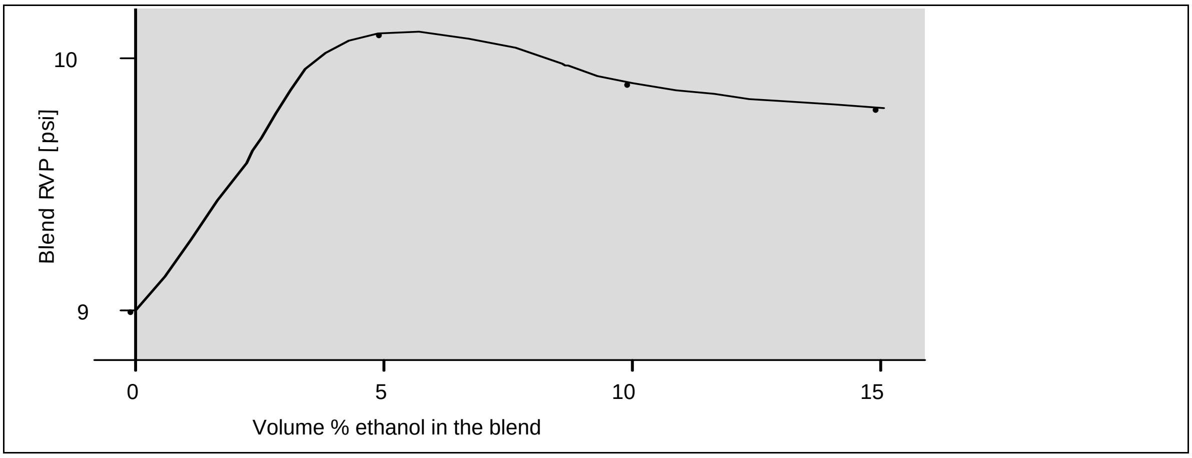


Figure 4-2. Example of the vapour pressure (RVP, expressed in psi; 10 psi equals 68.95 kPa) of a certain gasoline ethanol blend. The base gasoline in this case is Indolene HO III [25] and not European gasoline. Therefore, the figure is only representative regarding the type of shape of the curve and not regarding the absolute figures.

Maximum allowed ethanol in blends

The directive 98/70/EC allows 5 vol % ethanol (as oxygenates) in direct blends (E5), and 15 vol % ETBE added to gasoline (equals 7% ethanol). On top of this also a maximum oxygen content is defined. Since the focus in this report is on ethanol, we will concentrate on the 5 vol % maximum ethanol content.

Ethanol fuel efficiency

On a per litre basis, the energy density of ethanol is 32 % lower than European gasoline. One would therefore expect that driving on ethanol would increase the volumumetric fuel consumption for ethanol blends as compared to gasoline. For a blend of 5 % ethanol in gasoline this would be about a 1.6 % increase. Some literature, reporting practical fuel efficiency numbers, does not observe this increase in fuel consumption. This could be caused partly by the fact that the addition of oxygenates, such as ethanol, increases the octane number of gasoline and increases the fuel efficiency, so that the lower energy content of ethanol/gasoline blends would be - at least partly - compensated by a more complete combustion of the fuel [1; 25; 28-33].

However, research and reports on the influence of ethanol content in blends with gasoline are limited. Also the scope of research is limited and results from the USA may not be directly applicable to the European situation, due to differences in fuel composition, differences between vehicle engines and differences in test cycles. Other limitations of the available information are, for example, that for some tests older (1990) vehicles have been used, that fuel consumption for a limited number of engine loads has been measured, that research was only on one engine design, and that most research focuses on ethanol percentages of 10 % and higher. Additionally, it is not always clear if results on volumetric fuel consumption or on actual energy consumption (energy efficiency) are reported. Some researchers observed a slight increase in energy consumption while others report a slightly lower energy consumption. Finally it is important to note that oxygenates are already added to gasoline. It is not clear in how far this has been accounted for by the quoted authors.

The above mentioned 1.6 % increase in volumetric fuel consumption is generally smaller than changes due to differences in tyre pressure, outside temperatures or driving style. This makes it very difficult to measure in a normal drive cycle.

For blends with larger ethanol percentages than 10 vol %, an increase in volumetric fuel consumption must be expected, which is roughly linear with the difference in heating value. The larger the ethanol content, the higher the volumetric fuel consumption will be.

Summarising, on the one hand, literature tends to an equal volumetric efficiency of gasoline and ethanol blends (with less than 10% ethanol). On the other hand, there are indications that circumstances in which this may occur are limited as well. Due to this high degree of uncertainty, we work with the conservative assumption that the fuel engine efficiency when using low ethanol blends is equal to that of gasoline. In other words, in this report 1 GJ of ethanol is assumed to equal 1 GJ of gasoline.

4.2 The use of animal fats and recovered vegetable oil for FAME

Diesel specifications

The European Commission and the oil and automotive industries agreed in the Auto-Oil programme on tighter fuel specifications to reduce greenhouse gases and other pollutants. Auto Oil I resulted in specifications for the year 2000, in directive 98/70/EC; which came into effect on 1 January 2000. The directive also agreed some specifications for 2005 on sulphur and aromatics for gasoline and sulphur for diesel and banned the general sale of leaded gasoline from 1 January 2000. The directive has been amended by 2003/17/EC, with which the sulphur content is further limited. These European fuel **directives** cover the technical requirements, including chemical composition for gasoline and diesel [34].

Diesel further also must meet EN 590 (version 2003), the European **standard** for diesel, which describes the physical properties that all diesel fuel must meet if it is to be sold in the EU, Iceland, Norway or Switzerland.

EN 590 allows the use of additives on the condition that the final product meets the limits, thus a blend of biodiesel in diesel should also meet the current standard for ordinary diesel, the EN 590. It is explicitly stated that diesel fuel may contain up to 5 vol % biodiesel, providing the biodiesel meets the EN 14214:2001 specification, also refered to as the FAME specification.

The recent biofuel directive 2003/30/EC requires that biofuel blends in excess of 5 percent will be clearly labelled at the point of sale. This is to protect consumers from unknowingly filling their vehicles with fuel that may be unsuitable for their vehicle and that could invalidate their warranty. The directive refers to the FAME specification EN 14214.

To date, there were several national standardisation processes for biodiesel (see **Table 4-1**). In 1997 the European Commission gave a mandate to CEN (Comité Européen de Normalisation) to develop standards concerning minimum requirements and test methods for biodiesel.

Table 4-1. Existing European national standards for biodiesel [35; 36].

	Standard / specification	Year	Application[2)]
Austria	ON C1191	1997	FAME
Czech Republic	CSN 65 6507	1998	RME
France	JORF[1)]	1997	VOME
Germany	E DIN 51606	1997	FAME
Italy	UNI 10635	1997	VOME
Sweden	SS 15 54 36	1996	VOME

1) Journal Officiel de la République Française 14.9.1997
2) FAME : fatty acid methyl ester, RME: rapeseed methyl ester, VOME: vegetable oil methyl ester.

This evolved in the specification EN 14214. It is broadly based on the German DIN 51606, which is considered to be the highest standard currently existing, and is regarded by almost all vehicle manufacturers as evidence of compliance with the strictest standards for diesel fuels. During the drafting it was decided to use the same requirement for both FAME use as sole diesel fuel and FAME as blending component to EN 590 diesel fuel. A blend of 5 vol % FAME certified biodiesel in diesel can be expected to meet the EN 590[*], which has been demonstrated in practice. The result will still have to be diesel certified. The biofuels directive requires labelling of blends > 5 % and these blends cannot be certified EN 590. FAME to be used as a heating fuel is described in a separate standard: EN 14213.

Car specifications [37]

Car manufacturers will usually repair damage that occurs to a vehicle within the guarantee if proper fuel was used, i.e. that which falls within the specifications. However, if a fuel is used that falls outside the EN590 specifications car manufacturers will not repair them at their own cost.

The most serious problem, where engines fuelled with uncertified fuels are concerned, is the insufficient oxidation stability of the fuels which causes polymerization and the formation of sludge within the engine, leading to damage.

Tallow [3; 38-40]

Animal fats are currently used in the production of biodiesel in some processes in Europe. The biggest problem with low-grade tallow is the high level of free fatty acid, which gives very low yields in a simple single-stage process. Therefore, a pre-treatment or two-stage esterification is necessary, either of which increases process costs.

There are some issues that relate to the use of tallow in fuels that need to meet the EN 14214 standard for biodiesel. The key technical limitation to its use in standardised biodiesel and diesel is the poor behaviour of animal fat-methyl esters (animal fat-ME) at low temperatures. Animal fat-ME has a

[*] From the specifications it cannot directly be concluded that a blend of certified biodiesel in diesel automatically meets EN 590, because a few items of the FAME standard are defined less strict or different, as compared to EN590.

Cold filter plugging point* (CFPP) of about 10 - 15 °C, which implies that use at lower temperatures potentially causes plugging in engines. This is likely to mean that pure animal fat-ME does not meet the FAME standards, however in some instances national governments have transcribed the European standard, which does not specify a CFPP, in such a way that a high CFPP will not compromise the fuel meeting the standard. This is a technicality though, and the high CFPP is effectively a barrier to meeting the FAME standard in most countries. The CFPP of blends is close to the weighted average of diesel and biodiesel CFPP (proportional relation).

Other limitations that could stop animal fat–ME from meeting the standards are the high level of cholesterol in the fuel, and the iodine content.

Because of these limitations, animal fat ME should only be used when blended with other biodiesels e.g. rape-seed methyl ester, or with mineral diesel. Opinions vary on how high the proportion of animal fat can be in a blend with mineral diesel. Estimates are as high as 5 % in a blend with 95% mineral diesel. However, this blend would need the technicality described above to allow qualification as FAME.

Other blends, with smaller quantities of tallow, appear more realistic, and these would have to be determined empirically. The percentage tallow that would meet all FAME specifications in all member states would depend on the quality of the animal fat used as well as the processing technology. Some of the information on blending percentage is considered commercially sensitive as a result of the proprietary technologies used.

Recoverable vegetable oil [3; 38-40]

As with animal fats, the technical limit for the use of recoverable vegetable oil (RVO) in FAME standard biofuels comes from its poor low temperature behaviour. RVO-ME has a CFPP of about 0 °C.

Because RVO has already been used in frying for a long time, at high temperatures, the properties of the original vegetable oil will have changed, introducing some level of saturation and modifying chains to provide a variation in chain length. The oxidation stability of RVO-ME may be less than that of RME. On the other hand, RVO-ME and Animal fat-ME fuels may have better engine properties than RME because of higher cetane numbers. Provided that the biofuels or blends that are used meet the FAME standards, there should not be a problem with the engine.

As a result the esterified product will differ from that of the pure oil. Furthermore, each batch of RVO, with a different provenance, will have different properties. Therefore, as with the animal fats, a degree of experimentation is necessary to discover which blends of RME and RVO-ME meet the FAME (EN 14214) standard.

Estimates from experts put a likely blend at 15 - 20 % RVO in a biodiesel blend. Previously we have found expert estimates of a maximum of 10 % [41]. Other limitations may be in occasional high viscosities and high carbon residue (CCR) levels.

4.3 Maximum of biofuels allowed in blends

It was found that ethanol and biodiesel are only allowed to be blended to a maximum of 5 vol % in gasoline and diesel respectively (fuel standards EN 228 and EN 590). The reference percentages for the 2005 and 2010 targets are on energy basis. When correcting for the energy content per litre, the

* The CFPP is defined as the highest temperature (expressed as a multiple of 1 °C) at which the fuel, when cooled under the prescribed conditions, will not flow through a fine wire mesh filter, or requires more than 60 seconds for 20 ml to pass through or fail to return completely to the test jar.

maximum allowed by the standards is 3.4 % and 4.6 % respectively (see **Table 4-2**). Under the current fuel standards, it is thus not allowed to introduce blends of 5.75 % biofuels labelled as gasoline or diesel.

Table 4-2. Reference percentages and maximum allowed of ethanol in gasoline and biodiesel in diesel, on energy and volumetric basis.

	Reference percentage		Maximum allowed	
	Energy basis	**Volume basis**	**Energy basis**	**Volume basis**
2005				
Ethanol	2 %	2.9 %	3.4 %	5 %
Biodiesel	2 %	2.2 %	4.6 %	5 %
2010				
Ethanol	5.75 %	8.2 %	3.4 %	5 %
Biodiesel	5.75 %	6.2 %	4.6 %	5 %

A legal maximum for blending RVO and tallow derived biodiesel in FAME specified biodiesel, under condition that the blend is still FAME specified, has not been found. It seems that any blend would again need to obtain a FAME specification.

4.4 Infrastructure for fuel production and distribution [42]

Ireland has one refinery in Co. Cork which has been in operation since 1959, and a well-developed product distribution network involving both large multinationals and domestic independents.

The Whitegate refinery in County Cork produces a range of products including gasoline, liquefied petroleum gas, diesel fuel and heating oil. These products are then distributed to other parts of Ireland by sea or road, with some product being sold on the international market.

Roughly 35% of Irish demand for fuel is served by the Whitegate refinery [43] with the remaining 65% being imported. Imported fuel comes mostly from the UK, with some input from Norway. The balance depends on decisions made by the major oil companies.

Imported oil comes into one of several sea-fed terminals at:

- Dublin (main port);
- Cork;
- New Ross;
- Limerick;
- Galway; and
- Drogheda

Most of the UK-sourced oil comes from Milford Haven, with some also coming from Stanlow, Fawley and other UK refineries. The choice of refinery at origin and sea terminal depends on the companies involved.

Over 150 distributors operate in Ireland distributing products from any of the terminals to consumers and filling stations in all parts of Ireland. Distributors range greatly in size and nature, some are branded, some owned by major oil companies and others have formal agreements with the oil companies.

There are storage facilities across the country and some, including Bantry Bay and the Whitegate refinery store some of the National Reserves on behalf of the government National Oil Reserves Agency (NORA) which they currently estimate could last for 900 days with careful use [43].

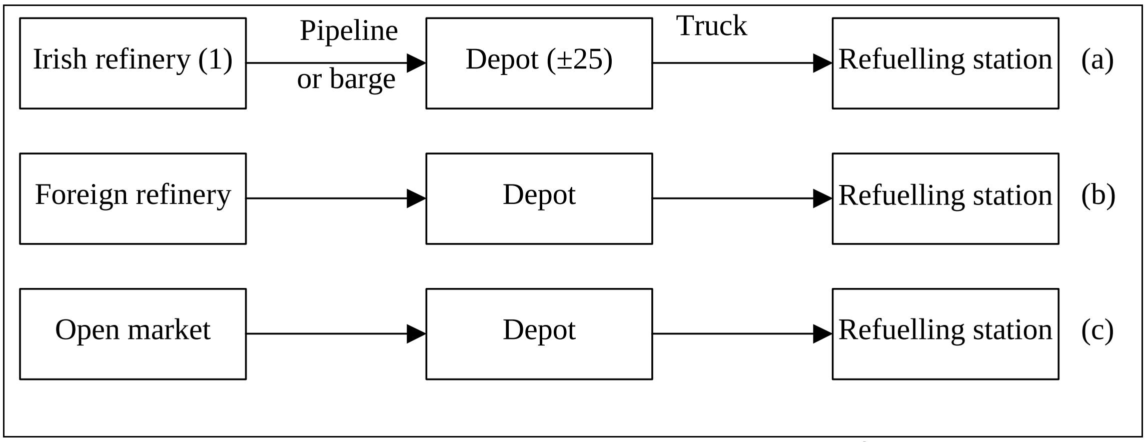


Figure 4-3. Existing gasoline and diesel production and distribution infrastructure in Ireland, it includes 1 refinery and approximately 25 intermediate storage depots.

5 Environmental Impacts

In order to look more closely at the environmental impacts of biofuels a selection of greenhouse gas (GHG) emission studies is made from a list of references. The total greenhouse gas emission equals the sum of all carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) emissions, expressed in CO_2-equivalents.

Six European studies have been selected. The main selection criteria were: country of origin, date of publication, and comprehensiveness. The selected studies and their acronyms that we use in this chapter are: General Motors (GM) [44], Ademe/Ecobilan [45], Concawe [46], Sheffield [47], ECN [48] and Arthur D. Little [49].

5.1 GHG emissions - method

Greenhouse gases are emitted in all parts of the biofuels' Well to Wheel (WTW) chains. This has been analysed in several environmental impact studies. The British "Sheffield" study [47] is considered as the most representative of Irish circumstances, since it is based on the current practice in the UK, where agricultural growing conditions are considered comparable with Ireland. It is also the most transparent and well-founded study of a range of selected literature [41]. Moreover the study covers three of our selected biofuel chains. Therefore, we use their average figures as the best estimate for RME, biodiesel from RVO/tallow and ethanol from beet and wheat. Results from other literature will be presented as a range in the final graph.

In this study, allocation is on the basis of societal pressures (market prices) and in contrast with General Motors and Ademe studies, not on the basis of extension of system boundaries (deduction with avoided impacts of co-products).

The RME allocation by market prices, according to Sheffield, is adopted for allocation between crude glycerine and biodiesel, rape meal and crude rape-seed oil, and between rape straw and raw rape-seed. The allocation of GHG outputs of ethanol from sugar beet is based on the effective prices of pulp for animal feed and raw juice.

N_2O emissions

N_2O is a main contributor to the GHG-emissions generated by the plantation of energy crops. The N_2O-emissions in practice depend on many factors like soil type, temperature, and precipitation. Measurements of direct N_2O-emissions at the location of the arable land result in a wide range of estimates. The formation and decomposition of N_2O in soils depend on various controlling parameters. The main factors are aeration, water content and availability of N and organic material. Aside from these factors, the amount of N_2O emitted from soils is influenced by the physical soil characteristics and the type of crop grown [50]. The applied N fertilizer that is not utilised by the crop is either stored in the soil profile of the field or is lost from the system through leaching of nitrate to groundwater, runoff of soil or nitrate to surface waters or volatilized through ammonia volatilisation or nitrification / denitrification as NO_x, N_2O and N_2 [44].

Within the total crop rotation cycle, the emissions with and without the energy crop have to be compared. The application of fertilisers causes N_2O-emissions in the field. The N_2O emissions are calculated, in most cases, according to the Intergovernmental Panel on Climate Change (IPCC) guidelines [51]. This is also the recommended method by the life cycle analysis (LCA) experts of the Centre for Environmental Studies, Leiden, the Netherlands [52]. More details on the way in which various biofuel studies have dealt with N_2O emission are presented by Van den Broek [41].

Yield and fertilizer use

Yields are interpreted here as both harvested yields per hectare, but also as the yield of liquid biofuel per tonne of harvested material. The product of the two can be expressed as a biodiesel yield or bioethanol yield per hectare. High yields lead to relatively low emissions per unit of product produced. Therefore, this is an important parameter for the final results.

The selected studies show quite comparable yield figures, There are differences, however, in terms of the amount of fertilizer applied (see also [41]).

Reference land use system

Reference land use is that land use that would have occurred when no energy crop had been cultivated. In the GM study the reference system contains rotational set-aside land planted with an N-fixing crop (i.e. Egyptian clover which displaces synthetic fertilizer), in one scenario, and a non N-fixing crop (i.e. rye grass) in another scenario. As a result, the plantation with Egyptian clover leads to a net additional use of synthetic fertiliser for the energy crop.

Sheffield has for RME and ethanol (beet and wheat), a reference system consisting of fallow set-aside, including diesel fuel consumption for mowing it.

A reference system based on fallow set-aside is incorporated into the calculations. For methylesters (ME) from recycled vegetable oil, production of the original vegetable oil is excluded from the calculations, since the primary energy inputs and GHG outputs for this should already be allocated fully to this main product and its principal uses.

Vehicle efficiency

Most studies presented results in terms of GHG emissions per MJ of fuel. We converted this into per km figures by means of the GM study. As their base vehicle they used a direct injection current 2002 production European Minivan Opel Zafira with automated manual transmission (MTA). For this purpose we chose the 2002 version of the Opel Zafira that was considered in the GM study. This has a fuel consumption that is about 6% higher than the base case Opel Zafira in the GM study, which is a version extrapolated to the 2010 timeframe. Current fuel efficiencies found elsewhere may be higher, but note that the choice for the values in **Table 5-1** does not have any impact on the comparison between fossil fuels and biofuels, since we use the same vehicle type as a starting point for all fuels considered.

Table 5-1. TTW Energy requirements of the power train combinations used in this report

Vehicle	Energy requirements (MJ/km)
Gasoline MTA SI	2.59
DI Diesel MTA	2.08

MTA - automated manual transmission; SI – spark ignition; DI – Direct injection; TTW – Tank to wheel.

5.2 GHG emissions – Results

Figure 5-1 presents the results of the different studies. For the fossil fuel references we use the GM study, since this is the only study which showed a detailed fossil fuel well to wheel greenhouse gas analysis.

Bioethanol from wheat

The best estimate well to wheel GHG emission for bioethanol from wheat was at about 1/3 of the gasoline emission. The high range (of the 14 cases included) is about 80% and the low range about 25%. Most estimates ranged between 30 and 60%.

Both the low and high extremes come from Concawe. Concawe interprets the EU Commission report [53] as “overly pessimistic”. Emissions avoided by straw credit are very low in the EU study and the energy output/input ratio is very high. The ethanol yield at this EU study is low and not in line with the other studies. The lowest Concawe emissions are from Gover ETSU [54]. No details were found on the explanation of this extreme value.

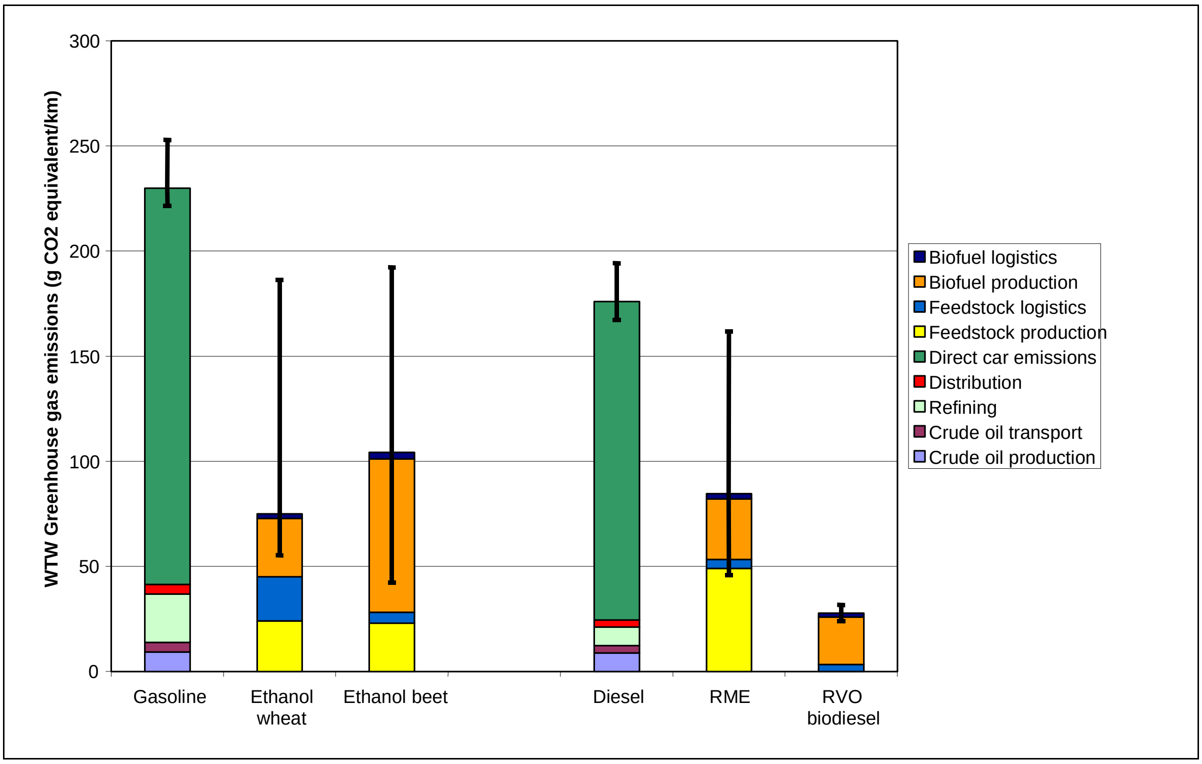


Figure 5-1. Well to wheel GHG emissions of biofuels versus fossil fuels, and breakdown into various steps in the chains. The bars present the best estimates, and the black lines the ranges in the literature studied [44; 47; 49].

Bioethanol from beet

The best estimate well to wheel GHG emission for bioethanol from sugar beet was about 45 % as compared to its fossil alternative. The high range (of the 17 cases included) is about 85 % and the low range about 20 %. Most estimates ranged between about 40 and 60 % of the fossil fuel emission.

The big range is caused by a big difference in use for the by-products. The lowest emissions occur when the by-product sugar beet pulp is used as fuel e.g. for heat generation, and the farming practices and N_2O emissions are calculated according to Ecobilan. The highest emissions occur with an ethanol plant integrated in a sugar refinery and rotational set-aside land planted with Egyptian clover which is a N-fixing crop and used as green cover crop which is plowed back into the soil for fertilization, and when the IPCC method for N_2O is used.

