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STIMULATING THE USE OF BIOFUELS IN THE EUROPEAN UNION: IMPLICATIONS FOR CLIMATE CHANGE POLICY

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[*]

Abstract

The substitution of fossil fuels with biofuels has been proposed in the European Union (EU) as part of a strategy to mitigate greenhouse gas emissions from road transport, increase security of energy supply and support development of rural communities. In this paper, we examine this opportunity, by focusing on one of these purported benefits, the reduction in greenhouse gas emissions. The cost of subsidising the price difference between European biofuels and fossil fuels per tonne of CO_2 emissions saved is estimated to be €174-269. Without including the benefits from increased security of energy supply and employment generation in rural areas, the current costs of implementing biofuel targets are high compared with other available CO_2 mitigation strategies, including biofuel imports. The policy instrument of foregoing some or all of the excise and other duties now applicable on transport fuels in EU15, as well as the potential to import low cost alternatives, mainly from Brazil, are addressed in this context.

Keywords: biofuels, greenhouse gas emissions, transport policy

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1. Introduction

Currently[2] transportation fuels pose two important challenges for the European Union (EU). First, under the provisions of the Kyoto Protocol to the Climate Change Convention, the EU has agreed to an absolute cap on greenhouse gas emissions; increased consumption of transportation fuels has resulted in a trend of increasing greenhouse gas emissions from this source.[3] The Kyoto imperative has become very salient with the approval of the protocol by the Russian Parliament, which brings it into effect as a legally binding obligation of the EU. Second, the dependence upon oil imports from the politically volatile Middle East generates concern over price fluctuations and possible interruptions in supply.

Increasing the use of alternative fuels can address both these challenges, by providing an opportunity to reduce greenhouse gases and other polluting emissions, and by improving the security of energy supply. Additionally, the development of biofuels may create new employment opportunities, especially in declining rural areas.

Despite legislative efforts in the EU to promote biofuels (discussed later) the policy implications of their use remain largely unexplored. In our analysis, we distinguish between commercial returns, comprising the revenues and costs that accrue to private individuals and companies, and economic efficiency, which incorporates the costs and benefits which accrue to society, including in particular the external benefits of CO_2 reduction.. Biofuels are currently uncompetitive with conventional fossil fuels (petrol and diesel) in Europe. However, can they become competitive once their social benefits, namely the CO_2 emissions reduction, security of energy supply and rural development are accounted for? This paper addresses this question by focusing on the first external benefit, the reduction in greenhouse gas emissions.

The commercial price of transport fuel in the European market and private marginal costs of supplying biofuels are compared in order to derive a threshold value per tonne of CO_2 reduction that must be achieved if biofuels are to compete in price with petrol an diesel in Europe. The gap between the marginal costs of biofuels and traditional fuels motivates the analysis of different mechanisms that would be needed to encourage the uptake of biofuels: an excise duty reduction, a subsidy to the production of biofuels and/or increased imports from cheaper non-EU producers. In addition, this threshold value, or the cost of reducing a tonne of CO_2 emissions using biofuels, can be contrasted with the marginal costs of achieving CO_2 reductions elsewhere in the system. It can be compared, for example, with the cost of technical measures in the transport sector to reduce greenhouse gas emissions or with the price of buying allowances in the CO_2 emissions trading market.

The remainder of this paper is structured as follows: section 2 provides the policy and technical context surrounding the adoption of biofuels in Europe. Section 3 computes the threshold value per tonne of CO_2 reduction that needs to be achieved for biofuels to be competitive with conventional transport fuels in Europe. Section 4 outlines the policy implications and Section 5 summarises our conclusions.

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[2] The analysis in this study uses data from 2002 to November 2004. The term ‘current’ is used to refer to these data. More specific dates are provided in the relevant tables.

[3] The European Commission’s White Paper “European transport policy for 2010: time to decide,” advanced the prospect of a rise of 50% in CO_2 emissions from transport between 1990 and 2010 under ‘business as usual’ policies.

2. European Policy and Technical Context

In accordance with the ‘flexible mechanisms’ of the Kyoto protocol, the EU has introduced a CO_2 emissions trading scheme to commence on a pilot basis in January 2005.[4] Although not included in this pilot phase,[5] reducing the transport sector’s emissions, and in particular emissions from road transportation, is a pressing issue as the latter currently represent 19% of total EU CO_2 equivalent emissions and are expected to increase (European Environment Agency, 2004). The European Commission foresees that three alternative transport fuels, hydrogen, natural gas, and biofuels, will replace transport fossil fuels, each by 5% by 2020 (Commission of the European Communities, 2001).

