GSI Global Subsidies Initiative

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RESEARCH REPORT

Biofuels At What Cost?

A review of costs and benefits of EU biofuel policies

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Bxx	A blend of diesel with xx per cent by volume of biodiesel, e.g., B5 has 5 per cent biodiesel by volume
B100	Pure biodiesel
CAPEX	Capital expenditure
CAP	Common Agricultural Policy
CBA	Cost-benefit analysis
CO_2	Carbon dioxide
CO_2 eq	Carbon dioxide equivalent
DfT	Department for Transport (United Kingdom)
DG AGRI	Directorate-General for Agriculture and Rural Development
EBB	European Biodiesel Board
EC	European Commission
EU	European Union
Exx	A blend of petrol with xx per cent by volume of ethanol, e.g., E15 has 15 per cent ethanol by volume
E100	Pure ethanol
FAO	Food and Agriculture Organization
FEDIOL	Federation of the EU Vegetable Oil and Protein Meal Industry
FQD	Fuel Quality Directive
GDP	Gross domestic product
IEA	International Energy Agency
ILUC	Indirect land use change
IRENA	International Renewable Energy Agency
LPG	Liquefied petroleum gas
MCF	Marginal cost of public funds
MTOE	Million tonnes of oil equivalent
NREAP	National Renewable Energy Action Plan
N2O	Nitrous oxide
OECD	Organisation for Economic Co-operation and Development
OPEX	Operating expenditure
PV	photovoltaic
R&D	Research and development
RED	Renewable Energy Directive
SPS	Single Payment Scheme (of the European Union)
UNCTAD	United Nations Conference on Trade and Development
USDA	United States Department of Agriculture

Conversion Factors

	TONNES	LITRES	SOURCE
Petrol	1	1,362	Department for Transport (DfT), United Kingdom
Diesel	1	1,195	DfT, United Kingdom
Ethanol	1	1,324	Biofuels B2B
Biodiesel	1	1,132	Biofuels B2B
	Tonnes	Tonnes of Oil Equivalent	
Ethanol	1	0.64	Eurostat (2013a)
Biodiesel	1	0.86	Eurostat (2013a)
Energy density			
Ethanol	64.8 per cent of petrol		Eurostat (2013a)
Biodiesel	90.5 per cent of diesel		Eurostat (2013a)

Biofuels—At What Cost?
A review of costs and benefits of EU biofuel policies

1.0 Executive Summary

This report evaluates the principal costs and benefits of the European Union's biofuels industry, based on an assessment of best available information. Depending on the availability of data, some costs and benefits are quantified, while others have not been due to a lack of systematic or disaggregated information. In reality, policy-makers do not always make their decisions based on considerations of the net impacts of given policies on the entire economy or social welfare; hence the approach taken in this report looks at the costs and benefits to key constituencies. The analysis does not look to assess the effect of given policies on the entire economy or social welfare (which can be explored through a classic cost-benefit analysis [CBA]) or cost-effectiveness analysis of policies, but rather adopts a practical approach to assessing costs and benefits as they impact recipient groups.

Key Findings

The report questions the success of EU biofuel policies in meeting the objectives that Member States have set out to achieve—increased energy security, improvements in environmental performance and the generation of additional economic value. The study found that a significant amount of public money, between EUR 9.3 and 10.7 billion in 2011, subsidized the use of conventional biofuels. The main subsidy programs supporting the biofuels industry are (a) market price support (the subsidy conferred to biofuel producers from Member States consumption mandates that provide a guaranteed market for their product and push prices upwards), (b) tax exemptions for biofuels (the full or partial non-application of excise taxes for transport fuels that are fully applied to competing products, gasoline and diesel), and research and development (R&D) grants (promoting the development of biofuel projects or technologies). Support to ethanol and biodiesel is estimated separately in order to determine the levels of support to each product. Dividing the total subsidy estimate for each product (ethanol and biodiesel) by the number of litres consumed for each in the European Union provides an estimate of subsidy per litre. In 2011, ethanol was subsidized between 48 and 54 euro cents per litre and biodiesel at between 44 and 51 euro cents per litre.

The study focuses on the October 17, 2012, European Commission (EC) (European Commission, 2012f) legislative proposal to limit food-based biofuels, counting toward the European Union's 10 per cent target for renewable energy in transport, at 5 per cent—close to the current levels. The report assesses the cost and benefits of allowing unconstrained conventional biofuel consumption to continue. This study finds that the Commission's proposal, if accepted, *will significantly limit the additional costs and benefits associated with moving to a 10 per cent market penetration of food-based biofuels*. The avoided costs are significant and amount to billions of euros per year. The main costs or savings would be:

Expenditure on Subsidies

- Saving between EUR 9.3 and 10.7 billion per year in 2020 if the level of conventional biofuel consumption remained at 5 per cent of energy in transport and didn't increase to meet the 10 per cent target.