Biodiesel from rape-seed

The best estimate GHG emission for biodiesel from rape-seed is about 50 % of that of conventional diesel. The range of the 23 cases studied varies between 25 % and 90 % of conventional diesel. The majority of the estimates fall between 30 % and 50 % of the conventional diesel emission.

The very broad range is caused by the GM study. The lowest value uses the Ecobilan N_2O method instead of the IPCC method and the by-product glycerin replaces conventionally produced glycerin. The highest value has a high use of fertilizer and the glycerin is used as fuel within the RME plant for heat generation.

Biodiesel from RVO

The GHG emissions from RVO biodiesel are 16 % of the conventional diesel emissions with a small range (14 – 19 %) around it. Only esterification and distribution are assumed to cause GHG emissions here.

Breakdown of the GHG emissions

The emissions of the feedstock production for RME are for almost 90 % caused by the production and use of the N fertiliser. For 75 % this component originates from N_2O emissions in the field. The main component of the biofuel (RME) production step is the esterification (being 70 % of the total biofuel production stage). GHG emissions from wheat feedstock production are caused for about 50% by N fertiliser use. In the case of beet this is about 80%. The wheat feedstock logistics are rather high, because of a fuel oil based drying step and because of the fact that in the cited study the overall GHG WTW emission for ethanol from wheat is relatively low. A very important element in the beet ethanol chain is the distillation step, which is responsible for about 80% of bioethanol production emission.

For fossil fuels, the indirect GHG emissions cover about 13% in the case of diesel and 17% in the case of gasoline. These indirect emissions are in both cases caused for about 50% by the refining process. Oil extraction covers about 30% of the WTW GHG emissions. The oil extraction GHG emissions are caused for about 25% by methane emissions during the extraction phase and for about 75% by CO_2 emissions. The data are based on a crude oil mix that originates for 35% from the North Sea, for 25% from Siberia and for 40% from the OPEC.

Future fuels: Fischer-Tropsch diesel and lignocellulose ethanol

The biomass Fischer-Tropsch (FT) diesel WTW emissions are very low. The best estimate came from the only full LCA found on FT diesel. It estimated the FT diesel WTW GHG emissions of a chain in which woody biomass is imported over sea from a distance of about 1000 km, at 15% of the diesel WTW chain: 27 g CO_2equivalent/km. Negative emissions of –16 g CO_2equivalent/km are reported in the ADL study [49], where the by-product (naphta) credits were larger than the emissions of the FT chain itself. The high end of the range found is 60 g CO_2equivalent/km [49].

A wide range was found for WTW GHG emissions from ethanol from ligno-cellulosic biomass (LC ethanol). This partly had to do with the lignin content of the fuel used. Fuels with much lignin, led in some studies (e.g. ADL) to a large by-product credit for the electricity produced, so that the net chain emissions became negative. However, there are also a few rather high estimates for straw based ligno-cellulosic chains. However, in the studies concerned, these were also extreme values of a wider range. The best estimate (also based on straw) was derived from the Sheffield study, since this was very well documented and since the ethanol wheat WTW GHG emission best estimate was also derived from this study. Sheffield estimated these emissions at 18 % of the gasoline emissions as used in this study, or 41 g CO_2equivalent/km. All estimates found ranged between –18 % and 81 % of gasoline.

5.3 Other emissions

Non-GHG emissions of biofuels versus fossil fuels have been presented in different ways by Ecotec [55], IEA [56] and Scharmer [57]. Of course, vehicle operational emissions will have to meet the same EURO 5 emissions standards regardless whether the fuel was of biomass or fossil origin.

Figure 5-2 shows well to wheel SO_x, NO_x, VOC, CO and PM emissions of biodiesel versus fossil diesel, according to Ecotec.

According to Ecotec [55], the biodiesel life cycle has only 20% of the sulphur emissions of the diesel life cycle. In the diesel chain, lower sulphur fuels will reduce tailpipe SO_x emissions. However, according to Ecotec, over 50% of the SO_x emission in the diesel life cycle arises during refining. Tailpipe emissions are only 25% of the overall diesel based SO_x emission. This means that the introduction of low sulphur diesels will only have a limited effect on the overall diesel based SO_x emissions.

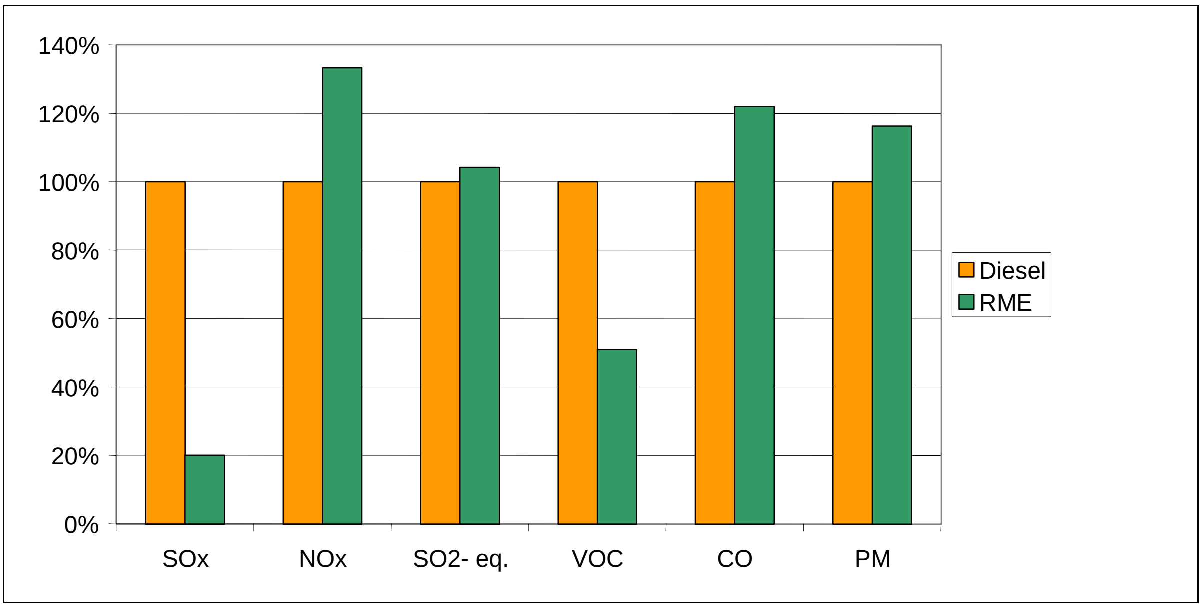


Figure 5-2. Biodiesel WTW emissions as compared to fossil diesel WTW emissions. The fossil emissions have been put at 100% for each of the emissions. On the basis of the SO_x and NO_x emission, the SO_2 equivalents have been calculated.

Life-cycle emissions of NO_x from biodiesel (on a "neat fuel" basis) are about 30% higher than from diesel. **Figure 5-3** shows that this difference mainly occurs during the feedstock production as a result of tractor use. This is also caused by the relatively low yield of rape-seed per hectare, which cause in field emissions to end up quite significant in the end result. Although no background data are presented, it is expected that NO_x emissions for the tractors as included by Ecotec are relatively high. This is derived from the fact that the Ecotec study is based on a study from ETSU of 1996, which probably referred to emission figures that originate from before 1996. Future more stringent NO_x emission standards for tractors would reduce the indirect NO_x emissions in the RME chain.

NO_x vehicle emissions of biodiesel are estimated by Ecotec [55] to be about 5% higher (on a "neat fuel" basis) than diesel NO_x emissions. This means that when the biodiesel or bio-oil is imported into Ireland, the NO_x emissions increase will be limited up to 5 % for pure biofuel.

In conclusion, the high NO_x emission found should therefore be regarded cautiously, since:

- It does not account for future more stringent emission limits (EURO-5).
- Reported values stem from only one literature source.
- The import of rapeseed or biodiesel would imply that indirect NO_x emissions are generated outside Ireland.
- With stricter emission standards also the indirect NO_x emissions (mainly by tractors) are expected to be significantly reduced in the near future.

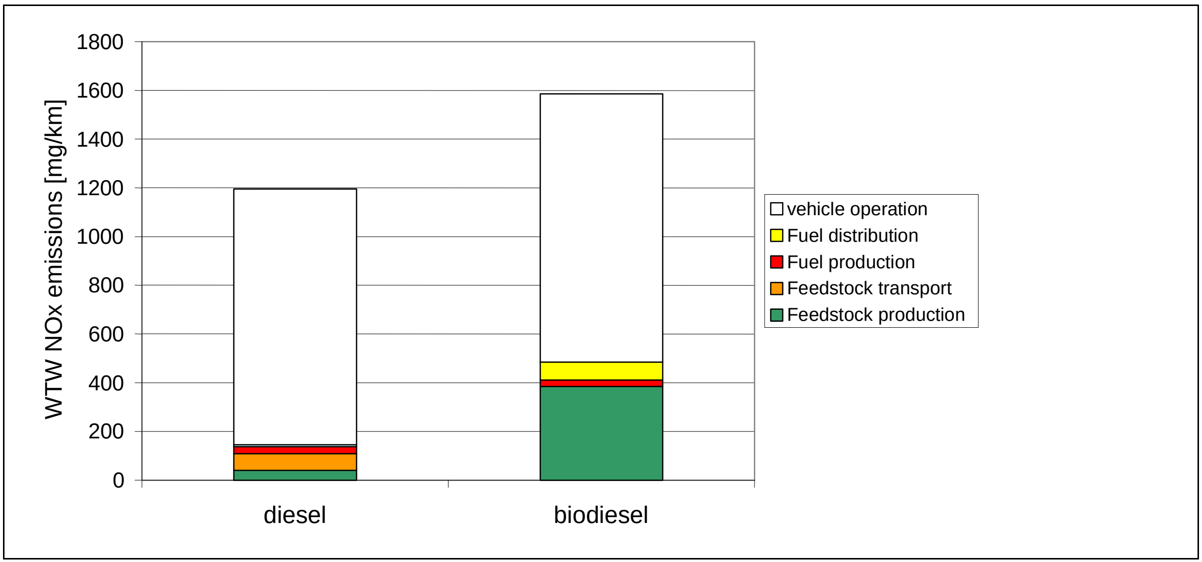


Figure 5-3. Breakdown of NO_x WTW emission for diesel and biodiesel on a "neat fuel" basis. [55].

Emissions of volatile organic compounds from biodiesel are about 50 % of those from diesel. VOCs are precursors to ground level ozone and associated with certain respiratory problems.

Life cycle emissions of carbon monoxide were about 20% higher from biodiesel than diesel. This arises mainly from emissions from agricultural machinery. In the future, CO emissions are likely to decline with the trend to higher yields and lower tractor engine emissions.

Particulate matter emissions, finally, are estimated to be about 15% higher with biodiesel on a WTW basis. This increase also stems largely from the emissions of agricultural machinery.

Ecotec did not include non-GHG emission data on bioethanol in their analysis. Such data were reported by the IEA [56].

Regarding bioethanol (from sugar/starch), the IEA data suggest higher NO_x emissions as compared to gasoline, although both the bioethanol and the gasoline range are very large. Since the share of the agricultural process with bioethanol in general is smaller than with biodiesel one would expect a smaller share of indirect NO_x emissions in the case of ethanol. In general, the IEA data are considered to be quite generic (high ranges resulting from a wide range of studies), from which it is rather difficult to draw firm conclusions.

CO and HC emissions appear lower on average with bioethanol, although, especially with HC the bioethanol range is rather large again. Because the gasoline based PM emissions are estimated to be zero, it makes more sense to compare with diesel here. The WTW bioethanol PM emissions are estimated to be about 35% of those of the diesel WTW chain. No quantitative data were available on a comparison on SO_x emissions. It can be expected that these will be lower with ethanol because of the fact that ethanol hardly contains any sulphur (2-3 ppm) [26].

The IEA study shows a very large range regarding the NO_x emissions of both diesel and biodiesel. However, biodiesel especially has a much higher upper level. The average value of biodiesel NO_x emissions is even 50% higher here than the average diesel NO_x value. The CO and PM diesel and biodiesel emission comparison shows quite a similar picture as with the Ecotec data.

A study by the "Union for the promotion of oil and protein plants" [57] cited NO_x WTW emissions that are about 13 % lower as compared to diesel. However, the same study cites sources in which the total acidifying emission from biodiesel is between 16 and 64 % higher than with fossil fuels. This is mainly caused by NH_3 emissions as a result of fertilisation during rape-seed cultivation.

Note that the emissions standards for petrol and diesel vehicles are expected to be reduced in the near future (2007/2008). This will especially affect diesel vehicles as they will most likely be forced to include particulate and NO_x storage traps. This would significantly reduce the difference between the emissions of biofuels and fossil derived fuels, and change the composition of **Figure 5-3**.

5.4 Other environmental impacts of biofuel feedstock production [58; 59]

Any change to existing land uses, cropping patterns and crop and residue markets has potential implications for biodiversity, water and air quality and rural landscapes. If biofuel industries are to develop successfully, it is important that their development be managed from the outset to ensure that any effects of feedstock supply are positive to the rural environment. These effects are considered for three categories of feedstock: residue materials, conventional crops already in production for other markets and new crops produced specifically for biofuel use.

Residues: It is envisaged in this report that these materials could play an important role as biofuel feedstocks, both in the 2005-10 period (e.g. RVO, tallow, molasses), and after 2010 with improved technologies (e.g. straw, wood residues). The provision of a profitable alternative outlet for these materials would reduce the risk of undesirable disposal practices being used for these materials e.g. in-field straw burning or RVO disposal via sewers or land-fills. It would also raise some of these materials to a higher level in the waste pyramid, from disposal/composting to recovery/recycling. No adverse environmental effects can be envisaged.

Conventional crops: In the first phase of biofuel development (2005-10) no more than a small increase in the total arable area (and in the area of conventional crops used for biofuels) is foreseen. Even an increase of 50 kha would leave 90% of agricultural land still in grass, and would do no more than return the arable area to its level of about 1978.

Within the arable area, restrictions on individual crops imposed by agronomic considerations and EU quotas would not allow more than minor changes in the current cropping pattern. The least desirable effect would be an increase in the proportion of cereals, leading to more mono-culture cropping and a reduction of biodiversity.

A moderate increase in the sugar beet area would have several desirable effects. As well as reducing continuous cereal production, as a spring-sown crop it would provide a stubble site for some over-wintering bird species. The growing beet crop also provides nesting sites for a number of bird species. The breakdown of plant residues after harvest provides some of the fertiliser needs of the next crop.

There is ecological evidence to suggest that oilseed rape is a relatively beneficial crop for biodiversity, in comparison with other autumn-sown arable crops (Hope & Johnson, 2003). Spring-sown rape would be preferable; as well as providing an over-wintering stubble site it requires lower pesticide and fertiliser inputs. A recent UK study of the health effects of rape pollen, while acknowledging that some atopic individuals may have an allergic response, concluded that “allergic responses to oilseed rape make very little contribution to the overall burden of allergy in the UK”. On the emission of VOCs, the report concluded that “on the basis of currently available data there is no direct evidence to suggest that VOCs are responsible for the adverse health effects reported to be associated with oilseed rape” [60]. Nevertheless, concerns about rape pollen as well as landscape effects should be acknowledged by avoiding planting close to built-up areas or in highly visible sites.

Little change in cultural practices should be expected where conventional crops are destined for a biofuel rather than a traditional use. In the longer term, some reduction in pesticide use on biofuel crops may be possible as a result of differences in quality standards for feeds and biofuels. Decisions that may be made on the use of genetically modified crops are difficult to predict but are unlikely to be influenced by the end use of the crop.

New crops: If processes for the conversion of lignocellulose to transport biofuel become feasible, high-yielding crops such as short-rotation willow or poplar, miscanthus and hemp may become of interest. Not much is known about the biodiversity impacts of producing these crops. Coppiced areas are inhabited by a wide range of small mammals and birds and should favour earthworms and herbivorous invertebrates. A concern would be the lowering of water table if planted near wetland habitats. Miscanthus is a non-native woody perennial rhizomatous grass; it requires low inputs, but there are as yet no reports on plantation biodiversity. Hemp is a spring-sown annual crop with a short growing season that would normally require no pesticides. It is unlikely to have any major environmental effects.

These crops grow to a height of 2.5 4 metres, so they would have more visual impact than conventional crops on the rural landscape. Site selection would therefore have to be given serious consideration, especially for the perennial crops.

Some use is already being made of coppice areas as sites for the disposal of certain effluents in accordance with nutrient management plans. This greatly improves the economic viability of the biofuel production with no apparent effects to date on ground-water quality, but its other environmental impacts need to be further monitored.

Conclusion: The use of residues for biofuel production would be environmentally desirable. The small short-term changes envisaged in the production of conventional crops would also have little effect, as long as the proportion of cereals is not increased. What is important is that the most environmentally friendly practices are used in the production of these crops; a recent UK study shows the effects of alternative cropping systems on their environmental impact [59]. The impacts of potential new crops are less well known, and need to be researched in the years remaining before their possible exploitation.

The use of set-aside land for biofuel production may be a cause for some concern. However, with the upcoming reduction of set-aside to 5% the effect of any change of use will be extremely small. Current management of fallow set-aside in Ireland is haphazard, and any environmental benefit derived from it is uncertain.

The transport and processing of these crops could also have unfavourable rural impacts. Many biofuel feedstocks have a low density, and it is important that they be transported without generating excessive traffic or structural damage on country roads. The location and scale of process plants would also need to be carefully planned to minimise traffic, visual impact and other environmental effects and to avoid difficulties with planning authorities.

6 Costs

This chapter starts with analysing the *production costs* of biodiesel and bioethanol. Also the production costs of the future biofuels FT diesel and lignocellulose ethanol are reported. The *delivered costs* include costs and margins for blending, distribution and retail. Here we will also show uncertainty ranges. The extra costs of biofuels compared to fossil fuels, combined with the benefit in greenhouse gas emission reduction, yields the costs of this greenhouse gas emission reduction.

6.1 Biodiesel

The production costs of rape-seed biodiesel are calculated by dividing the total annual costs by the total amount of biodiesel produced. The total annual costs follow from the feedstock costs (including agricultural subsidies), operational costs minus co-products revenues, and annual depreciation of the capital investment. Assumptions on feedstock costs and conversion are summarized in **Table 6-1**. The feedstock costs are based on estimate of Irish feedstock production costs, as presented in Chapter 3. The conversion efficiencies stem from international literature [41].

Table 6-1. Feedstock costs and conversion efficiencies used for the calculation of biodiesel and Fischer-Tropsch diesel production costs.

	Feedstock costs (€/tonne)	Conversion[1)] (l/tonne) [41]
Biodiesel		
rapeseed	250	356
RVO	290	990
Tallow	275	910
Fischer-Tropsch diesel		
medium term	52	200
long term	26	230

1) Feedstock to fuel.

The capital costs for seed pressing and esterification are taken from a study on the proposed Wexford installation, a small cold pressing plant at the scale that is likely to be practicable in Ireland. The capital costs of installations that esterify RVO or tallow are estimated to be 15 % more expensive than rape-seed oil esterification installations [41]. Revenues for cake are assumed to amount to 180 €/tonne, and for glycerol 120 €/tonne.

Results for the calculations are given in **Figure 6-1**. Although rape-seed is an expensive feedstock, the co-product revenues are considerable and make the total production costs to amount to about 21 €/GJ or 0.70 €/litre. This is about three times the current production costs of fossil diesel. Biodiesel from RVO or tallow is cheaper: about two times the production costs of fossil diesel. However, one has to realise that only a small fraction of RVO or tallow derived diesel may be allowed to be blended in RME to meet FAME specifications. Therefore, the results for a blend of 10 % RVO in RME are also shown.

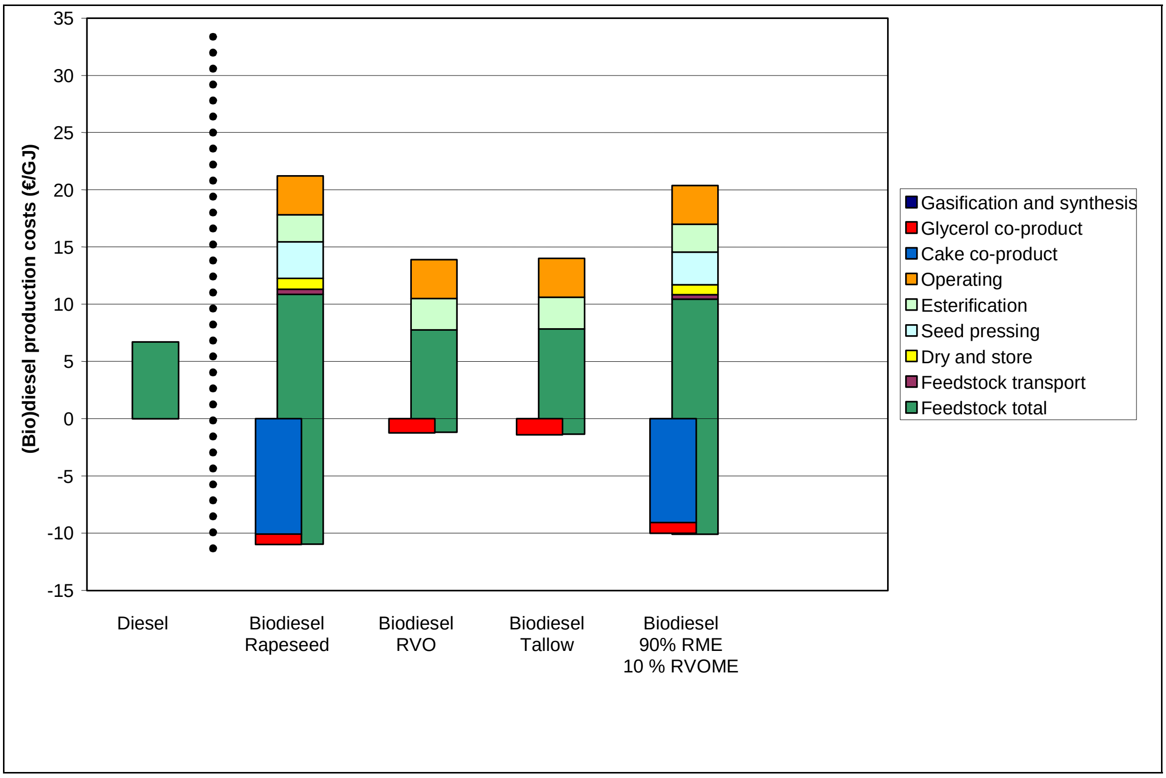


Figure 6-1. Production costs of diesel and biodiesel (excluding fuel distribution and blending).

6.2 Bioethanol

In like manner the production costs of ethanol can be calculated. Assumptions on feedstock costs and conversion are summarized in **Table 6-2**. Assumptions on the capital investment and co-product revenues for ethanol from wheat and sugar beet, are taken from an IEA study on bioethanol [61], which was selected recently as a best estimate within a range of studies. The production of ethanol from lignocellulosic biomass was previously assessed by Hamelinck [62].

Table 6-2. Feedstock costs (from resource chapter) and conversion efficiencies [41] used for the calculation of the production costs of ethanol from different feedstock.

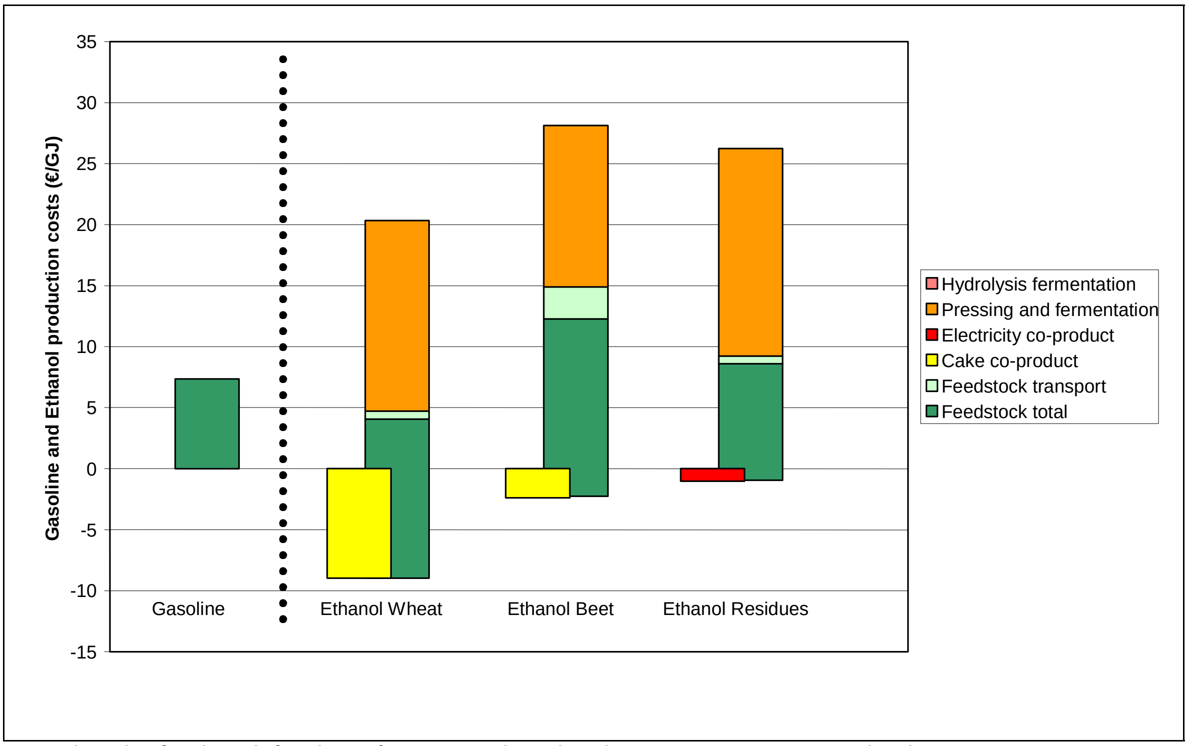
	Feedstock costs (€/tonne)	Conversion (l/tonne)
Wheat	98	355
Sugar beet	28	90
Residues	45	220
Lignocellulose long term	26	405

The results are shown in **Figure 6-2**. The production costs of bioethanol from sugar beet are considerably higher than that for production from wheat. The difference is mainly in the revenue for co-products. The lower ethanol yield from beet (per tonne wet) is more ore less compensated by the lower feedstock cost, so that the contribution of feedstock costs to the final costs is similar for beet and wheat.