Hydrogen is thought to be the transport fuel of the future, but due to infrastructure, cost and technical challenges, it is likely to be a medium rather than short-term solution. Compressed natural gas (CNG) also faces significant challenges. Although it provides an advantage in energy efficiency and hence CO_2 emissions over petrol (Greene and Schafer, 2003), it requires dedicated catalysts in order to avoid the emission of methane, another greenhouse gas.[6] These catalytic converters are expensive and are not suitable for bi-fuelled petrol/CNG vehicles. Additional disadvantages of CNG are its non-renewability, the absence in many countries of a distribution infrastructure, and its lower volumetric energy content requiring vehicles with larger and heavier tanks to store the fuel (Greene and Schafer, 2003).

Biofuels are an alternative motor vehicle fuel produced from biological material. They are viewed as an essential element in the development of alternative fuel markets, and some initiatives have already been introduced to promote biofuels in the EU. Under the European Directive on the promotion of the use of biofuels or other renewable fuels for transport (European Parliament and European Council, 2003), Member States are recommended to substitute a minimum of 2%, by 2005, and 5.75%, by 2010, of transport fuels with biofuels and other alternative fuels.[7] Furthermore, Member States are permitted to reduce excise duties on biofuels[8] (Council of the European Union, 2003). The Green Paper “Towards a European Strategy for Energy Supply” supports this initiative and it also serves the reforms of the Common Agricultural Policy to support rural economies, which decouple some subsidies from food production (Commission of the European Communities, 2003).

There are three categories of biofuels considered in the EU directive: (i) Plant oils, such as rape seed, soybean or palm, which can be used in a modified diesel engine or processed to produce biodiesel that can be used in a conventional diesel engine. (ii) Bioalcohol, such as methanol and ethanol, which can be produced from cereal crops, or sugar beets and can fuel modified petrol engines. (iii) Organic waste

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[4] Directive 2003/87/EC of the European Parliament and of the Council establishing a scheme for greenhouse gas emission allowances trading within the Community and amending Council Directive 96/61/EC. This text will apply to the existing 15 Member States, those Accession States who joined in May 2004 and other countries (such as Iceland, Norway and Switzerland) who choose to participate.

[5] In the first pilot phase (2005-2007) trading is confined to CO_2 emissions from power stations in excess of 20 MW (except incinerators), oil refineries, smelters, manufacture of cement (> 500 tonnes per day), ceramics including brick, glass, and pulp, paper and board (>20 tonnes per day). See footnote 2.

[6] Methane has a global warming potential 21 times greater than that of CO_2 emissions (on a mass basis over a 100-year period).

[7] Directive 2003/30/EC. These targets are indicative rather than mandatory but failure to meet them requires Member States to explain the discrepancy in their annual biofuels progress reports.

[8] Directive 2003/96/EC.

material which can be converted to biofuels (for example used cooking oils can be converted into biodiesel, and plant waste into bioalcohol).

These three categories of biofuels have gained the most attention in the EU as they are produced from materials that are suitable for agricultural production in the EU, or are widely available waste products. Currently, all other possibilities are either prohibitively expensive or energy intensive in their production.[9] For a general overview on biofuel choices and their characteristics see van Thuijl et al. (2003) or Fulton et al. (2004). There are many challenges facing alternative fuels before they can gain acceptance in the transport fuels market. The existing petroleum infrastructure is standardised and has extensive coverage, and the cost of biofuels is significantly higher than that of mineral oil fuels.

3. Biofuels vs. conventional fuels: the value of reducing CO_2 emissions

Although the amount of biofuels produced in the EU is growing, the quantities remain small compared to the total volume of mineral based transport fuels sold – approximately 0.3% of all EU petrol and diesel fuel in 2003 (Kavalov, 2004). This can be explained by the fact that the cost of biofuel in Europe remains higher than that of the fossil fuel it is intended to replace.