- Saving between EUR 4.2 and 4.8 billion per year in 2020 if the level of conventional biofuel consumption was not allowed to increase from 5 per cent of energy in transport to 7 per cent.
- As the costs of subsidizing the biofuels industry is spread across Member State governments, the European Commission and consumers, so would the savings from capping consumption of conventional biofuels. A reduction in the use of excise tax exemptions would be a savings for Member State governments with less revenue foregone. A reduction in research and development (R&D) grants would be a savings for the European Commission. A reduction in consumption mandates would ultimately lead to a savings for motorists using cheaper gasoline and diesel.

For comparison, the cost of the Cyprus economy bailout discussed in March 2013 is EUR 10 billion (Brown, 2013), while the total national government spending in Estonia and Latvia in 2011 amounted to EUR 11.6 billion.[1] In other words, the value of support the EU governments provide to the biofuel industry are comparable to public finances of a small European nation. In the meantime, the economic activity the EU biofuel industry generates is comparable to that of a relatively small European town such as Freiburg in Germany (see Figure 1, "Biofuelbourg," for more comparisons).

Additional Costs to Motorists

- While subject to a number of assumptions relating to future feedstock, biofuel and fossil-fuel prices and availability, the additional costs to motorists of using more expensive ethanol and biodiesel (as replacements for cheaper petrol and diesel) in year 2020 was estimated based on the following scenarios:
  - **(A) 2011 biofuel consumption levels (assuming biofuels contribute to 5 per cent energy in road transport through 2020):** an additional EUR 362 million spent on ethanol and EUR 4.9 billion spent on biodiesel.
  - **(B) EC Impact Assessment projects (assuming biofuels increase from 5 per cent [2012] energy in road transport to 8.5 per cent [2020], or 9.5 per cent by 2020, depending on road energy in transport projections):** an additional EUR 808 million on ethanol and an additional EUR 8.9 billion spent on biodiesel consumption.

Who benefits from the biofuels policy? The study identifies two new key issues:

First, the real beneficiaries of EU biofuel support policies may not be the EU biofuels industry. The benefits of the EU government support to biofuels are increasingly captured by non-EU suppliers rather than the EU farmers. The annual value of the EU biofuel market was EUR 13–16 billion in 2010-2011, of which only about half, if not less, trickled down to the EU farmers growing feedstock crops. Along the value chain the EU biodiesel industry purchased around EUR 3.5 to 4.5 billion worth of crop feedstock from the EU farmers, while the ethanol industry purchased 2.5 to 3.5 billion. Importantly, the EU biodiesel industry also imported about EUR 3 to 4 billion worth of feedstock such as palm oil, soybean oils, oilseeds, etc. The European Union also imported approximately EUR 0.5 billion worth of ethanol feedstock. While the EU farmers growing energy crops often benefit from higher commodity prices and longer-term supply contracts, they have experienced increased competition from foreign feedstock providers. For example, 44 per cent of biodiesel consumed in the European Union was produced using imported feedstock.

[1] The total national budget spending in Estonia amounted to EUR 6.1 billion in 2011, and that of Latvia in the same year was EUR 5.5 billion (Eurostat, 2012).

Secondly, there appears to be incongruence among the value of the biofuel industries' refining assets, the annual subsidy bill, and the overall market size of the industry. The overall investments made in biofuel industry in refining assets in the EU-27 countries is estimated at EUR 6.5 billion and is a bit more than half the cost of the London 2012 Olympics Games.[2] These investments appear relatively small in comparison to the size of the EU biofuels market at EUR 13–16 billion in 2010-2011 and the value of the annual subsidy between EUR 9.3 and 10.7 billion in 2011. In fact, the investment in biofuels production assets in the EU-27 is just a fraction of a single year's subsidy cost.

Are the Policy Objectives Being Met?

We now revisit the three key official objectives justifying the support provided to the EU biofuel industry: (a) reducing carbon emissions from transport, (b) supporting rural development, and (c) improving energy security. The performance of EU biofuel policies against meeting these policy objectives has been controversial and our report shows that, in many instances, the benefits have been marginal, unclear, or require greater monitoring and elaboration.

Climate and Environment Impacts

First, government support for biofuel has been an extremely expensive way to mitigate climate change even if indirect land use change (ILUC) is not taken into account. However, when a central ILUC factor is taken into account, as the European Commission advises, biodiesel no longer delivers any emissions reductions, but rather becomes a fuel that emits 2 million tonnes of CO_2 equivalent (CO_2 eq) emissions more than its fossil-fuel-based equivalent. Ethanol, in this case, does result in emissions savings, but the costs increase to between EUR 432 and EUR 493 per tonne of avoided CO_2 emissions. In the pursuit of environmental benefits, the report identifies increased biofeedstock production in the European Union has resulted in a range of unintended impacts. Based on 2008 data, the area of European land used to grow energy crops to supply biofeedstock to EU biofuel refineries is larger than the area of Belgium or the total agricultural land area of Portugal. Almost an equivalent area outside the EU serves the same purpose of supplying feedstocks to biofuels eventually consumed in the European Union.[3] European water resources consumed for biofeedstock and biofuel production are equivalent to the average annual water discharge of the Seine and Elbe combined.[4]