6.3 Future biofuels

Beyond 2010, more advanced biofuels may be produced such as Fischer-Tropsch diesel. This fuel can be produced by gasification of lignocellulose biomass and subsequent chemical synthesis [e.g. 62]. Cheaper feedstock (higher yields per hectare, easier logistics) and larger conversion scale could bring the production costs of those fuels to about 9 €/GJ.

In like manner the production costs of ethanol produced by hydrolysis fermentation from lignocellulose biomass was determined [41; 62].



Note that the feedstock for these fuels is produced without any agricultural subsidy.

Figure 6-2. Production costs of gasoline and bioethanol (excluding fuel distribution and blending).

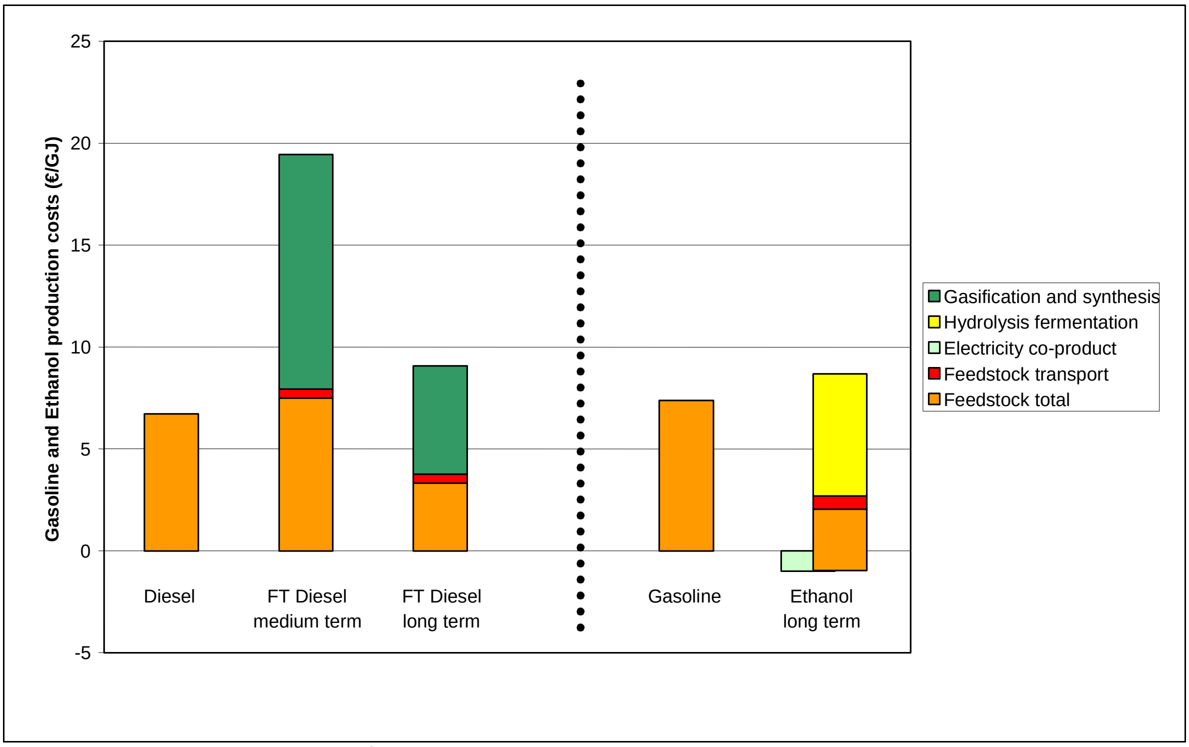


Figure 6-3. Production costs of FT diesel and lignocellulose ethanol.

6.4 Fuel delivered costs

To calculate the delivered costs of the fuel at the gas station (delivered to the customer), the costs for distribution of biofuels, required margins and retail are included. The base costs for distribution of diesel or gasoline amount 0.10 €/l fuel [41], the extra costs for the distribution of biofuels add about 1 eurocent per litre for biodiesel and 1.5 eurocent per litre for ethanol [41]. Costs for delivering ethanol also include the costs for adapting the gasoline to meet the vapour pressure specifications, these costs are about 3.5 eurocents per litre for blends of 5 % ethanol in gasoline. The resulting delivered costs are shown in **Figure 6-4** on energy basis, and in **Figure 6-5** on volume basis.

The volumetric results are not the right basis for mutual comparison of the various fuels, because of differences in heating value and vehicle fuel use of the various fuels considered. These values are presented, because the consumer is normally confronted with prices on a volumetric basis. The figure with results on energy basis incorporates the fact that the LHV (Lower Heating Value) of gasoline is 13 % lower that of diesel, the LHV of biodiesel 8 % lower than that of diesel, and of ethanol 32 % lower than that of gasoline.

The figures include ranges of values found in literature. Only a few sources reported on the delivered costs of RVO and tallow biodiesel, in the figures this results in small ranges.

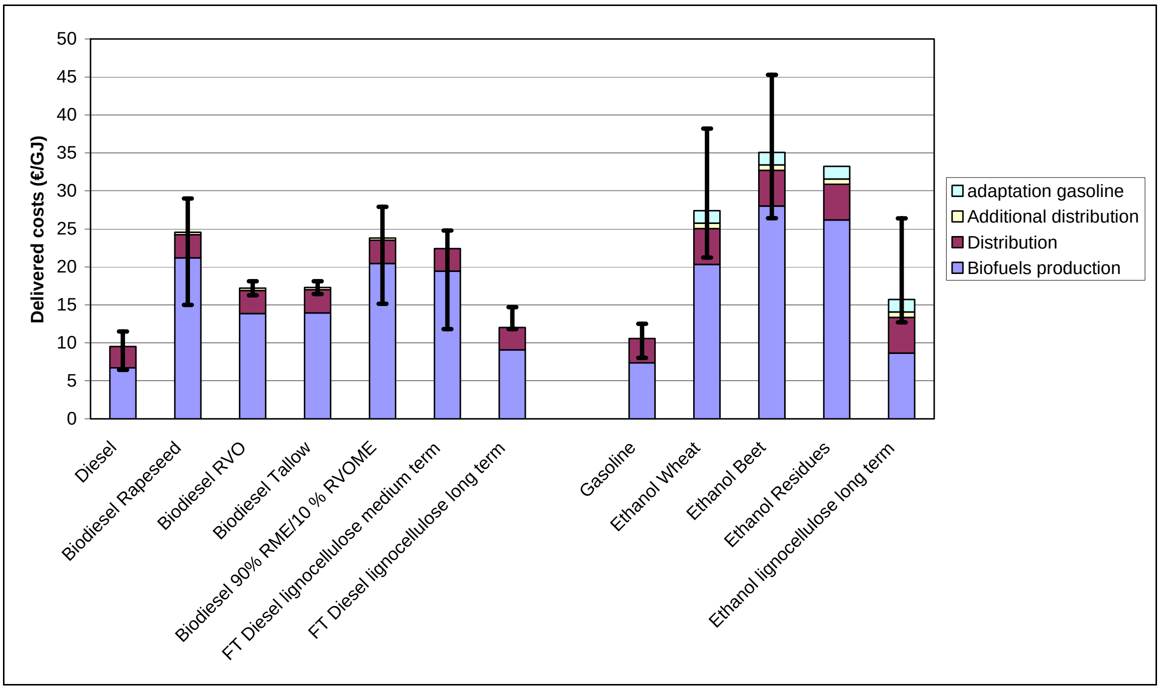


Figure 6-4. Cost comparison for fuels delivered at the gas station, on energy basis. Costs include the cost and margin for distribution and retail and exclude the excise duty and VAT. Ranges for these delivered costs are derived from various literature sources [41]. The bars represent the best estimate of Ecofys.

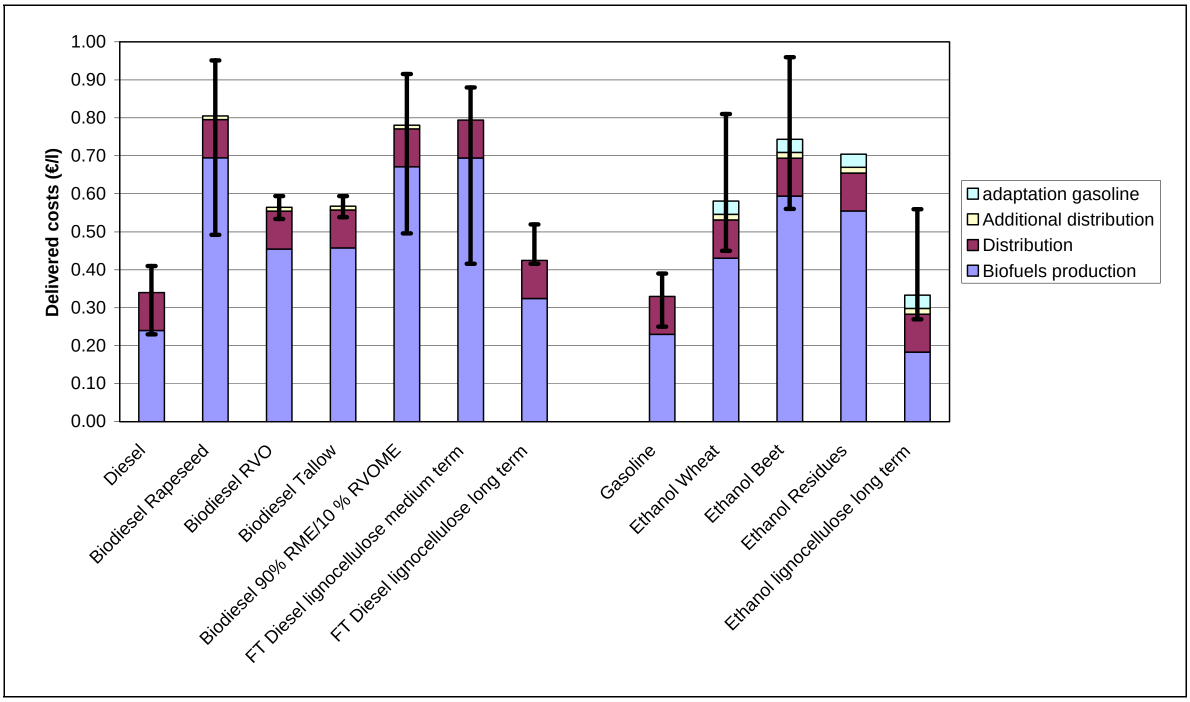


Figure 6-5. Cost comparison for fuels delivered at the gas station, on volume basis. Costs include the cost and margin for distribution and retail and exclude the excise duty and VAT. Ranges for these delivered costs are derived from various literature sources [41]. The bars represent the best estimate of Ecofys.

6.5 Excise duty exemption required to avoid a cost impact for the customer

The delivered costs in these figures are without excise duty or VAT. Whereas VAT will be the same for all fuels, variation of the excise duty maybe an instrument for stimulating the use of biofuels.

Two starting points could be taken for an excise duty reduction for biofuels. In the first starting point the price per litre would remain the same as for fossil fuels. However, because of the lower energy content of the biofuel blend, the consumer would have to tank more litres of fuel. Alternatively the price per GJ at the pump could be kept the same, in order to compensate for the additional litres that have to be bought.

If an excise duty would be compelled such that the prices of biofuels and fossil fuels would be the same on a volumetric basis, a litre of biodiesel from RVO or tallow would be excised with about 14 cent/l. This means an excise duty exemption of 22 cent/l. Delivered biodiesel from rape-seed, however, requires a much larger excise duty exemption of 47 cent/l. This is more than the total current excise duty on diesel (37 cent/l).

Ethanol from wheat requires an excise duty exemption of 25 cent/l compared to the gasoline excise duty of 44 cent/l. The delivered cost of ethanol from beet is comparable to the delivered cost of gasoline including duty; The exemption required, 41 cent/l, is almost as high as the duty itself.

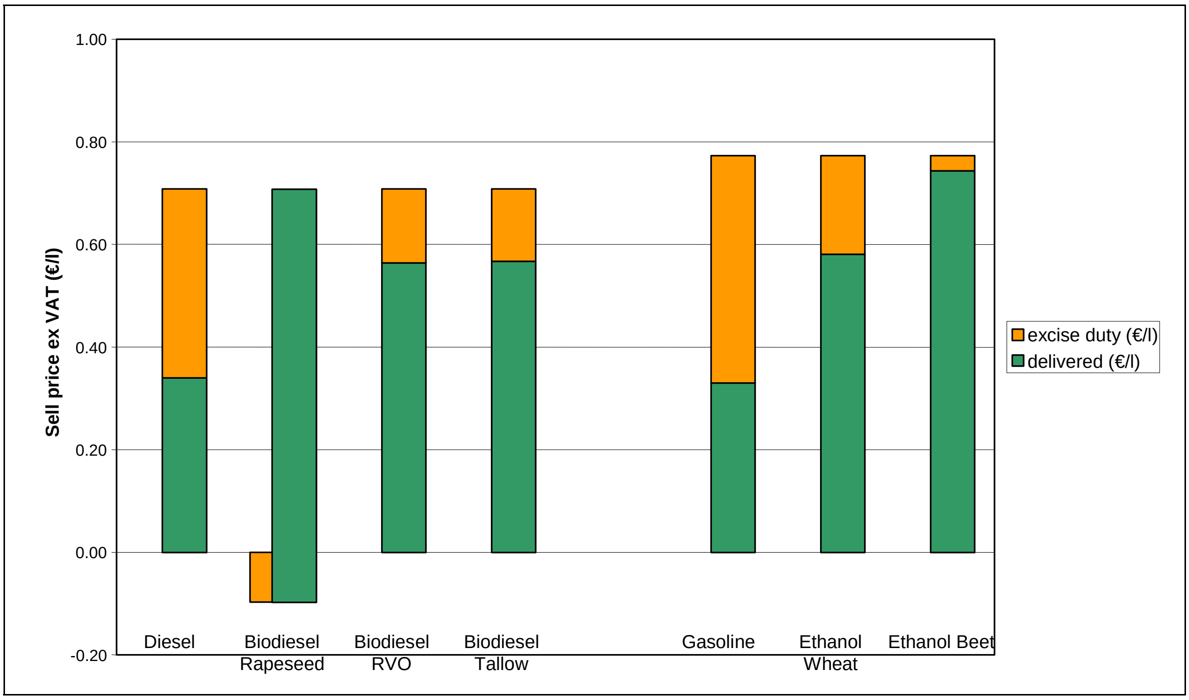


Figure 6-6. Excise duty (exemption) in €/l required to reach equal pump prices per litre fuel.

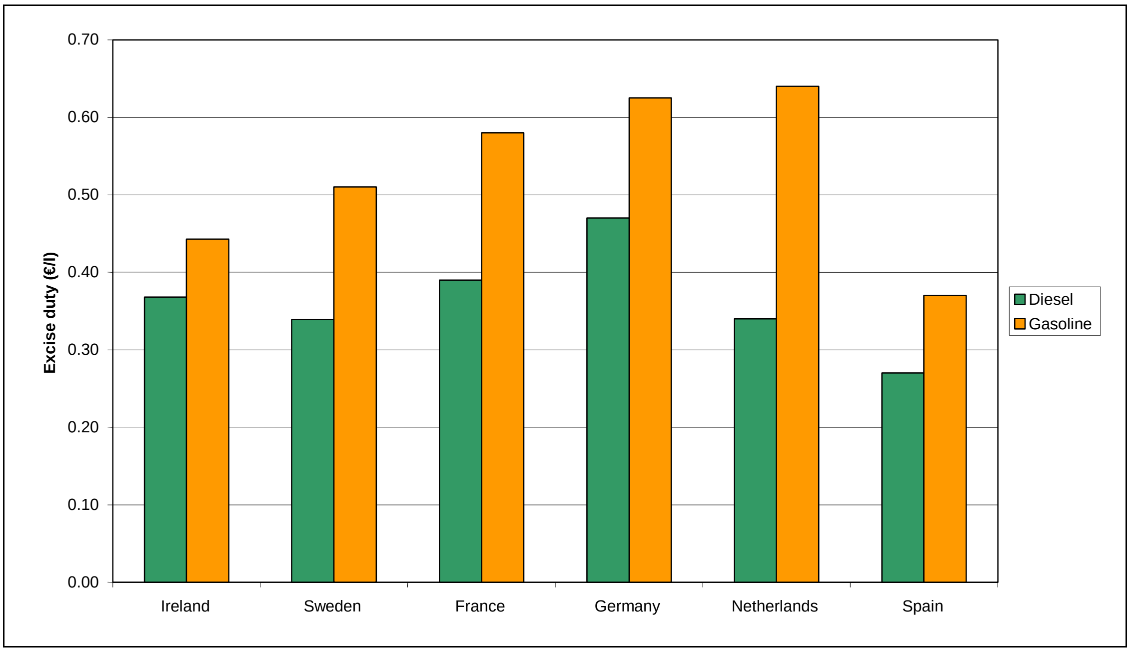


Figure 6-7. Excise duty on gasoline and diesel in several European countries [41; 63]

If one wants to achieve a same GJ price at the gas station, then also ethanol from wheat and beet require a duty exemption larger than the duty on gasoline. This is because a litre of ethanol contains less energy than a litre of gasoline. The negative excise duty for ethanol was not found in the recent Dutch study by Ecofys [41], because the duty on gasoline in the Netherlands is much higher than in Ireland. The excise duty in Ireland – especially for gasoline – is relatively low compared to other European countries (see **Figure 6-7**).

6.6 Cost of GHG emission avoided

The cost of GHG emission avoided can now be calculated by dividing the net cost of using biofuel (compared to using fossil fuel) in €/km by the net GHG emission reduction of using biofuel (compared to using fossil fuel) in $\text{tonne}_{CO2equivalent}$/km. This can be expressed by the following formula:

$$C_{GHGavoided} = \left(\frac{C_{driving,b} - C_{driving,f}}{E_{GHG,f} - E_{GHG,b}} \right) \times 1\ million \qquad (1)$$

with $C_{GHGavoided}$ = the cost of avoided GHG emissions, in €/$\text{tonne}_{CO2equivalent}$

$C_{driving}$ = the fuel costs for driving a car in €/km

E_{GHG} = the Greenhouse gas emission from using a fuel in $g_{CO2equivalent}$/km

subscript b indicates biofuel

subscript f indicates fossil fuel

The kilometric costs for using the fuel are found by dividing the delivered costs of a fuel (€/GJ) by the fuel efficiency (km/GJ) or the inverse fuel use. The fuel use for cars driving on diesel or biodiesel is assumed to be 2.08 MJ/km and for gasoline or ethanol 2.59 MJ/km (see section 5.1).

The resulting costs of GHG emission avoided is shown for two biodiesel and two bioethanol options in **Figure 6-8**. The cost of using RME or ethanol from wheat as an option to avoiding greenhouse gas emission is about 300 €/tonne$_{CO2equivalent}$. Note that the feedstock production costs included agricultural subsidies. The actual costs without any subsidy of these options are more expensive, about 550 and 450 €/ tonne$_{CO2equivalent}$ [41]. Long term costs when driving FT diesel or lignocellulose ethanol could be as low as 50 – 100 €/tonne$_{CO2equivalent}$ [41].

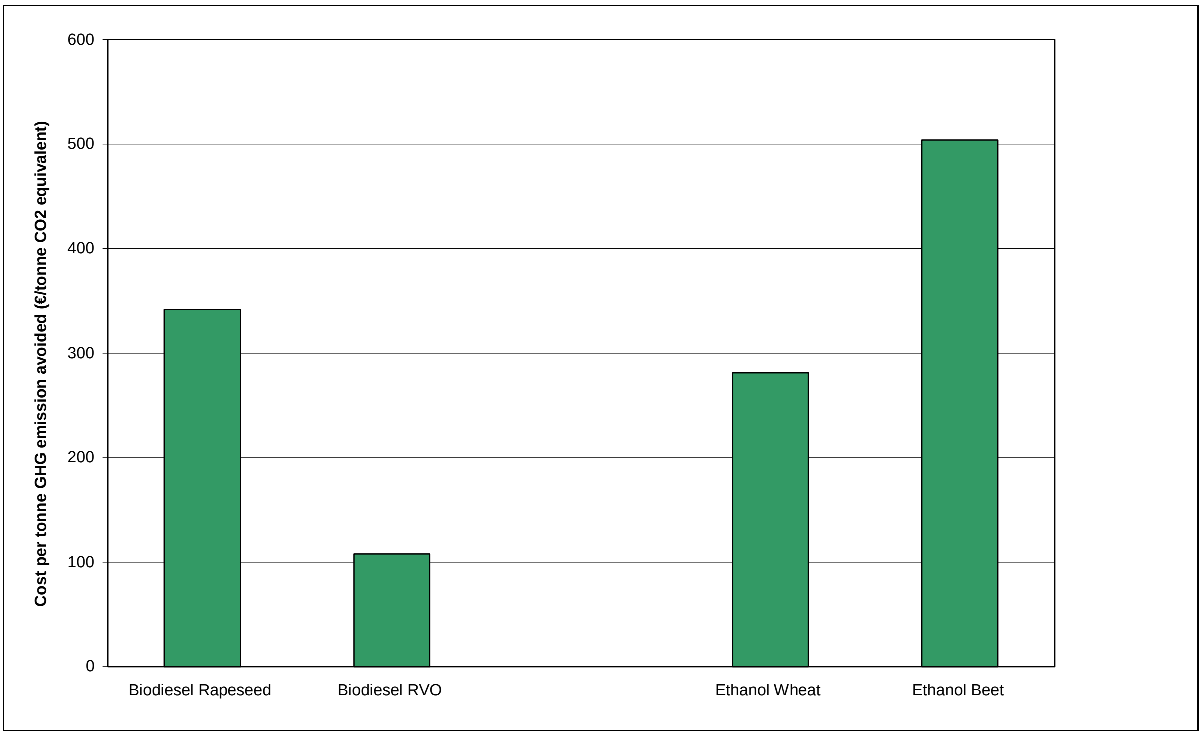


Figure 6-8. Costs of GHG emission reduction with biodiesel and ethanol. The avoided emission per km compared to diesel and gasoline use (derived from Figure 5-1) was divided by the excise duty exemption required.

7 Macro-Economic Impacts

7.1 Introduction

The selected fuels are analysed on their macro-economic impacts. This is done by input-output (IO) analysis. IO analysis is a partial analysis of the economy, concentrating on the production sector. It can be used to calculate what share of a certain expenditure will end up abroad and what share will end up as value added to the national economy [2]. The sum of all value added in a country is the Gross Domestic Product (GDP). By means of input-output analysis, all indirect impacts can be modelled on the basis of the Input-Output table. This is an overview table of the economy of a country that shows which sector buys from which sector in order to produce its products. The Irish IO table was delivered by Forfas [64]. In this study, IO analysis will be used to break the total cost of a biofuel and of its fossil competitor down into value added for Ireland, and imports. On the basis of these results, estimates can be given as well on the direct and indirect employment generation from the production of biofuels as compared to the production of fossil fuels. The same accounts for the impact on the Irish Treasury. A detailed description of the IO methodology applied in this study, with all steps undertaken, is presented in Annex D. Limitations of the application of the IO method for the analysis of bioenergy chains are discussed in by Van den Broek [2].

7.2 Results

Delivered costs

The delivered costs as presented in **Figure 6-4** (on GJ basis) have been broken down into import and value added. The result is shown in **Figure 7-1**, the two Figures show the same total values, the only difference is that the breakdown is expressed in another way.

Although we assume that the biofuels are domestically produced on set-aside land, the amount of import per GJ product decreases only slightly for some of the biodiesel cases compared to fossil diesel. Implementation of some of the bioethanol cases leads to even a slight increase of import. This is for almost 50 % caused by the production of the feedstock, where the agricultural machinery requires diesel, and the machinery itself (or the material it is made of) is probably for a certain part imported. The feedstock production and conversion, and the distribution of biofuels create much value added in the form of wages, because they are relatively labour intensive.