Production costs of biofuels vary and are dependent on the prices of raw materials, the method of production, the extent of refining undertaken, and the supplementary utilisation of by-products and waste. The cost estimates for biofuels utilized in this paper, reported in Table 1, come from a study for the UK Department for Transport (Haydock, 2003) to investigate international resource costs for biodiesel and bioethanol. The costs are highly variable depending on the various combinations of feedstock (column 2) and country of production (US, EU15 or Brazil; column 3). They are, however, within the range of values reported in other studies (see for example den Uil et al. (2003), Edwards et al. (2004) or Kavalov (2004), DfT (2004)). Note that because both biodiesel and bioethanol contain less energy per litre than the corresponding fossil fuel, the total cost per litre in the last column of table 1 is given as a cost per energy-equivalent litre in 2004 money.[10]

Table 1 shows that biodiesel produced in the US (mainly from soybean oil) is cheaper than biodiesel produced in the EU (mainly from oil seed rape). Bioethanol produced in the EU is most expensive when produced from straw and cheapest when produced from wheat. This result, however, varies across countries within the EU.[11] The cheapest bioethanol comes from sugar cane in Brazil.

To be profitable, biofuel prices must cover production and distribution costs and be competitive in price with conventional transport fuels. The European Oil Bulletin contains data on the final price paid by

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[9] In the medium term, technological advances in the thermochemical processing of biomass could produce biodimethylether, synthetic fuels and hydrogen, to take a few examples.

[10] Bioethanol contains 67% as much energy per litre compared with a litre of petrol and biodiesel contains 87% as much energy per litre compared with a litre of diesel (IEA, 2004). The energy-equivalent cost is the relevant variable since the targets contained in the EU biofuels directive are given on an energy basis. In addition, if consumers substitute a fossil fuel for a biofuel, the difference in energy content will most likely translate into increased fuel consumption and therefore this real cost must be taken into account when comparing fossil and biofuel prices.

[11] Some other studies indicate lower costs for bioethanol produced from sugar beet than from wheat for some EU15 countries (Armstrong et al., 2002; Henke et al., 2003; Edwards et al., 2004). A more recent related UK study (DfT, 2004) delivered a range of costs that were both above and below the values from Haydock (2004).

consumers in the EU for petrol and diesel and on the excise duties and value added tax (VAT) charged in all EU countries.[12]

In Table 2 we compare the pre-tax fossil fuel price (i.e. the price before excise duty and VAT), that would be the integral value assigned to biofuels on the market, with the actual costs of biodiesel (produced from EU15 oilseeds) and bioethanol (produced from EU15 wheat and sugar beet, and the cheapest Brazilian sugar cane) from table 1. Table 2 provides thus a rough comparison of the costs of biofuels with those of mineral fuels. A couple of considerations must be taken into account when using the pre-tax price of fossil fuels as proxy for their costs: the pre-tax fossil fuel prices do not subtract profit margins, and they are derived from erratic and very high (at the time of writing) oil spot prices. Both factors tend to inflate the fossil fuel costs and thus bias the cost difference with biofuels in the last column of table 2 downwards. Table 2 applies to current conditions, and thus ignores the evolution of the costs of biofuels in the medium and long term. Some studies predict that the costs of cellulosic ethanol will drop considerably to equal the pre-tax price of petrol after 2010 (Haydock, 2003; Fulton et al., 2004). Longer-term technologies such as the Fischer-Tropsch process are likely to reduce biodiesel costs significantly.

The message from table 2 is clear; biofuels are not cost competitive with conventional fossil fuels in Europe unless imported from Brazil. The natural question is whether they become competitive once their social benefits are accounted for, namely the reduction of CO_2 emissions, security of energy supply and rural development. For example, recent estimates have put the number of jobs that could be generated by achievement of the EU biofuel targets at 212,000 and 354,000 in 2010 and 2020, respectively, under current policies (Whitely et al., 2004). The focus of this paper, however, is on the social benefit that overrides the justification of the promulgation of biofuels in Europe, namely the reduction of greenhouse gas emissions from transport.

The estimation of greenhouse gas and energy balances of biofuels is complex. The full fuel cycle and not just the direct emissions during combustion must be considered for comparison with fossil fuels. While the combustion of biofuels is considered to be CO_2-neutral, (Intergovernmental Panel on Climate Change, 1996) their production requires energy inputs that may distort the positive energy and greenhouse gas balance. The final accounting is country-specific and is a function of the raw material cultivated, the utilisation of by- and co-products (for example, credits are given to the use of by-products as animal feedstuffs and fuel in the production process), and the agricultural yield (Henke et al., 2003; Shapouri et al., 2002).

Table 3 presents a range of estimates of the CO_2 equivalent emissions (or total greenhouse gas emissions weighted in terms of their global warming potentials) reduced as a result of utilising biofuels over the corresponding fossil fuel. The CO_2 emissions include cultivation, production, distribution and vehicle emissions for biofuels. The values are taken from a study by van den Broek et al. (2003), in the Netherlands, which represents the state of the art and provides a comprehensive collection of data from other studies carried out both by academic, public and industry groups.[13]

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[12] EU Oil Bulletin provides weekly and monthly average prices for transport fuels in EU15 and EU25. The data utilised n this study is from 8/11/2004. It is available at http://europa.eu.int/comm/energy/oil/bulletin/2004_en.htm.

[13] The Dutch study summarises values estimated by other studies such as GM (General Motors and L-B-Systemtechnik GmbH, 2002), CONCAWE (Armstrong et al., 2002), Ademe/Ecobilan (Commission of the European Communities, 2003b), Sheffield (Elsayed, 2003) and ECN (den Uil et al., 2003).

The wide range of values presented in Table 3 is a result of differences in calculation methods, production yields and the use of co- and by-products in the production chain in the studies collected by van den Broek et al. Column 3 presents the range of CO_2 g/km savings for bioethanol produced from sugar beet, wheat, and Brazilian sugarcane, and biodiesel produced from rapeseed compared with a 'standard' petrol or diesel vehicle.[14] The savings are presented in terms of a percentage of CO_2 emissions saved from the same standard vehicle in Column 4. Due to the wide range of estimates published, for simplicity this study chose a single set of estimates for further calculations. The study did not take an average, but instead selected values that did not have unrealistic use of co- and by-product credits and were most representative for Dutch and northern European conditions. These values are consistent with the study on resource costs in table 1, which are estimated for the UK, a region of comparable climate and market conditions to the Netherlands. They correspond to the estimates labelled "most likely" in columns 5 and 6. The last two columns of table 3 convert the estimates of the reductions in CO_2 emissions to the quantity of CO_2 emissions that would be saved by substituting 1000 litres of diesel and petrol with the energy equivalent biofuel litres. For example: 1.7 CO_2t /1000Litres saved for bioethanol from sugar beet = $\frac{125.8g/km}{0.074L/km} * 1000$.

According to table 3, both biodiesel and bioethanol have a positive energy balance. For biodiesel, the CO_2 equivalent savings range between 44-66% compared with conventional diesel. Table 3 also shows that bioethanol produced from Brazilian sugarcane has a better well-to-wheels energy balance than bioethanol produced from wheat and sugar beet in the EU. This is due to the high productivity of sugar cane crops in Brazil and the use of by-products (the remains of the crushed cane after the sugar is extracted) to provide energy to nearly all processing plants. In fact, many biofuel processing plants in Brazil are net exporters of electricity resulting in fossil fuel requirements near zero (Fulton et al., 2004).

With data on the commercial price (p), private marginal costs of supplying biofuels (MC_{Priv}) from Table 2, and on the tonnes of CO_2 emissions saved by the introduction of biofuels from Table 3, we can derive a threshold value per tonne of CO_2 reduction that needs to be achieved if biofuels are to compete with conventional transport fuels in Europe (MC_{Soc}).

$$MC_{Soc} = \frac{[MC_{Priv} - p]}{tCO_2 reduced} \qquad (1)$$

This threshold value represents the cost to society of reducing a tonne of CO_2 emissions using biofuels. Table 4 shows its estimation. The second column of table 4 contains the numerator of equation (1), the divergence between the value of commercial fuels on the market and the cost of production of biofuels derived in the last column of table 2; the third column contains the denominator of equation (1), the tonnes of CO_2 reduced derived in the last two columns of table 3. The last column of table 4 contains the threshold, i.e. the cost difference divided by the emissions savings. This threshold, or the cost per tonne of CO_2 emissions mitigated, is between €174-269 in Europe. However it is less than zero for bioethanol produced in Brazil from sugarcane.

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[14] Based on an Opel Zafira vehicle with the following energy/fuel usage: Petrol MTA SI – 2.59MJ/km or 0.074L/km; Diesel MTA – 2.080MJ/km or 0.054L/km

3. Policy implications

Society has a number of choices to reduce the amount of greenhouse gasses released in the atmosphere including switching to less carbon intensive fuels, reducing energy consumption, or carbon sequestration.