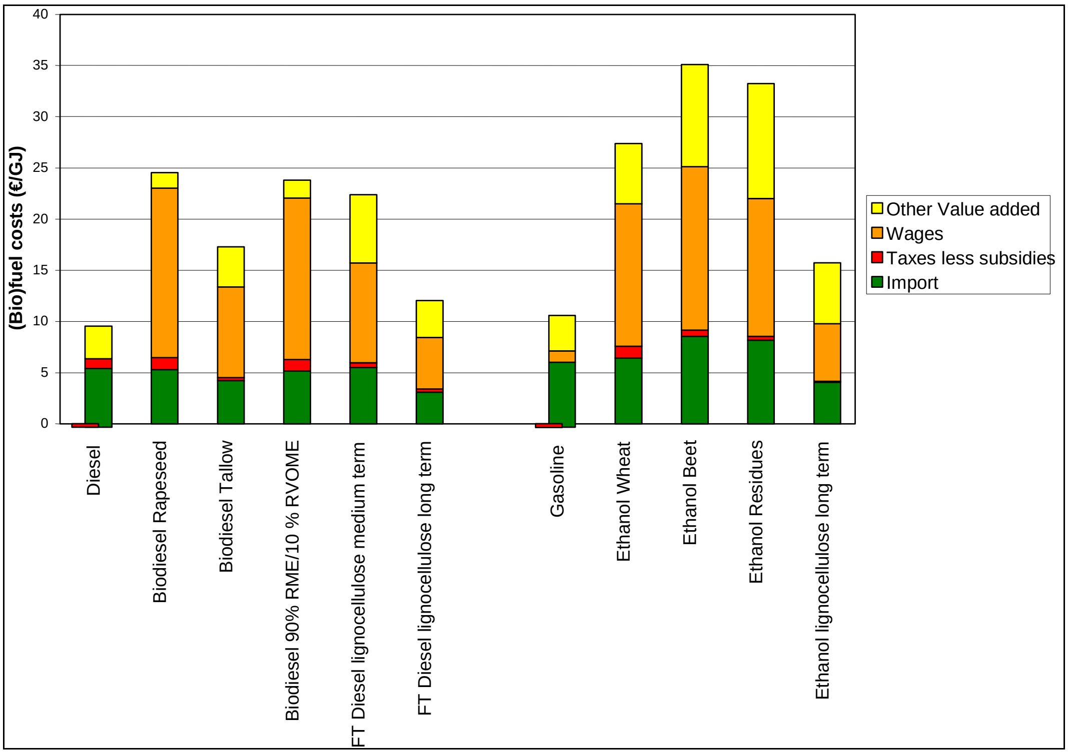


Figure 7-1. The fuel delivered costs (€/GJ) broken down in import and value added: taxes less subsidies, wages, and other value added.

Domestic production and import

We will now present the macro economic impact of a spectrum of options, ranging from additional indigenous production on set-aside land to direct import of the biofuel. We assume that imported products have the same price as when they are produced in Ireland. Although in some European countries bio-oil, biodiesel, wheat or ethanol may be cheaper, the products available to Ireland in a developed biofuels market may still be more expensive. Note that as the main driver for importing biofuels, the fact that Ireland cannot produce the required amounts of biofuel domestically is likely to be more important than slight price differences with other EU countries.

The options included are:

- Biodiesel from rapeseed produced on Irish set-aside land
- Biodiesel from imported bio-oil
- Imported biodiesel
- Ethanol from wheat produced on Irish set-aside land
- Ethanol from imported wheat
- Ethanol imported from the EU

If wheat (or rapeseed) is produced on non set-aside land, it substitutes feed crops. When the demand for feed crops remains the same, they should be thus additionally imported. In that case it does not matter significantly whether the wheat is imported for biofuel or feed purposes. This implies that the option of producing ethanol from wheat from non set-aside land, is similar to the option of producing ethanol from imported wheat.

On the world market, sugar cane ethanol is available in large amounts and much cheaper than ethanol produced from sugar beet or wheat in Europe. We therefore include also the option:

· Ethanol imported from Brazil

Here, of course, we do include a lower biofuel production cost as compared to indigenously produced biofuels.

Excise duty exemption to realise an equal GJ price

Figure 7-2 shows the results of the analysis. The total delivered costs for the various biodiesel options is the same 24 €/GJ, for the reason explained above. In Chapter 6 it was shown that the biofuels need excise duty exemption to be competitive with fossil derived fuels. We assume for the analysis in this chapter that an excise duty exemption is granted by the government to biofuels that will lead to equal product prices per GJ compared to fossil biofuels. Only in this case we can assume that the amount of money spent on transportation fuels by consumers will remain unchanged. This assumption is necessary for a reliable input-output analysis, as alternatively a significant change in the consumers' expenditures would have other macro-economic effects that are not reflected within the IO table. Note that excise duty exemption to arrive at similar GJ prices means that litre prices of biofuels will be lower than that of fossil fuels. Further, note that to arrive at equal GJ prices the amount of excise duty exemption required in all cases is larger than the current duty on the fossil fuels they replace (**Figure 7-2**).

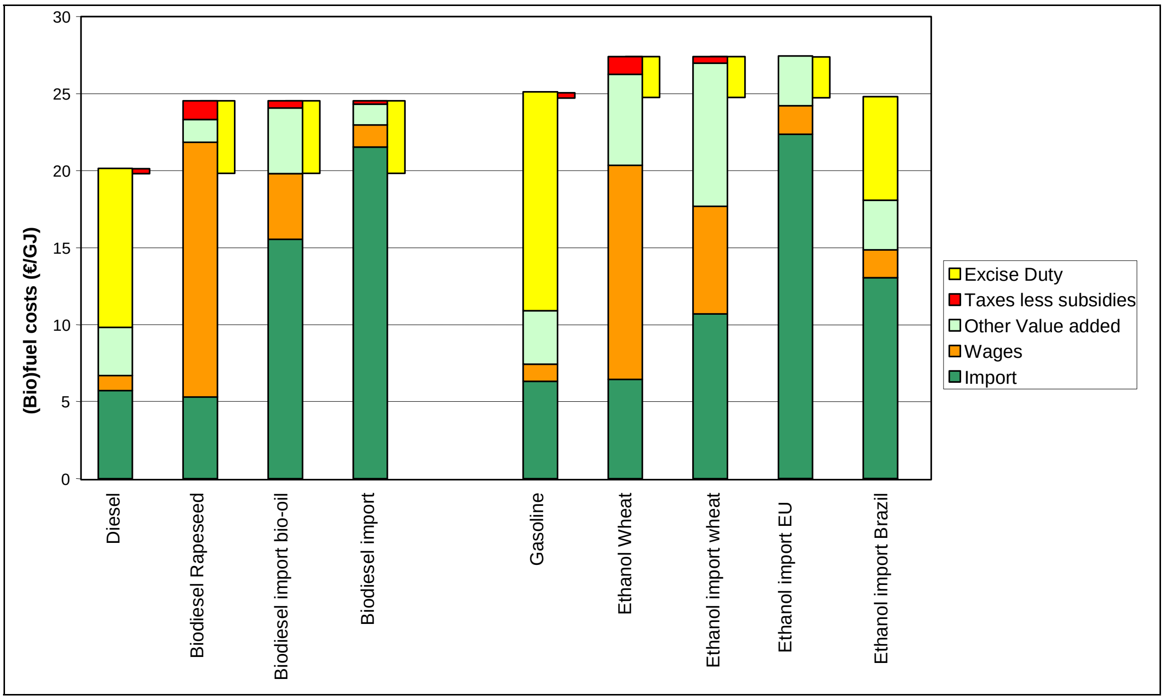


Figure 7-2. The breakdown of the GJ price of diesel, biodiesel, gasoline and bio-ethanol into import and value added (taxes less subsidies, wages, excise duty and other value added). A same delivered price per GJ is assumed. In the case of ethanol imported from Brazil (last bar) the item excise duty is actually the sum of excise duty and import tax.

If we include the excise duty (which is value added for the economy as well) and assume an excise duty reduction up to similar prices per GJ, the total value added to the Irish economy follows from addition of all items except import. This is shown in **Figure 7-3**, for the case of ethanol. The value added for the options biodiesel from rapeseed and ethanol from wheat are similar to the value added of the fossil fuels they replace. This is all under the condition that the crops are produced on set-aside land.

The import of ethanol from Brazil to Ireland is also included in the figure. The value added and wages that can be earned are the same as when bioethanol is imported from the EU. However, as the ethanol arrives at the border at a lower cost, the result of excise duty and import tax that can be imposed is positive.

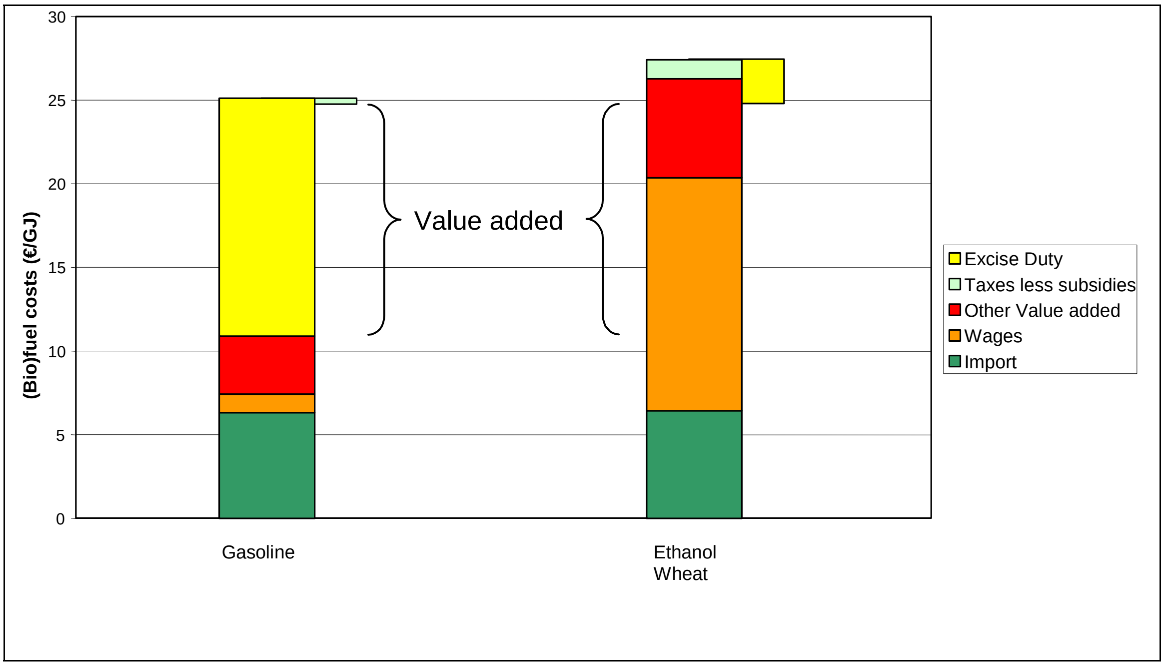


Figure 7-3. Value added of bioethanol from wheat compared to that of gasoline (€/GJ).

Impact on the treasury

For the same cases as presented in **Figure 7-2**, the impact on the treasury is analysed. It is the result of incomes to the treasury, such as excise duty and other taxes, and expenditures, such as subsidies and allowances for job seekers. The excise duty was already shown in **Figure 7-2** and calculated before. The item taxes less subsidies follows directly from the Input-Output analysis. Added value in the form of wages implies the creation of jobs. This decreases treasury spending on job seekers allowance (JSA). The most jobs per € wage are created in labour intensive sectors, such as agriculture. It is for this reason that the domestic production of bioethanol and biodiesel saves a lot on JSA spendings, see **Figure 7-4**. Nevertheless the money saved on JSA does not outweigh the loss of income on duty.

When biofuel or feedstock is imported from the EU, the spending on exempting fuel duty is larger than the saving on JSA and tax income. This means that from a macro-economic viewpoint these biofuels cost extra money to the treasury.

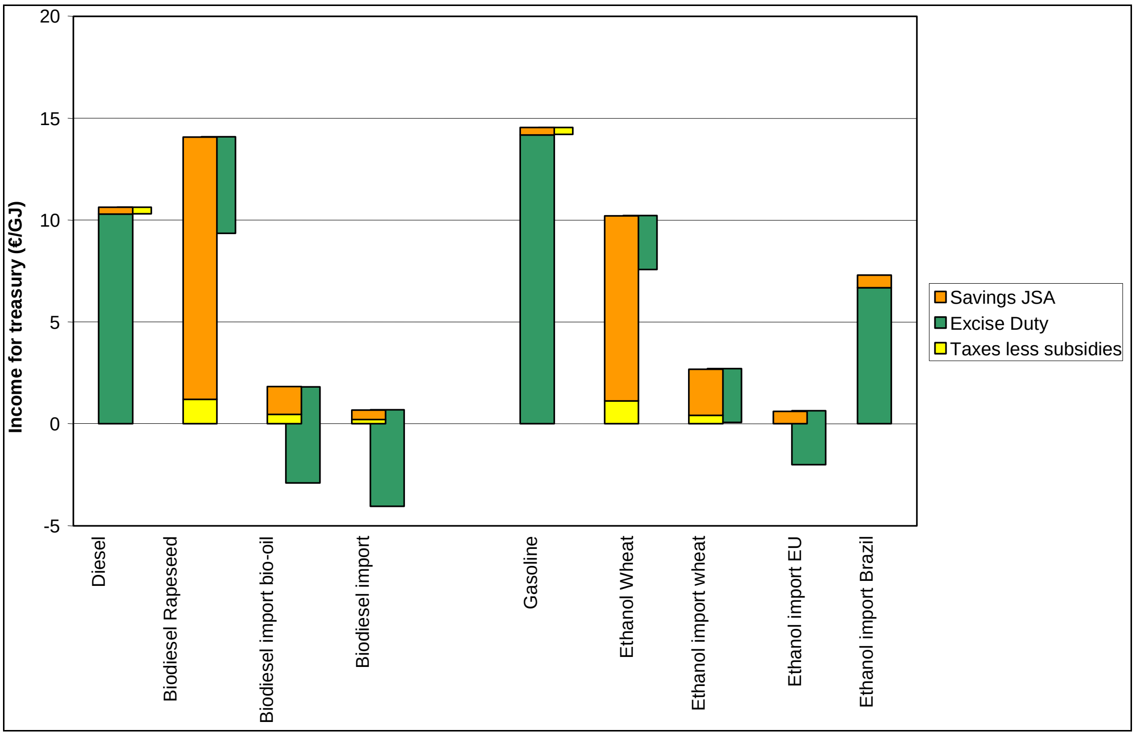


Figure 7-4. The net result for the treasury of the sum of excise duty income, additional taxes less subsidies and savings on job seekers payments. All costs are expressed as €/GJ. Equal selling price per GJ assumed.

Table 7-1 finally shows the amount of jobs created in the different scenarios of domestic production versus feedstock or biofuel import.

Of course, for the employment it does not make a difference whether a biofuel is imported from the EU or from elsewhere.

Table 7-1. Employment under different options (thousand man.year).

Diesel	**Biodiesel Rape-seed**	**Bio-oil imported**	**RME imported**
0.3	10	1.1	0.4
Gasoline	**Ethanol Wheat**	**Wheat imported**	**Ethanol imported**
0.2	5.2	1.3	0.4

7.3 Conclusions on the macro-economic results

- In general it can be concluded that bioethanol production from wheat on set-aside land scores similar to gasoline on the contribution to the GDP (i.e. value added creation). Job creation, however, is a factor 25 higher than with gasoline. Ethanol production from imported wheat creates somewhat less value added, creating 6 times more employment than with the current gasoline-based system. Imported ethanol from within the EC creates no net value added in Ireland at all. Employment genereation from imported ethanol (from EU or world) is only slightly higher than the employment from gasoline.
- The comparison between biodiesel and fossil diesel is rather similar. The main difference is that imported bio-oil for biodiesel production also scores significantly less in terms of value added creation when compared to fossil diesel. In the case of import of biodiesel, the net value added creation is negative.

- Total government income in the ethanol set-aside scenario is about half of the income that the government has with gasoline. Approximately 60 % of the total costs of the excise duty exemption (including the subsidy needed) can be earned back as a result of additional tax income and savings on unemployment payments. In the case of ethanol from imported wheat net government income per litre of ethanol sold is about zero (i.e. the income on savings from job seekers allowances and additional taxes equals the necessary fuel subsidy). In this import situation only about 15 % of the cost of the full excise duty exemption can here be recouped. In the case of imported ethanol, the net government income is negative. Only a few percent of the full excise duty exemption is earned back in this case. Ethanol can be imported from Brazil for much lower prices. Therefore the sum of import tax and excise duty that can be imposed is positive.
- We have argued that the wheat import case is basically similar to using wheat that is currently produced for feed purposes. The preceding bullet leads to the conclusion that for the GDP of Ireland it is only slightly more attractive to use currently produced Irish wheat instead of importing bioethanol from Brazil. For the treasury, however, importing bioethanol from Brazil is more attractive than importing wheat or using currently produced Irish wheat.
- When comparing biodiesel with diesel, a similar type of effect is observed in terms of the impact on the treasury, although exact figures are somewhat different.
- A maximum of only 1.1 PJ of biofuel (of the 3.5 and 12 PJ targets) can be produced on set-aside land in Ireland. Therefore, a significant component of the biofuels' feedstock will have to be imported. If current crops are used for bioethanol production, additional feed will have to be imported, which will have an impact comparable to that described above.

8 Import of Biomass and Biofuels

In Chapter 3 it was shown that a fair part of the 2005 target and a small part of the 2010 target amount of biofuels could be produced using Irish feedstock material. To meet both targets, import of either feedstock material, or biofuels will be necessary. In any case the Irish biofuels market cannot be seen in isolation from the European market. If biofuels would be more cheaply available elsewhere in Europe, import may be an attractive option. On the other hand, biofuels would be exported to other countries if there is a cost advantage.

The UK is one of the main trading partners for Ireland, and the largest exporter of fuel to Ireland (see Section 4.4). Therefore policy and legislation items in the UK are of high importance to the Irish biofuels market (Section 8.1). In Section 8.2 we will focus on the possibilities for import of biofuels from the EU. And in 8.3, the import of biofuels from the rest of the world is analysed.

8.1 UK policy background

National Drivers

There are currently several key policies in the UK that support an active stimulation of the biofuels market. The UK's energy white paper [65] is the central document for energy policy and has recommended that the UK put itself on a path towards a 60% reduction in carbon dioxide emissions from current levels by 2005. More specifically, the paper highlighted biofuels as a key approach in reducing transport emissions and made a commitment to assessing the overall energy implications of the large-scale use of biofuels. Several studies have already been completed as part of this assessment (E4tech, NCSA/IEEP) and consultations with key stakeholders are ongoing [66].

The EU Biofuels Directive is also important and in May 2004 the UK government published a consultation document on the UK's plans for implementing the Biofuels Directive. This document seeks views on the UK target for biofuels sales in 2005 and 2010, labelling of biofuel blends, and potential policy and support options for this market. The UK approach to the Biofuels Directive will include Wales and Scotland, although both of these Devolved Administrations are responsible for aspects of biofuels policy.

The UK intends to inform the European Commission of its 2005 target by July, shortly after the completion of the consultation process. However, the UK will defer a decision on the 2010 target until after a long-term policy approach has been chosen. The UK may wait until the EU deadline of July 2007 before publishing its intentions on the latter target.

Biodiesel is currently the only biofuel on sale in the UK, available at over 100 filling stations. Sales of biodiesel are approximately 2 million litres per month where total diesel sales are roughly 1700 million l/month. These figures show that biodiesel currently makes up less than 0.1% of the total diesel sales, and less than 0.05% of total gasoline and diesel sales. Although biofuels sales in the UK are predicted to grow over the coming years, the EU 2005 reference point of 2% energy content remains a very ambitious target.

Forecasts of biofuel use and production in the UK predict increased biodiesel production as the main source of increased biofuels sales in the UK, with large-scale bioethanol production unlikely in the short-term. The UK government has neither endorsed nor excluded the use of ETBE in the long-term as an alternative route to achieving increased biofuel penetration.

The estimates used in the UK's consultation document predict 12 million litres a month of biofuels sales in 2005. It is suggested that the UK sets this as the target for 2005. This target would represent no more than 0.3% of total gasoline and diesel sales in the UK, without a conversion to energy content as is used in the Biofuels Directive. However, the UK government maintains that there is not sufficient time to stimulate the market in a way that will come any closer to the EU reference point and therefore this is likely to be the target reported to the EU in July.

The majority of biodiesel produced in the UK at the moment uses waste vegetable oil (WVO) as the biological raw material as it is the cheapest source available. However, in the long-term limited supply and fuel quality issues could restrict the growth of WVO as a feedstock. Already palm and soya bean oil are imported, to a certain extent, for biodiesel production because of the lower cost implications. Some rape is imported from the continent for use in biodiesel production but it is much more costly than making biodiesel using other sources.

Argent Energy is building a new large-scale biodiesel production plant in Scotland. This facility is likely to be in operation by 2005 and will be able to produce 50 million litres of biodiesel at full capacity. The plant will convert tallow and waste oils into biodiesel and will be the first large-scale plant of its kind in the UK.

Through the assessment of the long-term potential of biofuels that the Department for Transport is currently carrying out several calculations were made. Assuming a maximum growing area of 4Mha, UK resources could supply a maximum of approximately 500PJ of biofuels. The total UK energy consumption by road transport was 1700PJ in 2002, so 2002 resources would have been able to supply less than 30% of total transport demand.

This calculation does not take into account growth of the road transport sector and more importantly, competition for biomass with the power generation sector which could reduce the availability of domestic raw materials for production.

Should biofuels be adopted in the long-term the UK foresees large-scale biofuel production being sourced from energy crops and using lignocellulosic processes. When domestic production is no longer cost-effective, or the limit of production has been reached, imports will become necessary.

Policy options

There are already financial incentives in place in the UK for biofuels sales. A 20p/l duty differential has been in place for biodiesel since July 2002 and in January 2005 this duty will be extended to bioethanol as well. It is expected that the introduction of the bioethanol duty incentive will stimulate sales of bioethanol in much the same way that biodiesel sales have grown. The budget in 2004 indicated that these incentives would remain for at least the next three years.

In terms of future financial policy, the UK government will investigate incentives for existing refineries to use biological inputs next to their traditional fossil fuels where technically possible ("input taxation"), and the use of enhanced capital allowances for production facilities.

In determining future policy, the main focus is the increase of sales of biofuels in the medium-term, however the UK government is also interested in encouraging domestic production over imports where this is compatible with EU Competition laws. The consultation that is currently in progress asks for stakeholder views on the extent to which the Government should support the development of the UK biofuels industry.

The UK consultation paper also includes a cost benefit analysis of meeting the EU reference points in 2005 and 2010 which estimates that the introduction of biofuels could cost 353 £/tonne carbon to meet the 5.75% reference point in 2010 (using sales as an estimate of energy content.) Although expensive compared to measures available in other sectors, this is a relatively low cost for carbon abatement in transport. The comparison with other sectors could become a key factor in determining the availability of raw materials for biofuels production versus the power generation sector.

Future regulatory and support measures being considered by the UK government include:

- Increased fuel duty incentives;
- A stepped approach to the fuel duty incentives to limit cost to the Exchequer;
- Renewable fuels obligation along a similar design to the Renewables Obligation in the electricity supply sector;
- Voluntary agreements with the oil industry (not favoured by industry);
- Regional capital grants for biofuels plants;
- Enhanced capital allowances for biofuels production processes;
- Research and development incentives e.g. Fischer-Tropsch biodiesel;
- Certification for imports.

It is important to bear in mind that UK sales of biofuels is the focus of many of these policy drivers, and therefore they may not affect the biofuel content of exports from the UK to Ireland. When a clear policy direction has been chosen it will become clearer whether the UK policy will stimulate a UK biofuel production industry, or merely encourage imports. The resulting strategy can then be assessed in more detail for its impact on Ireland.

Although the UK is likely to indicate a target below the EU reference point in 2005, the UK biofuels sector is confident that, with sufficient support, it could produce enough biofuels to reach the EU reference point for 2010. Other factors are also important in meeting the 2010 target, including considerations of engine limitations. The UK will not notify the Commission of its decision on the 2010 target until policy drivers have been considered, and may leave this decision until the 2007 deadline.

8.2 Biofuels from the EU25

To map the possible import of biofuels from, or export to other European countries, this section estimates the amounts and costs of biofuels in these countries. The analysis has been limited to the production of biodiesel from rape-seed and sunflower, and the production of bioethanol from sugar beet or wheat. The production of biofuels from residue streams has not been accounted for, neither has the (post 2010) production of biofuels from lignocellulose biomass.

The assessment of European biofuel production costs and potential was carried out by calculating the amount and costs of biofuels in separate regions (NUTS II*), and ranking the results by increasing production costs.