According to table 4, for all EU biofuels to be economically efficient as a measure to reduce CO_2 emissions – based on current costs and prices - the marginal benefit of reduction of CO_2 emissions would need to be at least €269 per tonne. To evaluate the magnitude of the numbers in table 4, an estimate of that marginal benefit is needed. The European CO_2 emissions trading scheme provides some direction, as the price per tonne of CO_2 emerging from this market will inform participants to what extent they should abate or purchase allowances if necessary.[15]

When comparing the cost of CO_2 reductions by utilising biofuels with the prices from the European CO_2 emissions market, it must be noted that current prices represent a conservative estimate of the value of the benefits to society of CO_2 abatement. Member States have given the participants very generous allocations, and the scheme only covers a fraction of each Member State's emissions. The marginal costs of abatement in the trading sectors are likely to be much lower than such costs in the non-trading sectors, i.e., if all the emissions in each Member State's Kyoto cap were included in the trading scheme, the equilibrium price per tonne of allowances would likely be higher than that in the current partial market (Convery and Redmond, 2004). Additionally, due to the prevailing high fossil fuel prices (between $40-50 per barrel in November 2004), the costs of achieving CO_2 reductions estimated in this paper are in the lower end of other estimates available in the literature (Fulton et al., 2004). Nevertheless, the estimated threshold cost of biofuels is significantly higher than the traded price of CO_2 emissions of around €8.50 per tonne CO_2. (See figure 1 for the development of the price a 2005 vintage EU allowance over the last 12 months).[16]

Moreover, the threshold cost is at the higher end compared with the costs of CO_2 emissions mitigation overall in the transport sector. Blok et al. (2001) estimated that the cost of technical measures to reduce greenhouse gas emissions in the transport sector would range between €73-350/tCO_2.

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[15] Although trading does not start until January 2005, there is a futures market for CO_2 emissions in operation.

[16] The EU allowance price development graph is based on "market closing" price information obtained from the Carbon Market Europe weekly newsletter – www.PointCarbon.com We are grateful to Luke Redmond for compiling it for us.

3.1 Costs of excise duty remission

Given the cost differential with fossil fuels, government intervention is needed in order to promote the market introduction of biofuels. A widely used method of subsidy in Europe is the remission of excise duties. The recent EU Directive on the taxation of energy products and electricity, permits partial or total exemptions in the level of taxation of biofuels (Council of the European Union, 2003). Many countries have already introduced an excise duty rebate on biofuels and others are considering doing so.

Table 5 compares the cost difference between a fossil fuel and the corresponding biofuel with the excise duty applied to mineral fuels in each EU15 country. This table shows that at current oil prices, the cost difference between bioethanol from wheat and petrol is lower than the excise duty applied to petrol in all EU15 countries except Greece, and a remission of excise duty would be sufficient to equalise the prices between fossil and biofuels. The situation is different, however, for bioethanol from sugarbeet, where for five countries the excise duty applied is lower than the cost difference. For diesel fuels, the cost difference between biodiesel and diesel is greater than the excise duties applied to diesel in all EU15 countries except the UK and Germany. The average excise duty on diesel in EU15 is however higher than the average cost difference between diesel and biodiesel, (partially as a result of the high excise duty on fuel in the UK).

Table 6 presents the revenue foregone in EU15 as a result of eliminating excise duties per tonne of CO_2 emissions saved. It is calculated as the value of excise duty foregone per 1000 litres of energy-equivalent biofuel sold (EU15 average), divided by the tonnes of CO_2 emissions saved per energy-equivalent litre of biofuel from Table 3[17].

The values in table 6 are comparable to the costs of directly subsidising the production and distribution cost difference between biofuels and mineral fuels in Table 4, excluding the values from Brazil. Since the costs of either remitting excise duty or subsidising the cost difference are comparable, the remission of excise duty may be preferred due to the ease of implementation. However, from a static economic efficiency perspective the direct subsidy entails lower costs, as the difference between biofuel and fossil fuel costs on average is currently lower than the excise duty. Direct subsidy also ensures that the price of a biofuel matches that of the corresponding fossil fuel. The excise duty remission currently applied in the EU is not tied to prevailing oil or biofuels costs; therefore the implicit subsidy given is not a function of the current price differential. This explains, for example, why the remission of excise duty for bioethanol from Brazil would cost €140/t CO_2 while a direct subsidy policy would result in no subsidy given, since the cost is competitive with petrol.