Biodiesel

In the period 2000 to 2010 rapeseed prices are expected to rise from 226 to 240 €/tonne and for sunflower seed from 245 to 271 €/tonne. Feedstock prices and average yields* for rape seed and

* The Nomenclature of Territorial Units for Statistics (NUTS) was established by Eurostat more than 25 years ago in order to provide a single uniform breakdown of territorial units for the production of regional statistics for the European Union. Since this is a hierarchical classification, the NUTS subdivides each Member State into a whole number of NUTS 1 regions, each of which is in turn subdivided into a whole number of NUTS 2 regions and so on. NUTS-2 regions have a population threshold of minimum 800 thousand and maximum 3 million [67].

sunflower were included as input values in this cost assessment. The average feedstock costs per hectare for rape-seed and sunflower used for 11 Member States was 650 €/ha and for the rest 300 €/ha[†]. These figures correspond to the average prices of 230 €/tonne for oilseeds in the EU. The selling price for rape seed cake was 0.104 €/kg and for glycerin 0.0833 €/kg [68]. However, if the biodiesel industry introduces large amounts of glycerin into the market, it is expected that this figure will be reduced substantially. In this respect, the pharmaceutical industry is paying close attention to the developments of the biodiesel industry and how the global market price of glycerin is affected by increasing the biofuels shares.

A cost assessment‡ has been carried out for all for all EU-15 Members States and their corresponding NUTS-2 regions in order to generate cost-potential curves (supply curves) and identify countries potentials as well as export possibilities among various Member States.

Bioethanol

A similar approach was used to evaluate the different cost components for bioethanol production from wheat and sugar beet.

The wheat yield figures for each Member State and their corresponding NUTS-2 in the period between 1998 until 2001, were obtained from EUROSTAT and DG Agriculture's statistics. The bioethanol conversion rate from wheat used in this assessment is 350 litres per tonne. In this calculation 900 €/ha was used for feedstock costs, corresponding to 140 – 180 €/tonne. No revenues for by-products are taken into account.

The cost assessment for bioethanol production from sugar beet assumes a net sugar beet feedstock costs of 26 €/tonne. This figure is based on the world sugar beet market prices and the B-quota for sugar beet. The category called co-product credit corresponds to the value of by-products obtained by the bioethanol production process. For the case of sugar beet the by-product generated is called sugar beet pulp and this is valued at 0.03 €/litre ethanol according to Enguidanos, Soria, Kavalov [69].

The conversion and blending costs are related to additional storage and logistics costs, and the costs of adapting gasoline to avoid excessive vapour pressure [70]. In these calculations it was assumed that ethanol with high purity (99.9 %) was used in a blend of 5 percent with gasoline. The distribution costs are those of bringing the fuel from the factory to the end-user, and they are estimated at 0.10 €/litre according to Van den Broek, et al. [41].

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[*] Average yields figures for each Member State and their corresponding NUTS 2 regions for the years 1999, 2000 and 2001 were obtained from EUROSTAT. The same applies to the case of bioethanol.

[†] European Commission, Prospects for Agricultural Markets 2002 – 2009, June 2002. 650 €/ha was used for Austria, Belgium, Germany, Denmark, France, Finland, Ireland, Luxembourg, Holland, Sweden and United Kingdom. For Spain, Greece, Italy and Portugal 300 €/ha.

‡ Unitary costs and consumption values for water, energy and other inputs were obtained from a detailed study from St. Stephen University. Input data from yields and other unitary costs figures were obtained from EUROSTAT New Cronos Database on 15[th] August 2003. The costs include the conversion from oil to methyl ester. From 1000 kg rape-seed, about 350 kg oil and 610 kg oil cake is produced. From 1000 kg sunflower seed, 400 kg oil is produced.

As a result of these cost assessments, total bioethanol costs from wheat in the EU 15 and new Member States vary from 0.60 up to 1.18 €/litre with an average figure of 0.74 €/litre (see **Table 8-1**). In the case of bioethanol from sugar beet, the average figure for EU-15 is slightly cheaper with 0.60 €/litre. Note that in this table bioethanol in Ireland costs respectively 31 €/GJ (0.65 €/l) and 27 €/GJ (0.57 €/l) when produced from wheat and beet. Wheat ethanol is here thus 11 €/GJ more expensive than was calculated in Chapter 6. This can completely be explained by the fact that revenues for the co-produced cake-meal are not incorporated here.

Cost – Potential Curves

In order to produce cost potential curves or supply curves for the various biofuel possibilities in the short-term (2010), it is necessary to obtain feasible potential figures for each Member States in the European Union context. For this purpose, some assumptions regarding land allocations for the production of feedstock for energy purposes were used based on the Prospects for Agricultural Markets for the period 2002 – 2009 from DG Agriculture.

The most recent reforms of the Common Agricultural Policy (CAP) stipulate that non-food crops (e.g. energy crops) can be produced in certain agricultural areas or set-aside land. The set-aside scheme allows Member States to establish compulsory and voluntary set-aside areas for non-food purposes. This

Table 8-1. Biofuel Costs – EU – 15 + 10 + 2.

	Bioethanol Total Costs		Biodiesel Total Costs
Country	Total Costs (Wheat)	Total Costs (Sugarbeet)	Total Costs
	Eur/L	Eur/L	Eur/L
AT	0,79	0,62	0,81
BE	0,66	0,61	0,67
DE	0,73	0,58	0,58
DK	0,77	0,63	0,69
ES	0,87	0,47	0,79
FR	0,71	0,72	0,69
FI	1,18	0,68	1,37
GR	0,87	0,54	0,72
IE	0,65	0,57	0,71
IT	0,87	0,61	0,72
LU	0,84	0,62	0,67
NL	0,66	0,58	0,56
PT	0,75	0,60	0,79
SE	0,88	0,55	0,79
UK	0,75	0,61	0,7
EU-15	0,80	0,6	0,75
CR	0,61	0,56	0,53
EST	0,76	0,47	0,60
LAT	0,70	0,50	0,58
LIT	0,61	0,49	0,56
HUN	0,60	0,54	0,58
POL	0,62	0,53	0,54
SLO	0,61	0,57	0,53
SLK	0,59	0,53	0,55
CYP	n.a.	0,37	n.a.
MAL	n.a.	0,37	n.a.
CC-10	0,64	0,52	0,56
BU	0,63	0,43	0,8
RO	0,64	0,44	0,7
CC-12	0,63	0,50	0,76
TU	0,70	0,54	0,54
EU-25	0,690	0,57	0,7

scheme remains unchanged in the latest CAP reform of 2003 (see summary of CAP reform in Annex B).

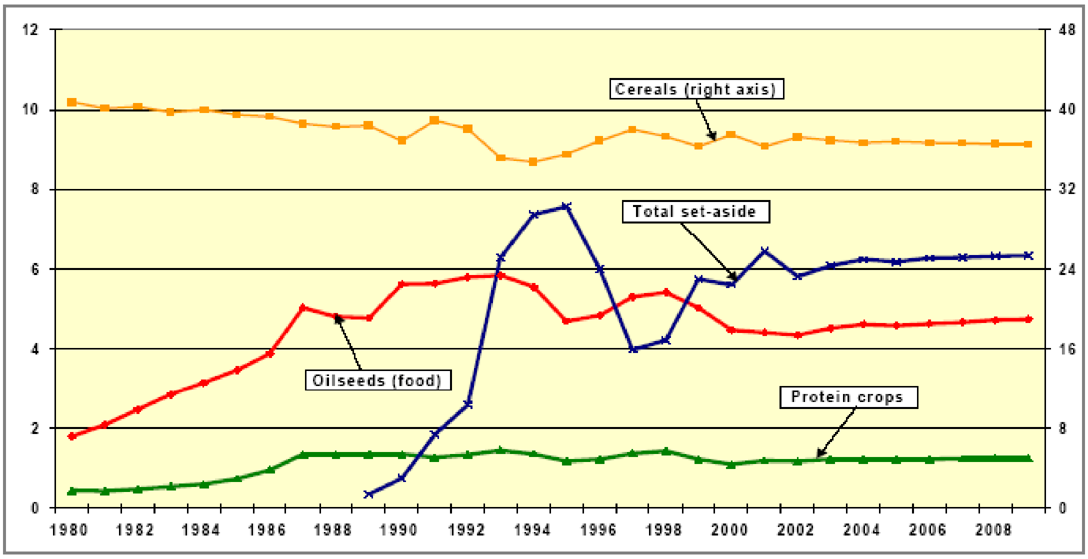

Figure 8-1. Arable Land Allocation– Set Aside Development 1989 – 2009 (mio. ha) [71].

As observed in **Figure 8-1**, the rate of development of the total area of set-aside land has been quite irregular during the 1990's fluctuating between 2 to 10 percent. The CAP reform in 2000 established 10 percent as a *compulsory set aside rate*, representing an advantage for the stable cultivation of non-food crops. If such land is used for the production of energy crops, security of supply might be guaranteed, however, feedstock prices are a decisive factor for production volumes and import/exports trade.

It is important to remark that the uncertainty in the permanence of this compulsory rate lends great uncertainty to the biofuels industry.

Within this framework the regional and national potential analysis for every member state was calculated based on the assumption that all crops harvested for the production of biofuels are grown on set- aside areas. The total area considered to calculate the different set-aside percentages is based on the *arable land* values and not on the *total land* records. An explanation of the way the information was organised for the purpose of building up the cost potential curves follows.

The maximum potential is defined as the current and future land availability multiplied by the corresponding yield of the crops for the production of each particular biofuel.

Bioethanol and biodiesel potentials were calculated based on an assumed set-aside rate of 15 percent which is likely to occur due to voluntary set-aside areas allocations as well as extra agricultural land used for non-food instead of food purposes. In regard to bioethanol, two potentials were calculated. The first one is calculated on the assumption that 15 percent set aside rate is used to grow wheat for bioethanol production. The second one is based on an assumption of 10 percent for wheat and 5 percent for sugar beet.

Furthermore, in the case of biodiesel, the share of production between biodiesel from rape-seed and sunflower was calculated based on the harvested areas during the period from 1998 and 2001 obtained from EUROSTAT. The historical land use showed the regions and countries where either sunflower or rape-seed or both were grown. From this figure, the percentage of sunflower and rape-seed in each particular region and Member State was calculated and these results were used to calculate the biodiesel potential.

For the purpose of obtaining ascending cost potential figures and maximum potentials the input information was arranged as follows:

- Cost figures were organized from the lowest options (cheapest regions) up to the most expensive ones.
- Potential information was calculated for each particular region at the NUTS 2 level. A country's maximum potential is defined as the cumulated sum of the potential of all regions.

Figure 8-2 shows the cost-potential curve (supply curve) obtained for biodiesel and bioethanol for the European Union from the cost assessment and biofuels potential calculations. Three scenarios are presented:

- Biodiesel Supply Curve – Potential calculation based on 15 % of arable land.
- Bioethanol from wheat Supply Curve – Potential based on 15 % of arable land.
- Bioethanol Supply Curve from wheat and sugar beet – Potential based on 10 % of arable land for wheat and 5 % set aside land for sugar beet.

The targets of the EU biofuel Directive are included in the graph. The 2005 targets of the EU biofuel Directive can be met by either biodiesel or bioethanol from wheat (all three scenarios). However, the 2010 Directive targets can only be met by bioethanol using one third of the bioethanol production from sugar beet (i.e. only scenario 3). The surplus production of biofuels after meeting the targets requirements is likely to occur at relatively high costs (above 35 €/GJ).

The total potential for bioethanol increases by about 68 % when replacing 1/3 of wheat area with sugar beet. This corresponds with on average a 2.5 times higher ethanol yield per ha.

The cost results observed in **Figure 8-2** will increase moderately in the case where Ireland is importing biofuels as a consequence of international transportation costs as well as customs and import taxes. **Table 8-2** includes the international transportation costs for both solids and liquids (waterway) from the various Member States. Observe that on average, the international transport costs from countries with surplus potential in 2005 (e.g. Germany, France) vary between 0.30 €/GJ and 0.45 €/GJ. Spain has higher costs of approximately 0.96 €/GJ, not considerably increasing the biofuel costs in Ireland.

International transport of biomass (pellets) will add about 0.5 €/GJ when transported in large ships (Panamax). For the case of ethanol transported in large amounts, the cost figures are likely to increase by approximately 0.2 €/GJ [62].

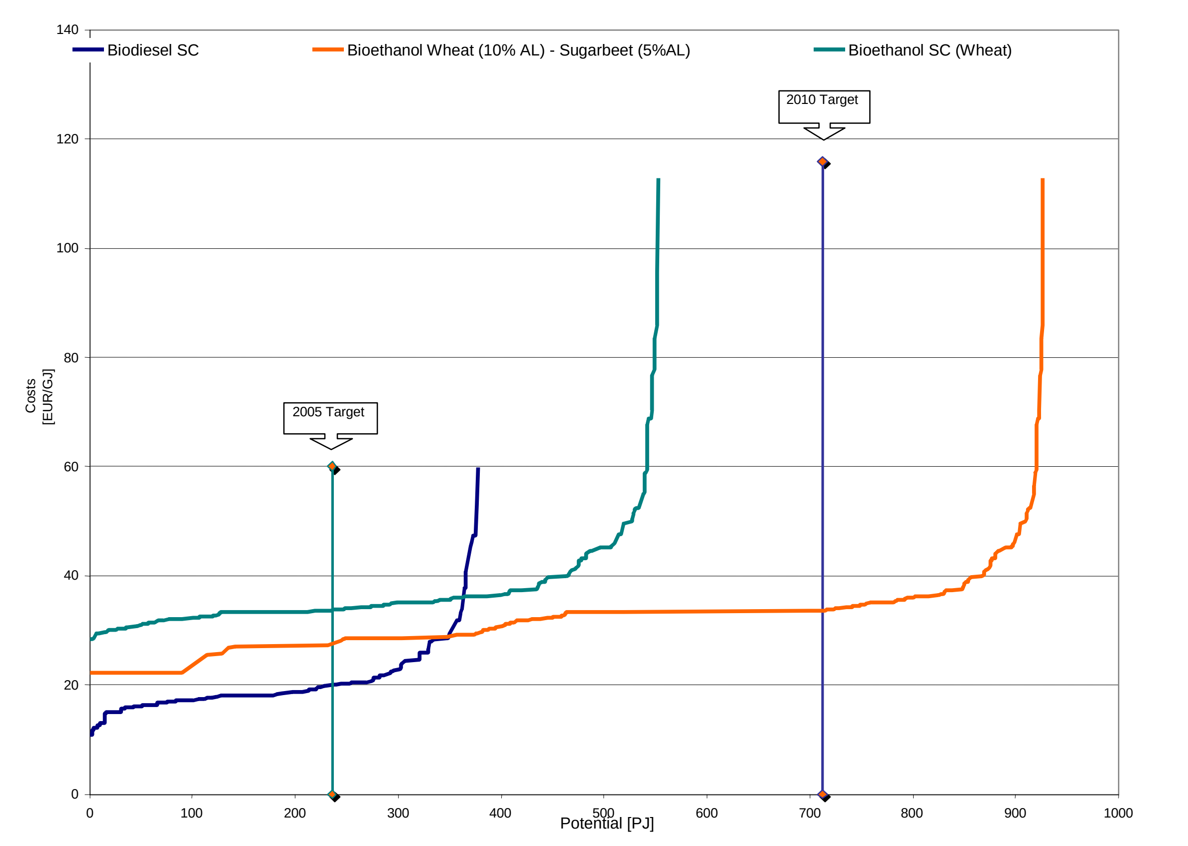

Figure 8-2. Cost – Potential Curve (supply curve) for biodiesel and bioethanol. The curves are mutually exclusive.

Table 8-3 includes information related to Irish customs duties as well as excise duties for alternative fuels for transportation imported outside the European Union (customs duties from imports inside the EU are zero). Information was provided by the Irish Customs Branch, Unit 2 Government Offices, Nenagh, Co. Tipperary.

Table 8-2. International transportation costs € /tonne.

		Costs (€/t)	
Country	Distance in km from Ireland, Dublin (waterway)	solids	liquids
AT	2300	26,60	12,20
BE	1300	14,20	9,80
DK	1700	17,30	11,20
FI	3300	39,90	27,72
FR	700	11,90	8,40
DE	1800	18,20	11,90
GR	5300	66,50	46,20
IT	4200	53,20	36,96
LU	1600	16,56	10,43
NL	1500	16,56	10,43
PT	1400	16,56	10,43
ES	2800	37,24	25,87
SE	3200	39,90	29,57
UK	240	8,40	7,80
PL	2600	33,25	24,02

Table 8-3. Irish import duties and excise rates for biofuels*, in €/litre and %.

Biofuel Type	Import duty	Excise rate
Biodiesel (RME) -Commodity N. 3824 90 9999 2501	6.5 %	0.368 Eur/L
Ethanol -Commodity N.2207 10 00 10 or 2207 10 00 92	0.192 Eur/L	0.368 Eur/L
ETBE	5.5 % (In some cases a preferential trade of 2% applies)	0.368 Eur/L

Figure 8-3 gives an idea about the countries with possible surplus production of biodiesel after covering the EU Directive target requirements in 2005. However, market forces such as higher biofuel selling prices or demand in other EU Member States, as well as higher reductions in excise duties are also factors that will foster trade inside the EU. Potential countries with relatively interesting surplus are France, Germany and Spain in the case of biodiesel. Observe that the New Member States are projected to have a strong biodiesel surplus in 2005, especially the Czech Republic, Hungary and Poland. If biodiesel production takes place at favourable costs, it may be possible for Ireland to import from these countries.

The countries with possible surplus production of bioethanol beyond the EU directive targets in 2005 are included in **Figure 8-4**. Market forces such as higher biofuel selling prices or demand in other EU Member States, as well as higher reductions in excise duties are also factors that will foster trade inside the EU. In the case of bioethanol from sugar beet and wheat as the main feedstock, the countries with higher surplus potentials are France, Germany, Spain, Italy and the UK. In regard to New Member States, Hungary, the Czech Republic and Poland are countries with higher potentials and export possibilities from these countries are likely to occur.

Figure 8-5 and **Figure 8-6** include the surplus potential for both biodiesel and bioethanol in 2010. Notice that for biodiesel none of the EU15 countries has the capacity to export unless more land is allocated to the growth of energy crops for biodiesel production. Furthermore, almost all the New Member States with the exception of Slovenia, can comply with the established targets, due to lower population densities and lower transport energy demand. Bulgaria and Romania potentially have a small surplus. Poland, Hungary and the Czech Republic have the largest surplus, and therefore export possibilities in 2010.

In **Figure 8-5** Ireland seems to be able to produce enough bioethanol on set-aside land to meet the 2010 target, where in the resource chapter the potential of biofuels from set-aside land was much smaller. This is caused by a different assumption of the set-aside rate of 5 % in the resources chapter, compared to 15 % here.

Compliance with the 5.75% target in the European Union could be accomplished without imports only in the case where ethanol is produced from wheat and sugar beet. However, other estimates, such as the one from Berg [73], reveal that the European Union is likely to be a net importer of ethanol in the short term. However, it is important to notice that all New Member States including Romania and Bulgaria could eventually comply with the proposed targets for 2010 and additionally countries like Poland, the Czech Republic, Hungary, Lithuania and Romania would be able to offer considerable amounts of bioethanol for export to other EU countries.

* Ethanol being imported for use as a biofuel will have a liability to Alcohol Products Tax. It will therefore require to be denatured. A recently issued Revenue Commissioners' Public Notice No. 1887 details the procedure for receipt and use of denatured and undenatured alcohol products without payment of Alcohol Products Tax [72].

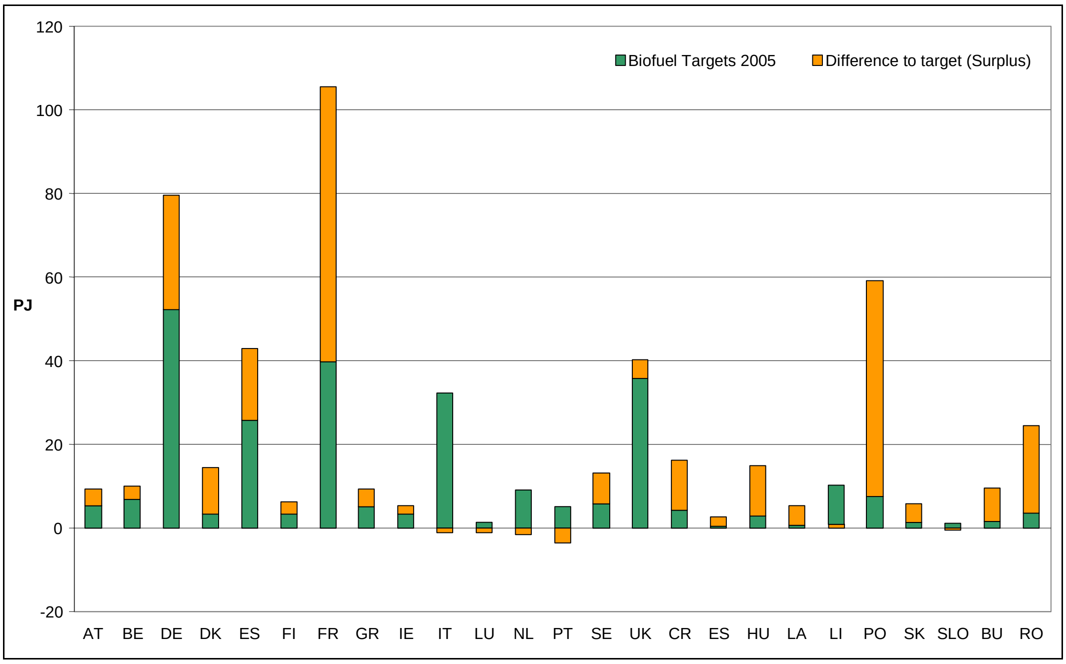

Figure 8-3. Biofuels Target and Difference to Target EU-15 +10+2 – Biodiesel Scenario 2005.

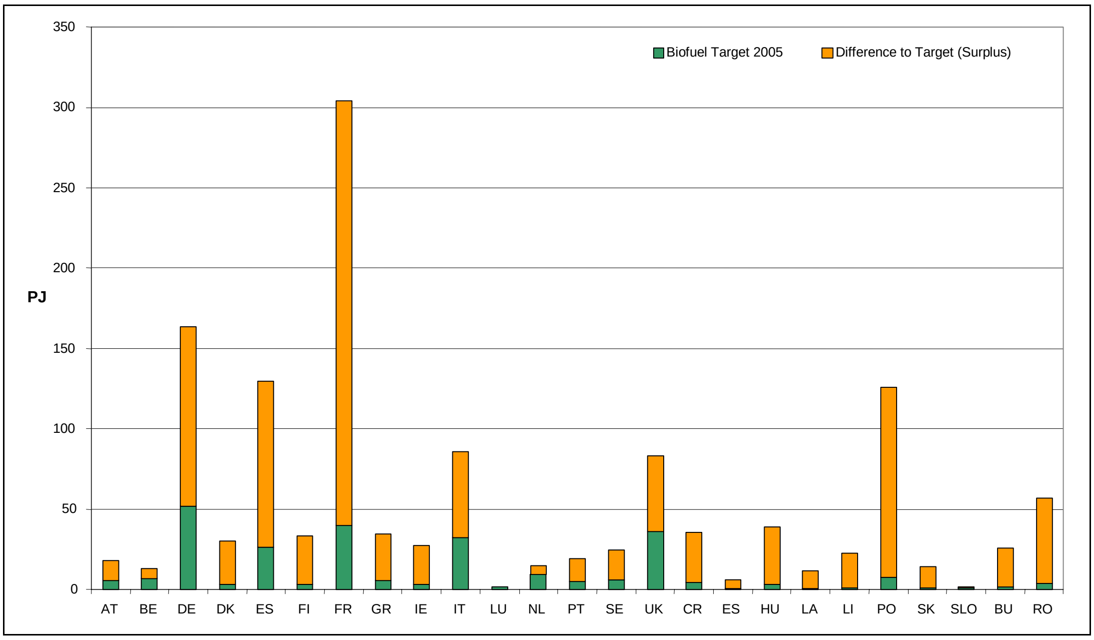

Figure 8-4. Biofuels Target and Difference to Target EU-15 – Bioethanol (2/3 wheat, 1/3 sugar beet) 2005.

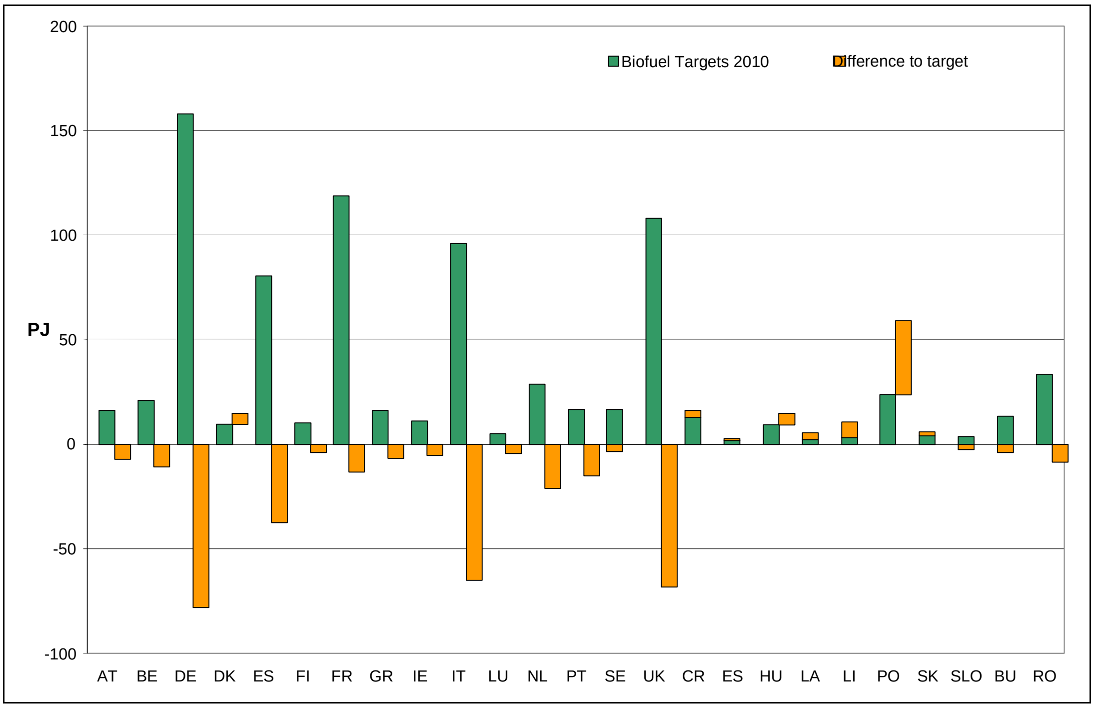

Figure 8-5. Biofuels Target and Difference to Target EU-15 – Biodiesel - 2010.