However, reducing excise duty on fuels would affect an important source of government revenue. Revenue from transport fuel excise duty in 2002 for the 15 Member States in the EU reached €178 billion (ACEA, 2004). Energy and transport taxes in 2002 made up 2.6% of total GDP and 6.3% of total taxation in EU15 (Commission of the European Communities, 2004). In addition, although on average the costs of remitting excise duties are comparable with the cost difference between biofuels and fossil fuels, for many countries, the remission of excise duty may not be sufficient to make biofuels, in particular biodiesel, competitive with mineral fuels. This situation could become more pronounced if fossil fuel prices drop from their current high level.

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[17] When the UK is excluded from the averages, the qualitative implications of the analysis do not change.

3.2 Tariffs and world prices

So far we have focussed primarily on biofuels produced in EU15. Do the results change if the accession of 10 new Member States[18] to the EU in 2004 is considered? Kavalov et al., (2003) estimate the potential contribution of the new Member States at 1% of the enlarged EU fuels market. With optimal technology, the potential rate of substitution could be 2% of diesel consumption and 3% of petrol consumption. This production is sufficient to meet the new Member States requirements under the EU biofuels Directive, but it can only be a small supplement to EU15 biofuel production. A significant finding of this study is that the biofuels reduction costs in accession countries appear to be similar to those in EU15, as lower factor costs are offset by lower yields.

Potential sources of cheaper biofuels are found in non-EU countries from South America and Asia. The bioethanol market in Brazil has been established since the launch of a biomass programme in the 1970s (the Proalcool programme). The Brazilian government has supported this programme with vehicle technology subsidies and fuel tax reductions. Currently it is mandatory to blend petrol up to 20-25% with anhydrous bioethanol. This rule has provided a stable market for bioethanol producers in Brazil over the last 30 years and created a low risk environment for investors. As a result, Brazil has a significant cost advantage in the production of bioethanol compared with the EU mainly due to large-scale commercial production (reaching 13.7 billion litres in 1997 (IEA, 2004)) and favourable conditions for the cultivation of sugarcane. This has led to cheap bioethanol and high capacities available for export.

From Table 2 it can be seen that if bioethanol imports from Brazil are used, the net costs per tonne of CO_2 reduction in the EU fall dramatically, to the point where it is competitive in private cost terms with petrol and diesel. Note however that this conclusion holds at current prices i.e., it relies on a sufficient Brazilian export capacity and assumes no import tariffs. Tariffs of approximately €0.1 per litre[19] exist on imported bioethanol to the EU. The EU Council Regulation[20] on laying down specific measures concerning the market in ethyl alcohol of agricultural origin, introduced a monitoring system from January 2004 affecting bioethanol imports. An export and import license scheme was introduced and the Commission has the power to administer tariff quotas “resulting from international agreements concluded in accordance with the Treaty from other legislative acts of the Council.” The IEA has called for the lowering of tariffs on biofuels (Fulton et al., 2004), and it appears that the EU is negotiating with Latin American countries to arrange reduced tariffs for the import of bioethanol into the EU.[21]

4. Conclusions

The substitution of fossil fuels with biofuels has been proposed in the EU as part of a strategy to mitigate greenhouse gas emissions from road transport, increase security of energy supply and support development of rural communities. This paper focused on one of these purported benefits, the reduction in greenhouse gas emissions, and examined whether implementing this measure is economically efficient. The current cost of subsidising the price difference between European biofuels and fossil fuels per tonne of CO_2 emissions saved is estimated to be €174-269. This is the threshold value that must be

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[18] Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovenia, Slovakia.

[19] Personal communication with Directorate General for Transport and Energy (DG TREN) 11/2004.

[20] Council Regulation No. 670/2003

[21] Personal communication DG TREN 11/2004.

assigned to one tonne of CO_2 emissions, in order for the biofuels measure to be economically efficient; it is high compared with other available CO_2 mitigation strategies, both within the transport sector and (especially) outside. CO_2 allowances in the EU are being traded at around €8.50 per tonne. The marginal abatement costs of CO_2 emissions for the road transport sector are in the range of €73-350/tCO_2. The cost of subsidising biofuels falls within the upper half of this range. It seems then that supporting biofuels is currently not efficient without including the economic benefits from additional employment generated or the resulting incremental security of energy supply. Even in this case, it is likely that these strategic and social objectives could be met by alternative means that are less expensive. The use of biofuels is efficient only when the bioethanol is imported from Brazil, assuming that the Brazilian supply is perfectly elastic and import tariffs are sufficiently low.

If the production of European biofuels for transport is to be encouraged, exemption from excise duties is the instrument that incurs the least transactions costs, as no separate administrative or collection system needs to be established. However, for some European countries, total exemption from the prevailing excise duties would not suffice to make production viable. Moreover, given the pressure that most EU countries are under to reduce budget deficits and taxes simultaneously, it seems unlikely that the stimulation of biofuels will be seen as a priority. These conclusions are valid at current costs and prices. It is conceivable that growth in the volume of the business will engender both economies of scale and innovation that will reduce costs substantially. However, the gap is very wide, and it seems unlikely that that it would be sufficient to allow Europe-originating biofuels to compete on a cost effectiveness basis with imports from Brazil or alternative abatement options.

Table 1. Costs per litre of bioethanol and biodiesel

Fuel type	Feedstock	Source of cultivation	Costs (€/1000litre)			
			Production	Distrib'n	Total	Total (energy eq.)
Biodiesel	Oil seeds	US	501	48	549	**632**
		EU15	621	46	667	**766**
Bioethanol	Wood	US	323	45	368	**549**
	Straw	EU15	620	42	662	**988**
	Wheat	EU15	451	42	493	**736**
	Corn	US	235	45	280	**418**
	Sugar cane	Brazil	190	45	235	**351**
	Sugar beet	EU15	513	42	555	**829**

Source: Haydock (2003)

Notes: Costs are for 2002, expressed in 2004 €. Inflation is assumed to equal 1.35% and the exchange rate: €1.429 = £1 (Office for National Statistics, UK, October 2004). Total costs include transport costs.

Table 2. Cost comparison of biofuels with mineral fuels

Biofuel	Biofuel cost €/1000 litres	Fossil fuel pre-tax price €/1000 litres	Cost difference €/1000 litre
Biodiesel	766	409	357
Bioethanol (wheat)	736	372	364
Bioethanol (beet)	829	372	457
Bioethanol (Brazil)	351	372	-21

Note: Fuel prices are weekly spot prices taken for week 8/11/2004 from the EU Oil Bulletin. The fossil fuel pre-tax price is estimated for each country using the fuel price before the individual VAT and excise duty, i.e. pre-tax price = (Market price)/(1+VAT) - (excise duty).
They are then averaged for the EU.

Table 3. Overview of CO_2 emissions savings from biofuels

	Feedstock	CO_2 emissions saved					
		Range		(most likely)		t/1000L (most likely)	
		g/km	%	g/km	%	petrol	diesel
Biodiesel	Oil seed rape	88.5 - 116.4	44 - 66	91.5	52		1.7
Bioethanol	Beet	37.8 - 187.8	16 - 82	125.8	55	1.7	
	Wheat	43.7 - 174.0	19 - 76	155.0	67	2.1	
	Brazil sugar	203 - 209	78 - 81	203.3	78	3.8	

Source: Dutch compilation (van den Broek et al., 2003); Fulton et al. (2004) for Brazil data.

Note: Brazil estimates exclude transport to Europe.

Table 4. Cost of greenhouse gas savings due to substitution of fossil fuel with biofuel

Biofuel	Cost difference €/1000 litre	CO_2 savings t/1000litres	€/tCO_2 saved
Biodiesel	357	1.7	210
Bioethanol (wheat)	364	2.1	174
Bioethanol (beet)	457	1.7	269
Bioethanol (Brazil)	-21	3.8	-6

Notes: The cost difference column comes from table 2 and CO_2 savings column from table 3.

Table 5. Comparison of excise duty to price difference between fossil fuels and biofuels in EU15, €/1000litres.