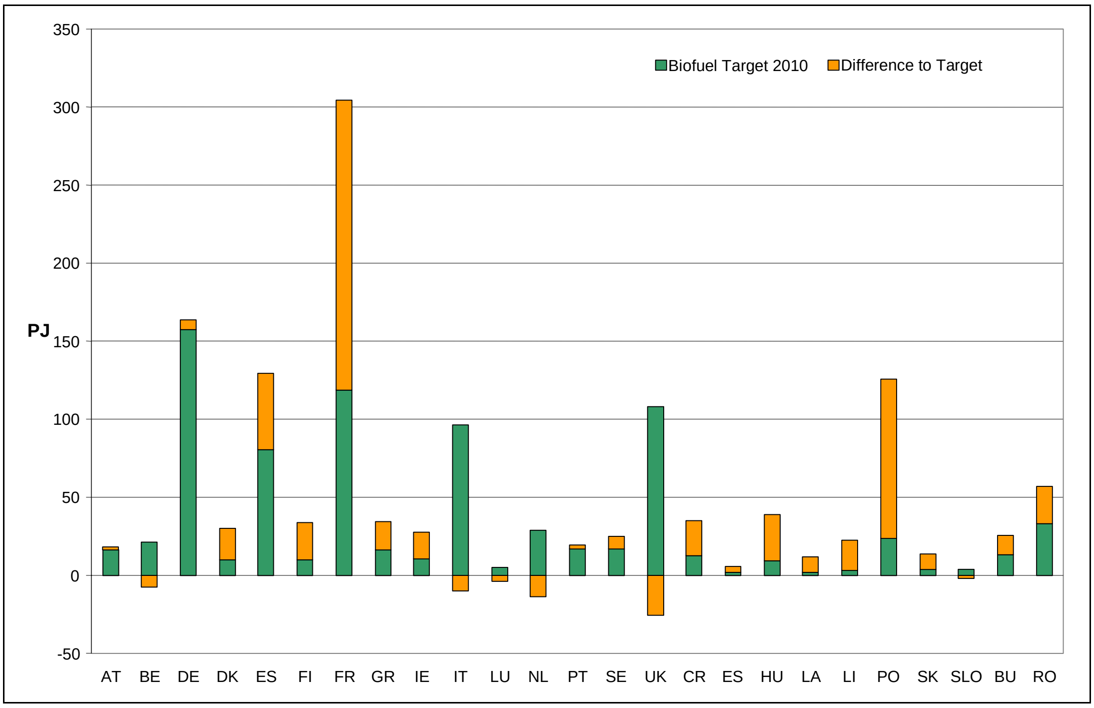

Figure 8-6. Biofuels Target and Difference to Target EU-15 – Bioethanol - 2010.

8.3 Biofuels from the world market

The recent trade agreements between the European Union and Mercosur* establishing import quotas of bioethanol from Brazil are a confirmation of the growing world ethanol market. Various producers' federations in Europe have expressed their concern in regard to this matter because such trade could affect the current support activities to promote the European biofuel industry. The import of ethanol at considerably lower prices from Asia or South America to the EU will have a significant effect on the competitiveness of the emerging biofuel industry in the short term.

The main exporting countries in the global ethanol market are Brazil, China, Thailand, Saudi Arabia, South Africa, USA, Australia, India and Argentina. **Figure 8-7** includes the trade volumes between the main importers and exporters worldwide [73]. Brazil and China are the countries that have the highest potential available for exporting. The world ethanol market prices according to Brazil figures (world's biggest producer) varied between 20 and 30 € cent/litre between 2001 and 2004 [74]. Future countries with relatively high export potential are Peru, Central American countries and Colombia.

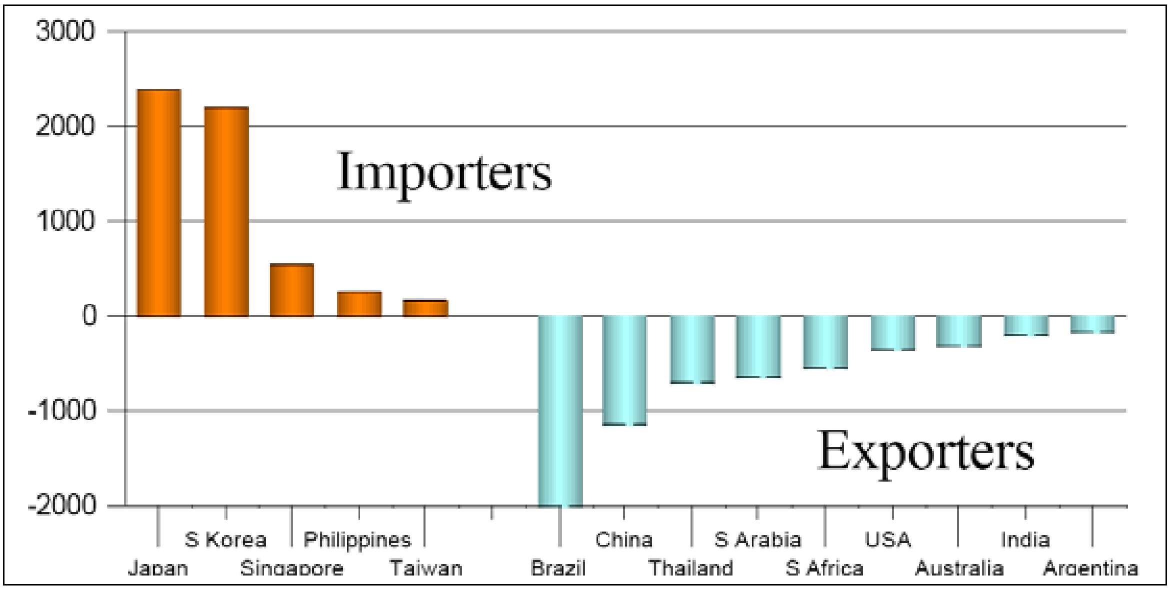

Figure 8-7. Trade volumes in 2002 (Million litres) [73].

* The Mercosur is a trade agreement among Argentina, Brazil, Paraguay, Uruguay, Chile and Bolivia with the goal to create a common market/customs union.

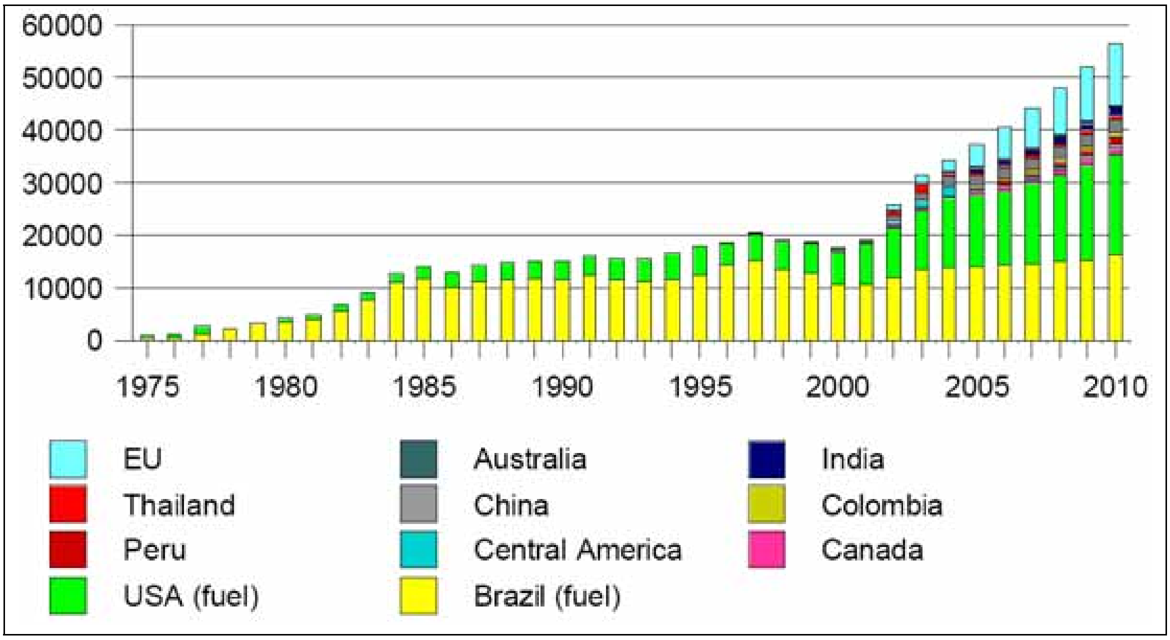

Figure 8-8. World Ethanol Production by Country (million litres) [73]. In 2003 Brazil's Production was ca. 16.000 million litres, and USA's was ca. 11.000 million litres.

In 2004, Brazil launched an 'ethanol futures' contract in New York with the aim to promote the development of an international market for green fuel and reduce uncertainty as well as price risks. Furthermore, a futures contract will establish a price benchmark and boost Brazilian exports in the short and medium term, according to producers, analysts and traders [75]. This kind of contract will definitely attract oil companies, refineries and distributors amongst others. These players are expected to be based mainly in the United States, and other countries like EU Member States, including Ireland, which have set up biofuel targets in their internal transportation markets. The futures market will therefore establish a price level for determined contracts that could offer profits and security to both the producer and consumer.

The short-term prospects are likely to remain the same however, the briefing note on Liquid biofuels states that ethanol production from sugar beet in Ireland merits special considerations because of its potential synergy with the existing sugar industry (SEI 2003). The study also specifies that *Greencore plc* has indicated an interest in building a plant to produce ethanol from beet and molasses covering approximately 25 percent of the indicative substitution target in 2005. Most of the necessary infrastructure is already in place, only the fermentation and distillation plant would need to be added. Therefore, if Ireland engages into building up the necessary infrastructure for the production of biofuels, it is likely that some import volumes will include feedstock materials if world market prices for wheat, rape and sunflower are favourable.

In accordance with the current perspective of the Irish biofuel market, it is very probable that the expected supply shortage to achieve the indicative substitution markets in 2005 will be met by imports rather than domestic production. Brazil and some Asian countries already exporting to the UK could be an attractive option for Irish producers. As an example, British processors obtain soy and palm oil at 50 - 100 €/tonne less than the UK produced rape-seed methyl ester (Institute of European Environmental Policy March 2004).

Furthermore, imported Brazilian bioethanol costs after blending and retail margins, can be as much as 0.16 €/litre (10 pence/litre) below UK alternatives made from sugar beet and wheat, according to the recent East of England Development Agency (EEDA) study [76]. The application of an import duty in

Ireland for denatured alcohol coming from Brazil, U.S or any other country outside the European Union is around 0.192 €/litre according to the Irish Customs Office [72]. This figure would bring costs closer in line with that of Irish-produced bioethanol.

Another important objection to imports arises from the fuel cost of shipment, particularly from long distances (e.g. Asia, Latin America). It should not be assumed that imports from the tropics will necessarily be unsustainable due to an increase in energy costs and balances. In contrast, there might be certain advantages in growing certain highly productive crops in tropical environments while efficient long distance transport, at relatively low costs, is not expected to affect the environmental energy balances considerably.

In addition, it is very likely that other EU Member States with lower customs rates for biofuels will import higher supplies. It is anticipated that there will be limited international trade transactions in refined liquid biofuels in the medium term due to scarcity of supply and increasing domestic European and Asian demands [76]. Major domestic sugar processors in UK are confident that they could compete with these figures if they receive adequate support.

8.4 Main conclusions

Compared to the targets of the biofuel Directive for 2005 the countries of the EU-15, as well as of the EU-25, show large surplus potentials in all three scenarios considered here (all biodiesel, all bioethanol from wheat, bioethanol from wheat and from sugar beet). In this case the surplus potential from biodiesel is available at the lowest costs of about 20 €/GJ.

Compared to the targets of the biofuel Directive for 2010 the countries of the EU-15 as well as of the EU-25 show surplus potentials only in the scenario with bioethanol from wheat (10% arable land) and from sugar beet (5 % arable land). The costs will be significantly higher in this case and amount to about 35 €/GJ.

The export potentials from other world regions (in particular from Brazil, China and Thailand) are very large compared to the size of the Irish market. If demand is likely to increase due to a cut in excise duties, or other support policies in the Irish market, an increased flow of imports is likely in the short term. In the long term the availability of imports and their likely price is not so clear, however, a futures contract, as established by Brazil could reduce price risks and uncertainty significantly.

The import of bioethanol from other EU Member States with potential surplus should include the international transportation cost figures as included in Table 8. This figure varies between 0.5 €/GJ and 2 €/GJ for bioethanol from Europe.

Where bioethanol is being imported from Latin America, transportation costs in large vessels are approximately 1 €/GJ additional to the Brazilian market price. Furthermore, import taxes of 9.1 €/GJ (0.192 €/l) should be added to the before mentioned figure.

9 Policy Incentives, and Evaluation

In this chapter we present a qualitative multi criteria analysis of various policy alternatives to stimulate the introduction of biofuels into the Irish transport sector.

Various implementation strategies have been analysed:

1. Excise duty exemption

   The government will exempt biofuels from excise duty in such a way that their cost at the pump becomes the same as that for fossil fuels.

2. Levy / subsidy

   A separate levy is introduced on top of the current excise duty. This money will not enter the government budget, but is used by a separate (government controlled) independent institute that subsidises biofuel producers per GJ of biofuel produced.

3. Irish obligation

   The Irish government introduces an obligation into the fuel market that each seller of transport fuels is required to redeem a number of biofuel certificates at the end of each year. Certificates are obtained by biofuels producers from an independent Issuing Body and can be freely traded within Ireland. Not fulfilling the obligation will be penalised by sufficiently high penalties (which will stimulate market players to fulfil the requirement).

4. EU obligation

   As with 3, but here the certification and obligation system will be an EU-wide system, so that certificates can be bought from producers in countries with lower biofuels costs.

5. Tender system

   This is the equivalent of the Alternative Energy Requirement in the electricity market. The government can launch tenders for batches of biofuels or the whole 2005 or 2010 directives. This will be done in competition to potential biofuel-producing companies.

The evaluation criteria in this multi-criteria analysis are described below:

a. Cost limitation for Government:

   The extent to which government spending can be minimised in reaching the biofuels targets.

b. Effectiveness

   The extent to which it can be expected that the biofuel targets will really be met.

c. Value for money for Government

   The ratio between a and b.

d. Implementation speed

   The extent to which a given policy measure will stimulate the rapid introduction of biofuels.

e. In line with other EU countries

   The extent in which the policy measure is in line with policy measures that are already in place, or planned for, in other EU countries.

f. Potential to stimulate new technology

   The extent to which the policy measure can be used to stimulate the development of new technology (e.g. LC ethanol or FT diesel).

g. Generates employment

   The extent to which the policy measure is expected to generate additional employment within Ireland.

h. Generates value added

   The extent to which the policy measure is expected to generate additional value added within Ireland

i. Cost limitation for users

   The extent to which increased fuel costs to consumers are being kept limited.

j. Market oriented

   The extent to which a policy measure can let the market mechanisms work optimally in reducing overall costs.

Table 9-1 shows the overall result of this multi criteria evaluation

Table 9-1. Multi-criteria assessment of implementation strategies.

Qualification	Excise duty exemption	Levy / Subsidy	Irish Obligation	EU Obligation	Tender
Cost limitation for Government	-	++	++	++	+
Effectiveness	+	+	+++	++	++
Value for money for Government	-	+	+++	++	++
Implementation speed	++	+	-	--	+
In line with other EU countries	+++	-	+	-	+
Potential to stimulate new technology	-	++	++	+	+
Generates employment	+	+	++	-	+
Generates value added	+	+	++	-	+
Cost limitation for users	+++	-	+	++	+
Market oriented	+	+	++	++	++

Excise duty exemption

Table 9-1 shows that the main advantage of an (partial) excise duty exemption is the fact that this system has already been implemented and/or is under consideration in some other EU countries, e.g. the UK, Germany and France. Further, it is an instrument that can be implemented on a relatively short term. Finally, it has the advantage that the users will not or hardly note any price difference in the products that they buy.

However, there are also disadvantages. First of all, it is an expensive measure for the government, because of the foregone tax income. Further, an excise duty exemption is a fiscal measure that normally cannot give firm long-term guarantees to market players. It is also likely to be rather inflexible in the sense that normally an exact definition of a blend (e.g. E5 or E2) will have to be given, which limits technological choices that can be made by market players, which may lead to sub-optimal cost levels. Finally, its effectiveness may be limited as well, because it is not sure whether the market players will indeed introduce the biofuels according to the necessary target as a result of the excise duty exemption. This is especially the case since this report has shown that with the Irish excise duty levels, in order to achieve an equal GJ price at the pump, a full excise duty exemption is likely to be insufficient for both ethanol and biodiesel.

Levy / subsidy

A biofuel subsidy per unit of biofuel produced can in principal be financed by means of an additional general fuel levy, which remains outside of the government budget and is handled by an independent government controlled body. This system is currently applied e.g. for renewable electricity in the Netherlands. This has the advantage that the government can more easily give juridically valid long term guarantees than would be the case with an excise duty exemption. A political advantage would also be that it is basically budget neutral for the government. However, of course, the other side of the coin is that the consumer will be confronted with an additional fuel levy. An instrument like this is normally more flexible for differentiation (as is e.g. shown in the Dutch example) between various types of fuels. This could e.g. lead to a government choosing for a higher level of subsidy for fuels with a relatively high CO_2 emission reduction. Since the government still has to define the level of subsidy required, the market orientation of this instrument is limited. The same accounts for the effectiveness, since no guarantee is given that the targets will actually be reached. An interesting feature, from a national economic point of view, is that the EU did allow the Netherlands only to give this subsidy to renewable electricity generated within the Netherlands.

Irish biofuel obligation

It is most likely not allowed to obligate market players to blend a certain percentage of biofuels within the fossil fuels, since normal gasoline and diesel have to be allowed into the market, because of EU regulations. However, current practice with electricity in e.g. Italy, Belgium and Sweden has shown that it is possible to oblige market players to redeem a certain amount of certificates. In this way an Irish biofuel obligation is likely to be possible if it will be implemented together with an Irish biofuel certification system. Such a system would give certificates to all producers (and possibly importers) of biofuels. These certificates could then be freely traded within Ireland, possibly apart from the physical fuel. An obligation for redemption of certificates would create the necessary demand for certificates, which will give them a market price. An advantage of this system, if well implemented, is that while the market mechanism will work optimally, at the same time the government has the guarantee that the targets will be met. Another advantage of certificates is that they can also eventually provide information regarding the sustainability and the quality of the biofuels. More details regarding such a certification system have been given by Van den Broek [41] and are currently under investigation by Ecofys and an environmental organization in the Netherlands.

Certificates are necessary for the implementation of an obligation. However, they can also be used as a vehicle for the implementation of other policy measures.

A disadvantage of an obligation on the basis of certificates is that the system may be more complex to implement. Although technically such a system has been proven to be operational within 6 month, establishing "the rules of the game" amongst the various actors may take some more time.

EU biofuel obligation

A similar picture as with an Irish biofuel obligation can be drawn for an EU biofuel obligation, based on an EU biofuel certificate system. Basically it is the same type of system, with the advantage that the market mechanism will work even better here in the sense that the fuels will be produced in those countries where the cost is the lowest and that all Member States will benefit from this. A disadvantage is the time needed to implement such a rather complex system, mainly because of the large amount of market actors and governments involved. However the current harmonization effort of renewable electricity certificates shows that also such a development, which is still fully based on initiatives of market players, can go relatively fast.

Tender

Basically biofuels can also be introduced into the market in a system comparable with the Irish Alternative Energy Requirement (AER) for renewable electricity. The government could open one or more tenders for the supply of biofuels to the Irish market and guarantee the cheapest bidder to pay him for the additional cost as compared to fossil fuels. Market mechanisms can work relatively well with such a system. Dependent on the type of tenders, even long term guarantees could be given. Its effectiveness can be good. A disadvantage can be the lack of steering such a tender towards the long term development of more efficient biofuel technology. Another disadvantage is that the government is still the actor to pay for the additional cost. However, this cost is likely to be lower than in the case of an excise duty exemption., because of the competition effect.

10 Conclusions

Irish fuel context

- Fuel consumption in the Irish transportation sector is expected to rise towards about 175 PJ in 2005 and 200 PJ in 2010. This means that the reference percentages from the EC biofuels directive equate to a 2005 target of about 3.5 PJ and a 2010 target of about 12 PJ.
- There is a lack of data to draw firm conclusions on the question of whether niche markets exist in Ireland that can fulfil the full Irish biofuel directive target. However, we expect that it is not very likely that a sufficiently large homogeneous niche market will be found, since the largest niche market found, the national bus companies, are insufficient to fill in even the full 2005 target.

Availability of biofuel resources in Ireland

- Technically, Ireland is capable of fulfilling the full biofuel directive targets with indigenously produced biomass. However, this would mean that part of agricultural productive land that is currently used for feed, is to be diverted to biofuel production. This will, in turn, induce additional feed imports.
- The amount of biofuels that can be produced from Irish residues is about half of the 2005 target. If, on top of this, currently unproductive set-aside land were used for biofuel production, about 79% of the 2005 and 23% of the 2010 target could be fulfilled with indigenous Irish biomass.
- In order to produce biodiesel and bioethanol that can compete with biodiesel and bioethanol production from other EU15 countries, it is most likely necessary to work with relatively large-scale plants. Implementation of such large-scale plants could be possible, if they relied not only on Irish feedstock, but partly on imported feedstock as well.

Technical issues relevant for biofuel chains

- Biodiesel can technically be blended in any ratio into conventional diesel fuel. However, biodiesel is more aggressive to certain coatings and elastomers than conventional diesel, so fuel systems need to be adapted for the use of pure biodiesel and for high percentage biodiesel blends. The relatively low biodiesel percentages in conventional diesel that are needed to meet 2005 Reference Percentages (RP) of the European Directive 2003/30/EC do not require vehicle modifications. The new diesel standard EN590:2003 will maximise the volumetric content of FAME in diesel to 5%. This corresponds with an energy share of about 4.6%, which is lower than the 2010 biofuel target.
- Biodiesel can also be produced from RVO or tallow. Low temperature behaviour of these fuels make it unlikely that they can meet the FAME specs as mentioned above. In order to achieve this, they will have to be blended with RME. Experts state the RVO part of such a blend should be limited to about 15-20%. For tallow this figure is expected to be lower, since its low temperature behaviour is worse than that of RVO biodiesel.
- In Europe, at present a maximum of 5 vol % ethanol is allowed in gasoline by European Directive 98/70/EC. This corresponds with an energy share of 3.4%. This is higher than the 2005 biofuel target, but lower than the 2010 target. Vapour pressure is a gasoline characteristic that is limited

to a maximum of 60 kPa by European Directive 98/70/EC. For ethanol percentages between 0% and 10 vol-% in gasoline, the vapour pressure shows a peak above this value. Changing the base gasoline properties (for instance by reducing the butane content) can remedy this issue, but it requires modification of the refineries product output, which incurs a cost.

- In spite of the 32% lower heating value of ethanol as compared to gasoline, some literature tends to an equal volumetric efficiency of gasoline and ethanol blends (with less than 10% ethanol) as compared to pure gasoline. On the other hand, there are indications that the circumstances in which this equality is true are limited as well. Because of the uncertainty on this point, this report has used the estimate that 1 MJ of ethanol replaces 1 MJ of gasoline (i.e. 1 liter of ethanol replaces 0.68 litre of gasoline).
- Meeting the 2005 Reference Percentage is possible under current fuel standards and directives with all biofuels considered. However, these standards and directives do not give sufficient space for meeting the 2010 Reference Percentage of the biofuel directive 2003/30/EC. One can only meet this directive by:
  - (Partly) using biofuels or biofuel/fossil fuel blends that do not meet the current fuel directive (98/70/EC) regarding ethanol or the current diesel standard (EN 590:2003) regarding FAME. This will imply that part of the current vehicle fleet will be unable, in its current state, to use those fuels.
  - Adapting the maximum ethanol percentage allowed in European Directive 98/70/EC and/or the maximum FAME percentage allowed in standard EN590:2003, before 2010. However, this will have to be agreed upon by the most important stakeholders, such as the car manufacturers and the oil industry.
  - Introducing new biofuels (other than ethanol and FAME) that do meet the current gasoline and diesel directives and standards.
- Transportation of the biofuels under consideration in general can be either by ship, rail, road or pipeline. In the case of biodiesel and ethanol/gasoline blends, it is particularly important that the ingress of moisture during transportation is limited as much as possible, to avoid fuel quality degradation. For this reason, ethanol/gasoline blends are not transported by pipeline in practice. During storage of biofuels, water ingress must also be avoided. Biodiesel and ethanol/gasoline blends should not be stored longer than a few months. It is recommended to store ethanol/gasoline blends in tanks with floating covers.

Environmental impacts

- The best estimate of GHG emission for biodiesel from rape-seed is about 50 % of that of conventional diesel. The majority the estimates lie between 30 and 50 %.
- The only study that analysed bio-methyl ester from RVO estimated a WTW GHG emission of 16% of the diesel emission within a small range (14-19 %).
- The best estimate of well-to-wheel GHG emission for bioethanol from sugarbeet was about 45 % as compared to its fossil alternative. Most estimates ranged between about 40 and 60 % of fossil fuel emissions.
- The best estimate of well-to-wheel GHG emission for bioethanol from wheat was at about 1/3 of the gasoline emission. Most estimates ranged between 30 and 60%.

- From the breakdown of the biofuel GHG emissions, we learned that with bioethanol from sugarbeet about 25% of the GHG emissions take place in the field. With bioethanol from wheat this is about 35% and with biodiesel this is about 60%.

- Biomass-based Fischer Tropsch diesel WTW GHG emissions are very low. It is estimated at about 15% of the diesel WTW chain. The overall range goes from – 9% to +34% of diesel emissions.

- A wide range was found for WTW GHG emissions of ethanol from ligno-cellulosic biomass. It is estimated that these emissions are about 18% of the gasoline emissions as used in this study. All estimates found (for the conservative estimate) ranged between –18% and 81%.

- Much less literature was found on well-to-wheel acidifying and toxic emissions than on GHG emissions. Reliability and representativeness is considered to be less than with the analysis of GHG emissions:

    - Well-to-wheel emissions on SO_x are found to be significantly lower for biodiesel.

    - NO_x emissions over the whole biodiesel chain are found to be about 30% higher. This higher NO_x emission is almost completely caused by tractor use during rape-seed production. It seems, however, to be based on relatively old emissions data. Future more stringent NO_x emission standards for tractors would reduce the indirect NO_x emissions in the RME chain. If the rapeseed or biodiesel is imported, the NO_x emission by tractor use is generated outside Ireland.

    - VOC emissions of biodiesel are found to be about half those of fossil diesel, but CO is found to be slightly higher.

    - Well-to-wheel PM emissions are found to be slightly higher with biodiesel.

    - Regarding bioethanol, the data suggest higher NOx emissions, although ranges reported in both the bioethanol and the gasoline based NOx emissions are very large. Reliability of the data seems to be relatively low.

    - CO and HC emissions appear lower on average with bioethanol.

Costs

- Because of different heating values, costs of biofuels and fossil fuels are best compared on the basis of their energy content. All costs presented below are at the refilling station and they include costs for blending and costs and margin for fuel distribution and retail but exclude excise duty and VAT. Feedstock costs are based on Irish data and conversion and distribution costs on international literature.

- Fossil diesel costs are about 10 €/GJ (0.34 €/l). Costs for RME are about 2.5 times higher. For biodiesel production from tallow and/or RVO this differences is less than a factor of 2. In the long term, Fischer Tropsch diesel is expected to be produced for a cost that is roughly 30% higher than fossil diesel.

- The difference between gasoline and ethanol is found to be slightly higher. Cost of gasoline at the refilling station is about 11 €/GJ (0.33 €/l). Ethanol (from wheat) can be produced for about 27 €/GJ (0.58 €/l). Long-term estimates for ligno-cellulosic biomass indicate cost levels of about 16 €/GJ (0.33 €/l).

- In order to get equal litre prices for the consumer at the pump for RME an excise duty exemption is required of about 47 ct/l (being higher than the actual excise, 37 ct/l). In the case of

RVO based biodiesel the required excise would be about 22 ct/l. In the case of ethanol from wheat, the excise duty exemption needed would be about 25 ct/l (as compared to an excise of 44 ct/l).

- The cost per tonne of CO_2-eq. avoided in the case of biodiesel is about 340 €/tonne. With RVO based biodiesel this is about 100 €/tonne. In the case of bioethanol, this is 300 - 450 €/tonne.

Macro-economic impacts

- In general it can be concluded that bioethanol production from wheat on set-aside land scores similar to gasoline on the contribution to the GDP (i.e. value added creation). Job creation, however, is a factor 25 higher than with gasoline. Ethanol production from imported wheat creates somewhat less value added, creating 6 times more employment than with the current gasoline-based system. Imported ethanol from within the EC creates no net value added in Ireland at all. Employment generation from imported ethanol (from EU or world) is only slightly higher than the employment from gasoline.
- The comparison between biodiesel and fossil diesel is rather similar. The main difference is that imported bio-oil for biodiesel production also scores significantly less in terms of value added creation when compared to fossil diesel. In the case of import of biodiesel, the net value added creation is negative.
- Total government income in the ethanol set-aside scenario is about half of the income that the government has with gasoline. Approximately 60 % of the total costs of the excise duty exemption (including the subsidy needed) can be earned back as a result of additional tax income and savings on unemployment payments. In the case of ethanol from imported wheat net government income per litre of ethanol sold is about zero (i.e. the income on savings from job seekers allowances and additional taxes equals the necessary fuel subsidy). In this import situation only about 15 % of the cost of the full excise duty exemption can here be recouped. In the case of imported ethanol, the net government income is negative. Only a few percent of the full excise duty exemption is earned back in this case. Ethanol can be imported from Brazil against much lower prices. Therefore the sum of import tax and excise duty that can be imposed is positive.
- We have argued that the wheat import case is basically similar to using wheat that is currently produced for feed purposes. The preceding bullet leads to the conclusion that for the GDP of Ireland it is only slightly more attractive to use currently produced Irish wheat instead of importing bioethanol from Brazil. For the treasury, however, importing bioethanol from Brazil is more attractive than importing wheat or using currently produced Irish wheat.
- When comparing biodiesel with diesel, a similar type of effect is observed in terms of the impact on the treasury, although exact figures are somewhat different.
- A maximum of only 1.1 PJ of biofuel (of the 3.5 and 12 PJ targets) can be produced on set-aside land in Ireland. Therefore, a significant component of biofuels feedstock will have to be imported. If current crops are used for bioethanol production, additional feed will have to be imported, which will have an impact comparable to that described above.

Import of biofuels

- Compared to the targets of the biofuel Directive for 2005 the countries of the EU-15, as well as the EU-25, show large surplus potentials in all three scenarios (as derived from the FORRES project: all biodiesel, all bioethanol from wheat, bioethanol from wheat and from sugar beet). In this case the surplus potential from biodiesel is available at the lowest costs of about 20 €/GJ (66 ct/l).

- Compared to the targets of the biofuels Directive for 2010, the countries of the EU-15, as well as the EU-25, show surplus potentials only in the scenario with bioethanol from wheat (10% arable land) and from sugar beet (5% arable land). The costs will be significantly higher in this case and amount to about 35 €/GJ (74 ct/l).
- The surpluses and price at which they actually become available for sale will be determined by the strategies chosen by most countries and the extent to which this leads to a level playing field between the EU countries
- The export potentials from other world regions (in particular from Brazil, China and Thailand) are very large compared to the size of the Irish (and EU) market.

Policy incentives

- Most EU countries currently choose excise duty exemption as the central policy instrument for the implementation of the biofuel directive. It is relatively easy to implement and has shown that it can work in Germany, Spain and France. However, disadvantages to this instrument are the fact that it gives no long-term guarantee, which is a disincentive for investments and innovation. Another disadvantage is that the cost to government is relatively high.
- An alternative is an obligation in combination with a certificate system. The sellers of transport fuel are then obliged to redeem a certain amount of biofuel certificates at the end of the year. An advantage of this system is that one has the guarantee that the target will be obtained using the market mechanism as a driver. Furthermore, it is a flexible system, which could incorporate other elements, such as information about the sustainability of (imported) biofuels, in the longer term. A disadvantage is that this policy may require more time than an excise duty to implement. Ideally, such an obligation should be implemented EU wide.
- Other alternatives are a system with a levy (outside of the government budget) on transportation fuels, from which one pays a subsidy to biofuels producers.
- Finally, the Irish government could organise tenders in order to procure the desired quantity of biofuels in the market (as was done with renewable electricity in Ireland).

11 Policy Recommendations

- The majority of the EU countries that communicated on their biofuel policy are currently working with or considering an excise duty exemption system. It is recommended, however, also to evaluate in more detail advantages and disadvantages of various alternative incentive systems. A first start for this has been made in Section 7.2 of this report, with the analysis of excise duty exemption.
- Value added for Ireland will be created when residues with little other uses will be used to the maximum for biofuel purposes and when set-aside land will become productive to a maximum extent. This could be considered in any policy definition.
- In a similar way value added is created when investments are attracted to Ireland. For this purpose, it will be necessary that any policy gives as much as possible a long-term incentive guarantee, preferably for periods of more than 10 years.
- Since it is likely that the full EC biofuel objectives can only be met by Ireland in the presence of direct or indirect imports, it can be recommended to assess in detail which way of importing biofuels may still give the maximum value added to the country. A first start for this has been given in this report. Here one could for instance compare in more detail (and based on concrete offers) import of slightly cheaper biofuels from other EU countries (e.g. the new Member States) versus import of significantly cheaper biofuels from outside of the EU (e.g. Brazil).
- Since there is a relatively large difference in performance between the short term biofuels and the second generation longer term biofuels, it is recommended to develop policies that stimulate the development of the latter types of fuels. One option to do this is to stimulate (international) R&D programmes on this subject. Information on the sustainability, carried on biofuel certificates, could also facilitate incentive differentiation between various environmental performance levels of biofuels.
- For a cost effective policy it is recommended that the government focuses at making a minimum of technological choices itself. Instead it could stimulate the market players to do this and create the economic and regulatory environment (e.g. with specific demands regarding sustainability) in which this can be done. A biofuel certification system could be a good vehicle for such a policy line, because of the tradability of the certificates.
- As a result, it is recommended to further investigate the possibility of a biofuel certification system, which can be introduced in Ireland or with other Member States that are open to this. This could facilitate policy incentives (especially in the case of a biofuel obligation), and open the possibility to provide information regarding the sustainability and quality of the biofuel supplied to the market.
- It is advised to the Irish government to make an explicit choice whether the target should be achieved mainly in the mainstream market (e.g. with low blends of bioethanol and biodiesel) or mainly in niche markets (e.g. with PPO or biodiesel that does not meet the FAME specs), since these markets may require different policy measures. Of course a combination of both is possible, but dedicated policy to both market segments will be more complex in that case.

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Annex A Directive 2003/30/EC

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DIRECTIVE 2003/30/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 8 May 2003

on the promotion of the use of biofuels or other renewable fuels for transport

THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty establishing the European Community, and in particular Article 175(1) thereof,

Having regard to the proposal from the Commission [1],

Having regard to the opinion of the European Economic and Social Committee [2],

Having regard to the opinion of the Committee of the Regions [3],

Acting in accordance with the procedure laid down in Article 251 of the Treaty [4],

Whereas:

(1) The European Council meeting at Gothenburg on 15 and 16 June 2001 agreed on a Community strategy for sustainable development consisting in a set of measures, which include the development of biofuels.

(2) Natural resources, and their prudent and rational utilisation as referred to in Article 174(1) of the Treaty, include oil, natural gas and solid fuels, which are essential sources of energy but also the leading sources of carbon dioxide emissions.

(3) However, there is a wide range of biomass that could be used to produce biofuels, deriving from agricultural and forestry products, as well as from residues and waste from forestry and the forestry and agrifoodstuffs industry.

(4) The transport sector accounts for more than 30 % of final energy consumption in the Community and is expanding, a trend which is bound to increase, along with carbon dioxide emissions and this expansion will be greater in percentage terms in the candidate countries following their accession to the European Union.

(5) The Commission White Paper 'European transport policy for 2010: time to decide' expects CO_2 emissions from transport to rise by 50 % between 1990 and 2010, to around 1 113 million tonnes, the main responsibility resting with road transport, which accounts for 84 % of transport-related CO_2 emissions. From an ecological point of view, the White Paper therefore calls for dependence on oil (currently 98 %) in the transport sector to be reduced by using alternative fuels such as biofuels.

(6) Greater use of biofuels for transport forms a part of the package of measures needed to comply with the Kyoto Protocol, and of any policy package to meet further commitments in this respect.

(7) Increased use of biofuels for transport, without ruling out other possible alternative fuels, including automotive LPG and CNG, is one of the tools by which the Community can reduce its dependence on imported energy and influence the fuel market for transport and hence the security of energy supply in the medium and long term. However, this consideration should not detract in any way from the importance of compliance with Community legislation on fuel quality, vehicle emissions and air quality.

(8) As a result of technological advances, most vehicles currently in circulation in the European Union are capable of using a low biofuel blend without any problem. The most recent technological developments make it possible to use higher percentages of biofuel in the blend. Some countries are already using biofuel blends of 10 % and higher.

(9) Captive fleets offer the potential of using a higher concentration of biofuels. In some cities captive fleets are already operating on pure biofuels and, in some cases, this has helped to improve air quality in urban areas. Member States could therefore further promote the use of biofuels in public transport modes.

(10) Promoting the use of biofuels in transport constitutes a step towards a wider application of biomass which will enable biofuel to be more extensively developed in the future, whilst not excluding other options and, in particular, the hydrogen option.

(11) The research policy pursued by the Member States relating to increased use of biofuels should incorporate the hydrogen sector to a significant degree and promote this option, taking into account the relevant Community framework programmes.

[1] OJ C 103 E, 30.4.2002, p. 205 and OJ C 331 E, 31.12.2002, p. 291.
[2] OJ C 149, 21.6.2002, p. 7.
[3] OJ C 278, 14.11.2002, p. 29.
[4] Opinion of the European Parliament of 4 July 2002 (not yet published in the Official Journal), Council Common Position of 18 November 2002 (OJ C 32 E, 11.2.2003, p. 1) and decision of the European Parliament of 12 March 2003 (not yet published in the Official Journal).

(12) Pure vegetable oil from oil plants produced through pressing, extraction or comparable procedures, crude or refined but chemically unmodified, can also be used as biofuel in specific cases where its use is compatible with the type of engines involved and the corresponding emission requirements.

(13) New types of fuel should conform to recognised technical standards if they are to be accepted to a greater extent by customers and vehicle manufacturers and hence penetrate the market. Technical standards also form the basis for requirements concerning emissions and the monitoring of emissions. Difficulties may be encountered in ensuring that new types of fuel meet current technical standards, which, to a large extent, have been developed for conventional fossil fuels. The Commission and standardisation bodies should monitor developments and adapt and develop actively standards, particularly volatility aspects, so that new types of fuel can be introduced, whilst maintaining environmental performance requirements.

(14) Bioethanol and biodiesel, when used for vehicles in pure form or as a blend, should comply with the quality standards laid down to ensure optimum engine performance. It is noted that in the case of biodiesel for diesel engines, where the processing option is esterification, the standard prEN 14214 of the European Committee for Standardisation (CEN) on fatty acid methyl esters (FAME) could be applied. Accordingly, the CEN should establish appropriate standards for other transport biofuel products in the European Union.

(15) Promoting the use of biofuels in keeping with sustainable farming and forestry practices laid down in the rules governing the common agricultural policy could create new opportunities for sustainable rural development in a more market-orientated common agriculture policy geared more to the European market and to respect for flourishing country life and multifunctional agriculture, and could open a new market for innovative agricultural products with regard to present and future Member States.

(16) In its resolution of 8 June 1998 ([1]), the Council endorsed the Commission's strategy and action plan for renewable energy sources and requested specific measures in the biofuels sector.

(17) The Commission Green Paper 'Towards a European strategy for the security of energy supply' sets the objective of 20 % substitution of conventional fuels by alternative fuels in the road transport sector by the year 2020.

(18) Alternative fuels will only be able to achieve market penetration if they are widely available and competitive.

(19) In its resolution of 18 June 1998 ([2]), the European Parliament called for an increase in the market share of biofuels to 2 % over five years through a package of measures, including tax exemption, financial assistance for the processing industry and the establishment of a compulsory rate of biofuels for oil companies.

(20) The optimum method for increasing the share of biofuels in the national and Community markets depends on the availability of resources and raw materials, on national and Community policies to promote biofuels and on tax arrangements, and on the appropriate involvement of all stakeholders/parties.

(21) National policies to promote the use of biofuels should not lead to prohibition of the free movement of fuels that meet the harmonised environmental specifications as laid down in Community legislation.

(22) Promotion of the production and use of biofuels could contribute to a reduction in energy import dependency and in emissions of greenhouse gases. In addition, biofuels, in pure form or as a blend, may in principle be used in existing motor vehicles and use the current motor vehicle fuel distribution system. The blending of biofuel with fossil fuels could facilitate a potential cost reduction in the distribution system in the Community.

(23) Since the objective of the proposed action, namely the introduction of general principles providing for a minimum percentage of biofuels to be marketed and distributed, cannot be achieved sufficiently by the Member States by reason of the scale of the action, and can therefore be achieved better at Community level, the Community may adopt measures, in accordance with the principle of subsidiarity as set out in Article 5 of the Treaty. In accordance with the principle of proportionality, as set out in that Article, this Directive does not go beyond what is necessary in order to achieve that objective.

(24) Research and technological development in the field of the sustainability of biofuels should be promoted.

(25) An increase in the use of biofuels should be accompanied by a detailed analysis of the environmental, economic and social impact in order to decide whether it is advisable to increase the proportion of biofuels in relation to conventional fuels.

([1]) OJ C 198, 24.6.1998, p. 1.

([2]) OJ C 210, 6.7.1998, p. 215.

(26) Provision should be made for the possibility of adapting rapidly the list of biofuels, the percentage of renewable contents, and the schedule for introducing biofuels in the transport fuel market, to technical progress and to the results of an environmental impact assessment of the first phase of introduction.

(27) Measures should be introduced for developing rapidly the quality standards for the biofuels to be used in the automotive sector, both as pure biofuels and as a blending component in the conventional fuels. Although the biodegradable fraction of waste is a potentially useful source for producing biofuels, the quality standard has to take into account the possible contamination present in the waste to avoid special components damaging the vehicle or causing emissions to deteriorate.

(28) Encouragement of the promotion of biofuels should be consistent with security of supply and environmental objectives and related policy objectives and measures within each Member State. In doing so, Member States may consider cost-effective ways of publicising the possibilities of using biofuels.

(29) The measures necessary for the implementation of this Directive should be adopted in accordance with Council Decision 1999/468/EC of 28 June 1999 laying down the procedures for the exercise of implementing powers conferred on the Commission ([1]).

HAVE ADOPTED THIS DIRECTIVE:

Article 1

This Directive aims at promoting the use of biofuels or other renewable fuels to replace diesel or petrol for transport purposes in each Member State, with a view to contributing to objectives such as meeting climate change commitments, environmentally friendly security of supply and promoting renewable energy sources.

Article 2

1. For the purpose of this Directive, the following definitions shall apply:

(a) 'biofuels' means liquid or gaseous fuel for transport produced from biomass;

(b) 'biomass' means the biodegradable fraction of products, waste and residues from agriculture (including vegetal and animal substances), forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste;

(c) 'other renewable fuels' means renewable fuels, other than biofuels, which originate from renewable energy sources as defined in Directive 2001/77/EC ([2]) and used for transport purposes;

(d) 'energy content' means the lower calorific value of a fuel.

2. At least the products listed below shall be considered biofuels:

(a) 'bioethanol': ethanol produced from biomass and/or the biodegradable fraction of waste, to be used as biofuel;

(b) 'biodiesel': a methyl-ester produced from vegetable or animal oil, of diesel quality, to be used as biofuel;

(c) 'biogas': a fuel gas produced from biomass and/or from the biodegradable fraction of waste, that can be purified to natural gas quality, to be used as biofuel, or woodgas;

(d) 'biomethanol': methanol produced from biomass, to be used as biofuel;

(e) 'biodimethylether': dimethylether produced from biomass, to be used as biofuel;

(f) 'bio-ETBE (ethyl-tertio-butyl-ether)': ETBE produced on the basis of bioethanol. The percentage by volume of bio-ETBE that is calculated as biofuel is 47 %;

(g) 'bio-MTBE (methyl-tertio-butyl-ether)': a fuel produced on the basis of biomethanol. The percentage by volume of bio-MTBE that is calculated as biofuel is 36 %;

(h) 'synthetic biofuels': synthetic hydrocarbons or mixtures of synthetic hydrocarbons, which have been produced from biomass;

(i) 'biohydrogen': hydrogen produced from biomass, and/or from the biodegradable fraction of waste, to be used as biofuel;

(j) 'pure vegetable oil': oil produced from oil plants through pressing, extraction or comparable procedures, crude or refined but chemically unmodified, when compatible with the type of engines involved and the corresponding emission requirements.

Article 3

1. (a) Member States should ensure that a minimum proportion of biofuels and other renewable fuels is placed on their markets, and, to that effect, shall set national indicative targets.

(b) (i) A reference value for these targets shall be 2 %, calculated on the basis of energy content, of all petrol and diesel for transport purposes placed on their markets by 31 December 2005.

([1]) OJ L 184, 17.7.1999, p. 23.

([2]) Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market (OJ L 283, 27.10.2001, p. 33).

(ii) A reference value for these targets shall be 5,75 %, calculated on the basis of energy content, of all petrol and diesel for transport purposes placed on their markets by 31 December 2010.

2. Biofuels may be made available in any of the following forms:

(a) as pure biofuels or at high concentration in mineral oil derivatives, in accordance with specific quality standards for transport applications;

(b) as biofuels blended in mineral oil derivatives, in accordance with the appropriate European norms describing the technical specifications for transport fuels (EN 228 and EN 590);

(c) as liquids derived from biofuels, such as ETBE (ethyl-tertio-butyl-ether), where the percentage of biofuel is as specified in Article 2(2).

3. Member States shall monitor the effect of the use of biofuels in diesel blends above 5 % by non-adapted vehicles and shall, where appropriate, take measures to ensure compliance with the relevant Community legislation on emission standards.

4. In the measures that they take, the Member States should consider the overall climate and environmental balance of the various types of biofuels and other renewable fuels and may give priority to the promotion of those fuels showing a very good cost-effective environmental balance, while also taking into account competitiveness and security of supply.

5. Member States shall ensure that information is given to the public on the availability of biofuels and other renewable fuels. For percentages of biofuels, blended in mineral oil derivatives, exceeding the limit value of 5 % of fatty acid methyl ester (FAME) or of 5 % of bioethanol, a specific labelling at the sales points shall be imposed.

Article 4

1. Member States shall report to the Commission, before 1 July each year, on:

— the measures taken to promote the use of biofuels or other renewable fuels to replace diesel or petrol for transport purposes,

— the national resources allocated to the production of biomass for energy uses other than transport, and

— the total sales of transport fuel and the share of biofuels, pure or blended, and other renewable fuels placed on the market for the preceding year. Where appropriate, Member States shall report on any exceptional conditions in the supply of crude oil or oil products that have affected the marketing of biofuels and other renewable fuels.

In their first report following the entry into force of this Directive, Member States shall indicate the level of their national indicative targets for the first phase. In the report covering the year 2006, Member States shall indicate their national indicative targets for the second phase.

In these reports, differentiation of the national targets, as compared to the reference values referred to in Article 3(1)(b), shall be motivated and could be based on the following elements:

(a) objective factors such as the limited national potential for production of biofuels from biomass;

(b) the amount of resources allocated to the production of biomass for energy uses other than transport and the specific technical or climatic characteristics of the national market for transport fuels;

(c) national policies allocating comparable resources to the production of other transport fuels based on renewable energy sources and consistent with the objectives of this Directive.

2. By 31 December 2006 at the latest, and every two years thereafter, the Commission shall draw up an evaluation report for the European Parliament and for the Council on the progress made in the use of biofuels and other renewable fuels in the Member States.

This report shall cover at least the following:

(a) the cost-effectiveness of the measures taken by Member States in order to promote the use of biofuels and other renewable fuels;

(b) the economic aspects and the environmental impact of further increasing the share of biofuels and other renewable fuels;

(c) the life-cycle perspective of biofuels and other renewable fuels, with a view to indicating possible measures for the future promotion of those fuels that are climate and environmentally friendly, and that have the potential of becoming competitive and cost-efficient;

(d) the sustainability of crops used for the production of biofuels, particularly land use, degree of intensity of cultivation, crop rotation and use of pesticides;

(e) the assessment of the use of biofuels and other renewable fuels with respect to their differentiating effects on climate change and their impact on CO_2 emissions reduction;

(f) a review of further more long-term options concerning energy efficiency measures in transport.

On the basis of this report, the Commission shall submit, where appropriate, proposals to the European Parliament and to the Council on the adaptation of the system of targets, as laid down in Article 3(1). If this report concludes that the indicative targets are not likely to be achieved for reasons that are unjustified and/or do not relate to new scientific evidence, these proposals shall address national targets, including possible mandatory targets, in the appropriate form.