Country	Petrol cost difference (wheat)	Petrol cost difference (sugarbeet)	Petrol cost difference (Brazil)	Petrol excise duty	Diesel cost difference	Diesel excise duty
Austria	345.0	437.7	-40.6	424.7	333.0	310.1
Belgium	376.1	468.8	-9.5	564.2	340.1	332.9
Denmark	375.1	467.8	-10.5	547.4	386.9	369.9
Finland	379.9	472.6	-5.7	597.3	382.3	346.8
France	411.0	503.6	25.3	589.2	376.9	416.9
Germany	403.2	495.9	17.6	654.0	362.9	470.0
Greece	323.7	416.4	-62.0	296.0	315.4	245.0
Ireland	365.1	457.8	-20.5	443.0	362.3	368.0
Italy	320.8	413.5	-64.8	558.6	338.4	403.2
Luxembourg	349.7	442.3	-36.0	442.1	364.2	252.9
Netherlands	336.3	429.0	-49.3	664.9	358.3	380.4
Portugal	341.5	434.2	-44.1	522.6	325.6	308.3
Spain	341.8	434.5	-43.8	396.0	335.6	294.0
Sweden	381.1	473.8	-4.5	520.8	361.6	362.2
UK	413.4	506.0	27.7	707.2	416.5	707.2
Average	**364.2**	**456.9**	**-21.4**	**528.5**	**357.3**	**371.2**

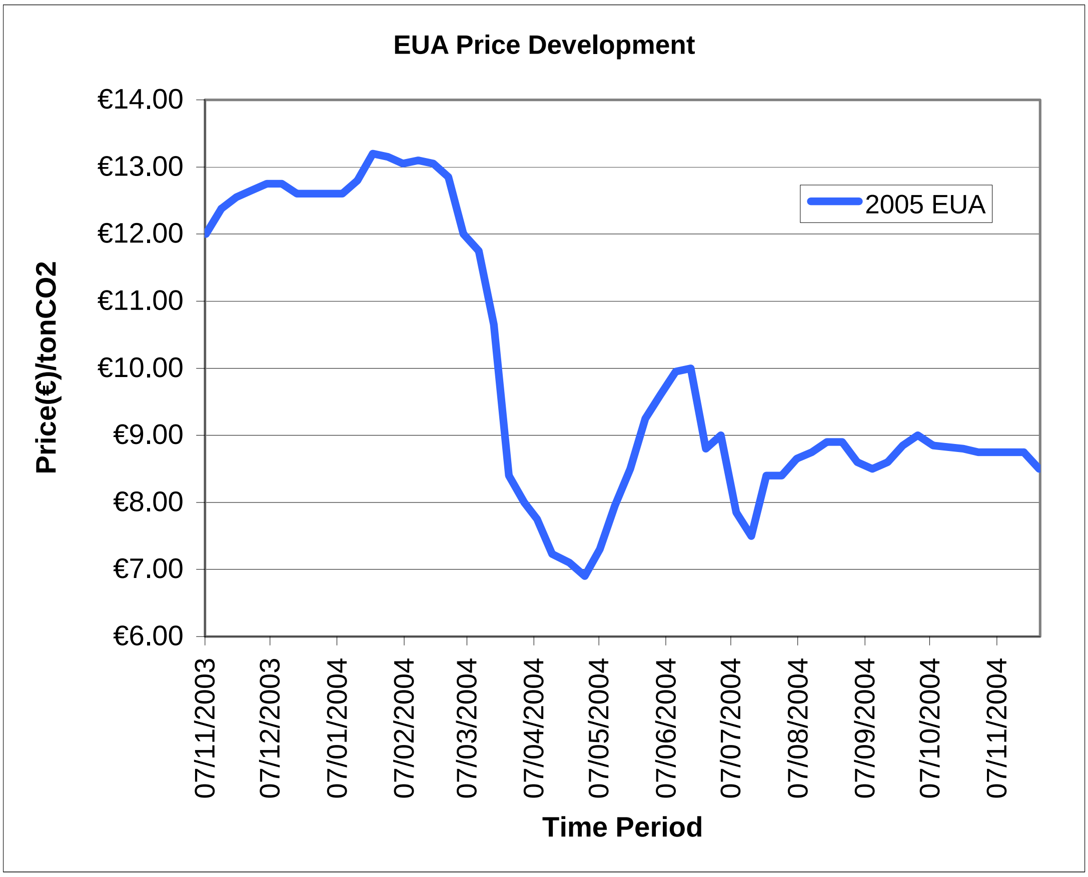
Sources: EU Oil bulletin, 08-11-2004; Haydock (2003).

Table 6. Cost of excise duty exemption for biofuels, EU15 average

Biofuel	**€/t CO2**
Biodiesel	218
Bioethanol (wheat)	252
Bioethanol (beet)	311
Bioethanol (Brazil)	140

Notes: Excise duty cost = average EU15 excise duty for fossil fuel (Table 5)/ CO_2 savings from subsitution with corresponding biofuel.

Figure 1. Price Development of 2005 Vintage European Union Allowance (EUA)



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