Article 5

The list contained in Article 2(2) may be adapted to technical progress in accordance with the procedure referred to in Article 6(2). When adapting this list, the environmental impact of biofuels shall be taken into account.

Article 6

1. The Commission shall be assisted by a Committee.

2. Where reference is made to this paragraph, Articles 5 and 7 of Decision 1999/468/EC shall apply, having regard to the provisions of Article 8 thereof.

The period laid down in Article 5(6) of Decision 1999/468/EC shall be set at three months.

3. The Committee shall adopt its Rules of Procedure.

Article 7

1. Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with this Directive by 31 December 2004 at the latest. They shall forthwith inform the Commission thereof.

When Member States adopt these measures, they shall contain a reference to this Directive or be accompanied by such reference on the occasion of their official publication. The methods of making such a reference shall be laid down by the Member States.

2. Member States shall communicate to the Commission the provisions of national law which they adopt in the field covered by this Directive.

Article 8

This Directive shall enter into force on the day of its publication in the *Official Journal of the European Union*.

Article 9

This Directive is addressed to the Member States.

Done at Brussels, 8 May 2003.

For the European Parliament	*For the Council*
The President	*The President*
P. COX	M. CHRISOCHOIDIS

Annex B Summary CAP Reform 2003

Issue	CAP reform 2003 – Subsidies for Energy Crops
Operational period	By 31st December 2006, the Commission shall submit a report to the Council on the implementation of the scheme, accompanied, where appropriate, by proposals taking into account the implementation of the EU biofuels initiative.
Specification	An aid of 45 € per hectare per year shall be granted for areas sown under energy crops (this do not apply to regular set aside entitlements and payments, though certain energy crops-short rotation coppice-on set aside land will be eligible for set aside payment). Energy crops shall mean crops supplied essentially for the production of the following energy products: • Products considered biofuels listed in Article 2, point 2 of Directive 2003/30/EC of the European Parliament and of the Council of 8 May 2003 on the promotion of the use of biofuels or other renewable fuels for transport. • Electric and thermal energy produced from biomass.
Major Issues	The CAP Reform proposals mention a series of national or Community ceilings, quotas and maximum guaranteed quantities. • For Energy crops (maximum guaranteed area - MGA) A MGA of 1 500 000 ha was established by the CAP reform. Originally the purpose of this aid was to compensate for the abolition of non-food set-aside. However, as the non-food set-aside has been re-introduced in the final CAP reform texts, the attractiveness of this scheme decreases and an overshooting of the MGA becomes unlikely. • Non-food set-aside (forecast quantities covered by contracts) A limit of 1 million metric tons expressed in Soya bean meal equivalents has been set for quantities of by-products for feed or food uses as a result of the cultivation of oilseeds on land set-aside. This limit is subject to the Blair House agreement, meaning that any change would need to be negotiated with the US. For this reason the agreed limit is maintained in the proposals rather than adjusted.

Annex C Arable Aid Applications

SUPPLEMENTARY DETAILS RELATING TO ARABLE AID APPLICATIONS IN 2002

NON-FOOD USE OF SET-ASIDE LAND

Set-aside lanc may be used for the provision of materials for manufacture within the European Community of products not primarily intended for human or animal consumption.
The annual and perennial crops permitted are set out in ***Table 1*** and ***Table 2*** below. These crops may only be grown if destined for a permitted end use defined in ***Table 3***. (Commission Regulation 2461/1999).

Table 1	
Annual raw materials that may be grown on set-aside land when destined for use in the manufacture of the permissible end products set out in Table 3. These raw materials need to be covered by a contract.	
CN Code	**Brief description of products**
0602 90 59	Other outdoor plants (eg. Kenaf Hibiscus Cannabinus L. and Chenopodium) with the exception of Euphorbia lathyris, Sylibum marianum and Isatis tinctoria.
0701 90 10	Potatoes
0713 10 90	Peas (Pisum arvense L.) other than those for sowing
0713 50 00	Broad beans other than for sowing
ex 0714 90	Jerusalem artichokes (provided that they do not undergo the process known as hydrolysis as defined by Commission Regulation (EEC) No 1443/82 either in their natural state or as intermediate products such as inuline or as by-products such as oligo fructose or as any co-products)
0810 30 10	Blackcurrants
ex 0810 90 85	Fruits of the species Aronia arbutifolia, sea buckthorn and elder
0904 20	Fruits of the genus Capsicum or of the genus Pimenta, dried or crushed or ground
0909	Seeds of anise, badian, fennel, coriander, cumin or caraway; juniper berries
0910 50 00	Curry
0910 99 10	Fenugreek seed
ex 0910 99 91	Spices, other than mixtures
ex 0910 99 99	Spices, other than mixtures
1001 90 99	Spelt, common wheat and meslin other than for sowing
1002 00 00	Rye other than seed
1003 00 90	Barley other than seed
1004 00 00	Oats other than seed
1005 90 00	Maize (corn) other than seed

Table 1	
Annual raw materials that may be grown on set-aside land when destined for use in the manufacture of the permissible end products set out in Table 3. These raw materials need to be covered by a contract.	
CN Code	**Brief description of products**
1007 00 90	Grain sorghum other than hybrids for sowing
ex 1008 10 00	Buckwheat other than seed
ex 1008 20 00	Millet other than seed
ex 1008 90 10	Triticale other than seed
ex 1008 90 90	Other cereals other than seed
1201 00 90	Soyabeans other than for sowing
1202 20 00	Shelled ground nuts
ex 1204 00 90	Linseed other than for sowing but destined for uses other than textiles
ex 1205 00 90	Rape or colza seeds other than for sowing (only those types referred to in Articles 4(1) and 4(2)(a), (b), and (c) of Commission Regulation(EC) No. 2316/1999.
1206 00 91 1206 00 99	Sunflower seeds other than for sowing
1207 30 90	Castor oil seeds other than for sowing
1207 40 90	Sesamum seeds other than for sowing
1207 50 90	Mustard seeds other than for sowing
1207 60 90	Safflower seeds other than for sowing
ex 1207 99 91	Hemp seeds other than for sowing and mentioned in Annex B to Commission Regulation (EC) No 1164/89, destined for uses other than textiles.
1207 99 99	Other oil seeds and oleaginous fruits other than for sowing
ex 1209 29	Bitter lupin
ex 1211	Plants and parts of plants (including seeds and fruits), of a kind primarily used in perfumery, pharmacy or for insecticidal, fungicidal or similar purposes, other than lavender, lavandin and sage
1212 91	Sugar beet (provided that sugar, as defined by Commission Regulation (EEC) No. 1443/92, is not produced from it, either as an intermediate product, co-product or by-product)
1212 99 10	Chicory roots (provided that they do not undergo the process known as hydrolysis as defined by Commission Regulation (EEC) No 1443/82 either in their natural state or as an intermediate product such as inuline, or as a by-product such as oligofructose, or as any co-products)
1214	Swedes, mangolds, fodder roots, hay, lucerne (alfalfa), clover, sainfoin, forage kale, lupins, vetches and similar forage products
ex 5302 10 00	True hemp, raw or retted for processing into products not covered by

Table 1

Annual raw materials that may be grown on set-aside land when destined for use in the manufacture of the permissible end products set out in Table 3. These raw materials need to be covered by a contract.	
CN Code	**Brief description of products**
	Regulation (EC) No. 1673/2000.
Chapter 14	Vegetable plaiting, stuffing or padding materials or those used in brooms or brushes; vegetable products not elsewhere specified or included eg. Broomcorn, (Sorghum vulgare var. technicum)

Table 2

Perennial raw materials which may be cultivated on land subject to non-rotational set-aside provided they are intended for the manufacture of the products listed in Table 3. These do not need to be covered by a contract.	
CN Code	**Brief description of products**
ex 0602 90 41	Short-rotation forest trees with a harvest cycle of 10 years or less
ex 0602 90 49	Trees, shrubs and bushes producing plant material covered by CN code 1211 and by Chapter 14 of the Combined Nomenclature, excluding all those which can be used for human or animal consumption
ex 0602 90 51	Outdoor multi-annual plants (e.g. Miscanthus sinensis), other than those which can be used for human or animal consumption, in particular those producing plant material covered by CN code 1211, other than lavender, lavandin and sage, and by Chapter 14 of the Combined Nomenclature
ex 0602 90 59	Euphorbia lathyris, Sylibum marianum and Isatis tinctoria
1211 90 95	Digitalis lanata, Secale cornutum and Hypericum perforatum, excluding plant material which can be used for human or animal consumption.

Table 3

Permitted end-uses of crops in Tables 1 and 2 grown for non-food use on set-aside land.

All products of the combined nomenclature

with the exception of:

All of the products falling within Chapters 1 to 24 of the combined nomenclature with the exception of:

All products within CN Chapter 15 which are intended for uses other than for human or animal consumption

CN code 2207 20 00, for direct use in motor fuel or for processing for use in motor fuel

Packaging material falling within CN codes ex 1904 10 and ex 1905 90 90 on condition that proof has been obtained that the products have been used for non-food purposes according to the provisions of Article 9(2) of (EEC) Regulation No 334/93

Table 3
Permitted end-uses of crops in Tables 1 and 2 grown for non-food use on set-aside land.
all products falling within Chapters 25 to 99 of the Combined Nomenclature, all products falling within Chapter 15 of the Combined Nomenclature and intended for uses other than human or animal consumption, products covered by CN code 2207 20 00 and intended for direct use in motor fuel or for processing for use in motor fuel, packaging material covered by CN codes ex 1904 10 and ex 1905 90 90,on condition that proof has been obtained that the products have been used for non-food purposes in accordance with Article 15(4)of Regulation (EC) No. 2461/1999, mushroom spawn covered by CN code 0602 91 10, lac,natural gums,resins,gum-resins and balsams covered by CN code 1301, saps and extracts of opium covered by CN code 1302 11 00, saps and extracts of pyrethrum or of the roots of plants containing rotenone covered by CN code 1302 14 00, other mucilages and thickeners covered by CN code 1302 39 00,
all agricultural products listed in Table I and products derived therefrom by an intermediate process and used as fuel for energy production,
all products listed in Table 2 and products derived therefrom and intended for energy purposes
all products referred to in Commission Regulation (EEC)No 1722/93, as last amended by Regulation (EC)No. 87/1999, on condition that they are not obtained from cereals or potatoes cultivated on land set aside and that they do not contain products derived from cereals or potatoes cultivated on land set aside,
all products referred to in Council Regulation (EEC)No 1010/86, as last amended by Commission Regulation (EC) No 1148/98, on condition that they are not obtained from sugarbeet cultivated on land set aside, and that they do not contain products derived from sugarbeet cultivated on land set aside.

Strict rules apply to the growing of these crops and producers should be advised that improper use of set-aside land will cause loss of benefits and possible penalties.

Annex D Maximum Guaranteed Area for Oilseeds

MAXIMUM GUARANTEED AREA FOR OILSEEDS

Under an agreement between the European Union and the United States there is a maximum guaranteed area (MGA) for oilseeds in the European Union of 5.484 million hectares. This is divided between the 15 Member States. Ireland's MGA is 4,500 Ha. Penalties will apply if the MGA for the EU is exceeded. These penalties will be borne by the Member States that exceed their MGAs. The national penalties will be repeated in the following year if the EU ceiling is again exceeded.

(5) MAXIMUM GUARANTEED AREA FOR PROTEIN CROPS

A maximum guaranteed area (MGA) in the European Union for Protein Crops for which aid may be granted has been established at 1.4 million hectares. Where the area for which aid is claimed exceeds this MGA, the area per farmer for which aid is claimed shall be reduced proportionately for the year in question.

(6) MAXIMUM GUARANTEED AREA FOR ENERGY CROPS

A maximum guaranteed area (MGA) in the European Union for Energy Crops for which aid may be granted has been established at 1.5 million hectares. Where the area for which aid is claimed exceeds this MGA, the area per farmer for which aid is claimed shall be reduced proportionately for the year in question.

(16) PAYMENTS

Rates of payment in the 2004 Arable Aid Scheme year are the same as in 2003, **with the exception of the payment rate for Protein crops - see below.**

Payment of Arable Aid shall commence on 16 November 2004.

Arable Aid may be claimed in respect of the crops listed in the following table and paid at the rates per hectare shown below for 2004.

The rates indicated may be subject to change if:

(a) the national base area is exceeded **or if**

(b) the EU maximum guaranteed area for oilseeds, protein crops or energy crops is exceeded.

Crop		***2004/2005 Rate per hectare***
Cereals (including mixtures of cereals, oilseeds, linseed, Hemp and Flax grown for fibre)	€	383.04

Maize Silage	€	365.40
Protein Crops	€	383.04
Setaside	€	383.04

PROTEIN CROP PREMIUM PAYMENT

The payment rate for Protein Crops has been set at **€383.04** per hectare. However, a supplementary premium payment shall also be made at the rate of € 55.57 per hectare.

AID FOR ENERGY CROPS

The rate of aid for Energy crops claimed under the Energy Crops Scheme has been set at €45 per hectare. While the Energy Crops Scheme includes all crops with the exception of sugar-beet, any payments under the Arable Aid Scheme would of course be restricted to crops eligible for payment under the Arable Aid Scheme.

Annex E Basic Methodology of Input-Output Analysis

E.1 Macro-economic modelling

The basic principles of the economic modelling methodology are as follows:

- Assessment of the "with and without" cases. The macro-economic analysis of the introduction of a new product (the biofuel) and the related industry is best based on a *with/without* basis. The economic impact of implementing the change (eg by certain government measures) needs to be compared with the economic impact of not implementing this change. Often such an analysis is done on a *before/after* basis (comparing of the present situation with a certain future situation). This does however not fully reflect the fact that the business as usual scenario (in this case using 100% gasoline derived from fossil fuels) may also change in the future, because measures regarding energy efficiency improvement that will be undertaken anyway in the transport sector.
- Combining efficiency with accuracy. Full scale dynamic macro-economic modelling (eg by general equilibrium models) will require the use of rather complex and expensive models, although their results will generally model reality relatively accurately. Simple Input-Output models, combined with micro economic analysis of the product chain under consideration, are relatively time efficient to undertake. Although they are less reliable in terms of results, they can still provide a first order estimate of the macro-economic impacts.

E.2 The impact of an individual project (or product) on the Gross Domestic Product (GDP) and employment

The total cost (c) of a product can be split into three segments:

1) value added,

2) intermediate expenditures in the productive sector of the economy and

3) imports (see "round 0" in Figure E-1).

Value added consists of all types of income for the various economic actors in society, such as salaries (income from labour), interest (income from capital), land rent, profit (income from entrepreneurship) and taxes minus subsidies (government income). The total gross value added in an economy (which includes depreciation) adds up to the GDP. Therefore a project's contribution to the GDP can be represented by the amount of value added in its cost.

In turn, the intermediate expenditures can be subdivided into the same three components, and so on (see "round 1" and further in Figure E-1). Finally, the cost can be divided into imports (direct and indirect) and value added (direct and indirect).

The split into segments in round 0 in Figure E-1 can be derived directly from the calculation of the cost. Using the standard input-output method it is possible to come directly from the cost breakdown of round 0 to that of round n. In the section below, this standard IO method is discussed in more detail, after presenting the normal structure of the standard input-output table.

Employment creation can be included as a non-monetary variable that is important in view of the macro-economic objectives.

Figure E-1 shows the division of the cost into the segments of import, intermediate expenditures and value added. (In the figure Int. exp. means intermediate expenditure, v.a. means value added and imp. means import).

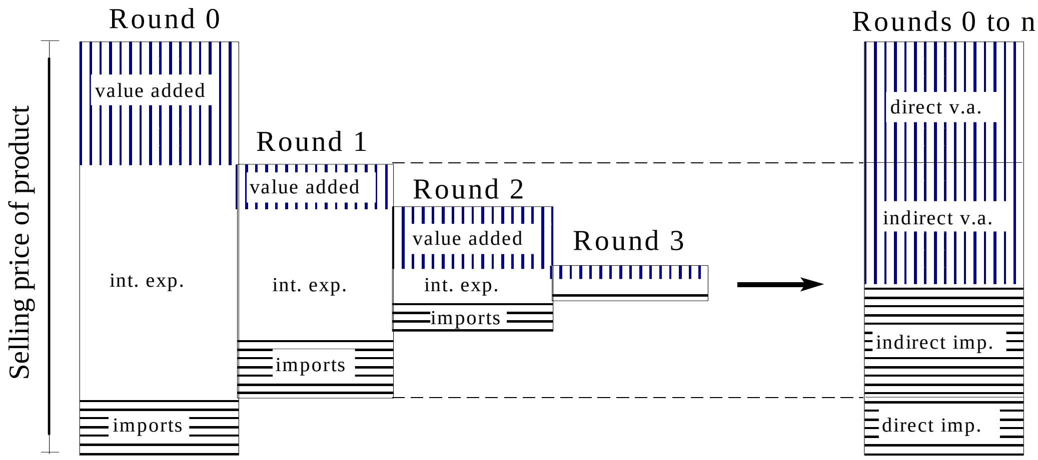

Figure E-1. Product Cost Segmentation.

E.3 The standard input-output table

The starting point for the standard input-output method is the input-output transaction table (Equation 4), which is available as standard statistical information for most countries in the world.* For this study, the Irish Input-Output table was supplied by Forfas [64].

The elements z_{ij} form the intermediate (inter-industry) section (Z matrix), representing the demand of sector j for products from sector i.

The final demand for products of sector i is represented by y_i, m_i indicates the imports by sector i and x_i is its total production. The production factors (w_i) consist of wages (for the production factor labour), rent (for land), interest payment (for capital) and profit (for entrepreneurship). Government income is represented by g_i, representing taxes minus subsidies.

Because demand has to equal supply, IO must meet:

$$\forall i: \quad x_i = \sum_{j=1}^{n} z_{ij} + y_i = \sum_{j=1}^{n} z_{ji} + w_i + g_i + m_i \qquad \textbf{(1)}$$

The value added created by sector i can be calculated as:

$$v_i = w_i + g_i \qquad \textbf{(2)}$$

This value added is called the gross value added if depreciation is included in the profit (gross profit) and is the net value added if the profit is a net profit (without depreciation). The sum of the gross value added of all n sectors in the economy gives the gross domestic product of a country:

$$GDP = \sum_{i=1}^{n} (w_i + g_i) \qquad \textbf{(3)}$$

*In this description, capital letters represent matrices (including vectors) and lower case letters are scalars.

$$
\mathbf{IO} = \left[\begin{array}{ccccc|cc}
z_{11} & z_{12} & z_{13} & \cdots & z_{1n} & y_1 & x_1 \\
z_{21} & z_{22} & z_{23} & \cdots & z_{2n} & y_2 & x_2 \\
z_{31} & z_{32} & z_{33} & \cdots & z_{3n} & y_3 & x_3 \\
\vdots & \vdots & \vdots & \cdots & \vdots & \vdots & \vdots \\
z_{n1} & z_{n2} & z_{n3} & \cdots & z_{nn} & y_n & x_n \\
\hline
w_1 & w_2 & w_3 & \cdots & w_n & & \\
g_1 & g_2 & g_3 & \cdots & g_n & & \\
m_1 & m_2 & m_3 & \cdots & m_n & & \\
\hline
x_1 & x_2 & x_3 & \cdots & x_n & &
\end{array}\right] \qquad (4)
$$

E.4 The standard input-output method

The aim of the standard input-output method in the application under consideration is to split the cost of a product (or project) into (direct and indirect) value added and (direct and indirect) imports, or in other words: to come from round 0 to round n of Figure E-1. The assumption is made that the elements z_{ij} in the intermediate part of the IO matrix are linear with the total production of commodity j:

$$z_{ij} = a_{ij} x_j \qquad \textbf{(5)}$$

In this way it is possible to define a normalised A matrix, called the technological matrix, with the element a_{ij}

$$\forall_{i,j} : \ a_{ij} = \frac{z_{ij}}{x_j} \qquad \textbf{(6)}$$

In the same way it is possible to normalise (subscript "nr") the value added and import parts of the IO matrix.

$$\forall_i : \ w_{nr,i} = \frac{w_i}{x_i} ; \ g_{nr,i} = \frac{g_i}{x_i} ; \ m_{nr,i} = \frac{m_i}{x_i} \qquad \textbf{(7)}$$

Figure E-2 shows the structure of this normalised matrix and is a schematic representation of the economic system analysed (a, left-hand side) and the technological matrix and its normalised value added and import vectors (b, right-hand side). The arrows represent the flow of products.

The first part of Equation 1 can now be rewritten in matrix terms:

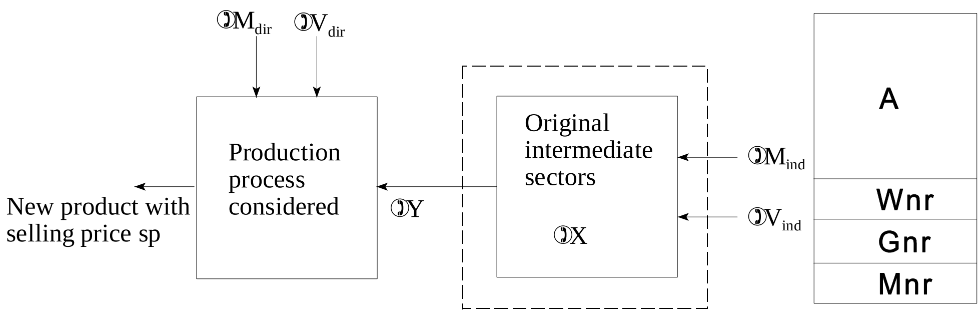

Figure E-2. Schematic of the economic SYSTEM.

$$X = AX + Y \qquad \textbf{(8)}$$

or

$$(I - A)\,X = Y \qquad \textbf{(9)}$$

where I is the unit matrix. Assuming the inverse of (I-A) exists, multiply both sides by it:

$$(I - A)^{-1}(I - A)\,X = (I - A)^{-1}\,Y \qquad \textbf{(10)}$$

leading to:

$$X = (I - A)^{-1}\,Y \qquad \textbf{(11)}$$

The term $(I-A)^{-1}$ is called the Leontief inverse. Under the assumption that the average values of the A matrix are also representative for the marginal variation of vector X as a result of a marginal variation in vector Y, then:

$$\Delta X = (I - A)^{-1} \Delta Y \quad \textbf{(12)}$$

In turn, the marginal variation in X has repercussions on the value added and the imports in the economy. The marginal (indirect) variation in imports and value added can now be calculated as:

$$\begin{aligned} \Delta m_{ind} &= M_{nr} \Delta X \\ \Delta v_{ind} &= \Delta W + \Delta G = (W_{nr} + G_{nr}) \Delta X \end{aligned} \quad \textbf{(13)}$$

E.5 Application of the standard IO method to new products

In the application of the standard IO method it is assumed that there is an additional demand for the product (e.g. additional demand for bioethanol) whose macro-economic impact needs to be assessed. Therefore, the production process for this product (e.g. production of bioethanol from biomass) is not yet included in the standard IO table and the direct (round 0) demand for inputs from the existing intermediate sectors (e.g. fertilisers, tractors or diesel) can thus be considered to be exogenous. Therefore, this direct demand of the new production process can be represented as an additional final demand vector ΔY, which will cause an additional production ΔX of the existing productive sectors.

In order to calculate the impact of a certain project or product on the gross domestic product, the cost (c) has to be broken down into direct value added, v_{dir} ($=w_{dir}+g_{dir}$), direct import, m_{dir}, and direct intermediate expenditures, ine_{dir} (round 0 of Figure E-1). These direct intermediate inputs have to be converted into a (n x 1) ΔY vector, which means that for each separate cost item it has to be decided in what sector of the national economy it is produced (Equation 14).

$$c = v_{dir} + m_{dir} + ine_{dir} = v_{dir} + m_{dir} + \sum_{i=1}^{n} \Delta y_i \quad \textbf{(14)}$$

With this ΔY vector, representing the first order (round) of the demand for intermediate products for the project under consideration, the total resulting additional production ΔX in all sectors in the economy can be derived from Equation 12 and the indirect marginal induced imports and value added (Δm_{ind} and Δv_{ind}) from Equation 13. The total value added and import part of the cost can than be calculated as:

$$\begin{aligned} v &= v_{dir} + \Delta v_{ind} = v_{dir} + (W_{nr} + G_{nr}) \Delta X \\ m &= m_{dir} + \Delta m_{ind} = m_{dir} + M_{nr} \Delta X \end{aligned} \quad \textbf{(15)}$$

By definition, the sum of these two items equals the cost (c) of the product considered:

$$c = v + m \quad \textbf{(16)}$$

With data on the employment per sector (e_i) and the direct employment creation of the project under consideration (e_{dir}) it is now also possible to calculate the total employment created by the project. Therefore, it is again necessary first to normalise the employment figures:

$$\forall_i : \quad e_{nr,i} = \frac{e_i}{x_i} \quad \textbf{(17)}$$

after which the total employment creation can be calculated in a similar way as in Equation 15 :

$$e = e_{dir} + \Delta e_{ind} = e_{dir} + E_{nr} \Delta X \quad \textbf{(18)}$$

Employment per sector could be split into different types of employment, such as low, medium and high cost employment. In this case, each type of employment gives one input vector e_i and one resulting vector e.