Rural Development

Secondly, supporting rural development through creating rural jobs, raising EU farmers' incomes, and supporting economic activity in rural and undeveloped areas is another key policy objective. However, the number of people, the duration and quality of jobs due to EU biofuels industry, is unclear and subject to debate. Including direct, indirect and induced jobs based on biofuel production multipliers the number of jobs generated by the industry 2011 was estimated at 121,911. The accuracy and value of job multipliers is questionable, there is no tracking in official EU data on the jobs generated by the biofuels industry. A simple assessment of jobs at EU biofuel production facilities

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[2] The reported cost of the London 2012 Olympic Games was GBP 8.9 billion, or EUR 11 billion at the October 2012 exchange rate (Herman, 2012).

[3] Biofuels consumed in the EU in 2008 have been produced from feedstock growing on land area of approximately 3.6 million hectares in the EU and 3.3 million hectares in other parts of the world (Ecofys et al., 2011).The area of Belgium is 3.1 million hectares and the total agricultural land area of Portugal is 3.3 million hectares (Eurostat, n.d.).

[4] The water footprint of biofuels consumed in the EU was estimated at between 44 and 88 km^3, depending on the crops used and assuming that the share of biofuels in every country would have reached 5.75 per cent of transport fuel consumption in 2010 (Melkko, 2008). The part of European water resources used to this end was estimated at 39km^3. The annual discharge of the Seine is estimated at 15.8 km^3 and the annual discharge of the Elbe at 23.7 km3 (Kempe, Pettine & Cauwet, 1991).

based on 2011 production figures estimated jobs across all EU-27 countries to be 3,630. Based on country-level production figures and attendant jobs, only 31 percent of jobs from ethanol and 35 percent for biodiesel were located in the economically undeveloped Convergence Regions (as classified by the EU). The majority of jobs appeared to be located in EU-27 countries containing the more prosperous Competitiveness and Employment Regions. The robustness of data on green jobs is clearly weak and biofuel employment levels require official monitoring if this is a recognized outcome sought by the European Union in subsidizing the biofuels industry between EUR 9.3 and 10.7 billion per year. In terms of promoting higher farm incomes, if biofuel market support were to be removed in the European Union, farmers' revenues would likely decrease, mainly due to lower prices for agricultural commodities. But, according to the available modelling results, farmers would be able to re-orient some of their sales to external markets—also in the light of the growing global demand for food.

Energy Security

Thirdly, in terms of improving the energy security of the European Union, the role of biofuels has been so far limited. At present, biofuels produced in the EU meet about 4 per cent of the demand for motor fuels (5 per cent if imported biofuels are included; see Section 6.1.4, "Reduced Consumption of Fossil Fuels"). Thus the EU's current biofuel production effectively replaces the output of 2 or 3 large fossil-fuel refineries,[5] reducing EU expenditure on petroleum products by EUR 2.7 billion on gasoline and EUR 8.5 billion on diesel (based on 2012 figures).

What Are the Alternatives?

Viable alternatives are available to EU policy-makers in order to achieve the public policy objectives for which biofuels are subsidized. In terms of emissions savings, the EU's proposed tightening of the current emission standard for passenger vehicles (reducing average fleet emissions from passenger cars from 130 grams of CO_2 per kilometre [g/km] by 2015, to 95 g/km by 2020) provides a viable low-cost policy measure with multiple benefits. The implementation of a 95 gCO_2/km emissions standard by 2020 provides a cost-effective means of abating carbon dioxide (CO_2) compared to subsidizing the production and consumption of biofuel. With estimated additional manufacturing costs to the automotive industry of EUR 1,000 per vehicle to move from the 130 gCO_2/km to the 95 gCO_2/km emissions standard, the cost of abatement is EUR 133 per tonne of CO_2 avoided, nearly 20 times cheaper than the average CO_2 abatement cost for biofuels assuming central ILUC factors. If fuel savings are included in this calculation, there are negative abatement costs (in that money is actually being saved by reducing emissions) of minus EUR 434 per tonne of CO_2 avoided. It also reduces motoring costs (assuming EU average petrol prices with full taxes) from EUR 16,460 to EUR 12,051 for the lifetime of the vehicle, a savings of EUR 4,255[6] per vehicle. A reduction in the use of petroleum products will lead to a reduction in oil consumption, thereby helping reduce the EU's reliance on foreign produced oil. Assessing both direct impacts from increased spending on vehicle technology and indirect impacts that result from lower fuel bills across the economy, research by Cambridge Econometrics & Ricardo-AEA estimated 365,000 net additional jobs would be generated by current EU vehicle low emissions policies (Cambridge Econometrics & Ricardo-AEA, 2013, p. 5)—more than three times higher than the biofuel industry estimates of their own jobs.

The following table contains a summary of the key figures generated as part of this analysis. The table provides a useful overview of the important economic and non-economic costs and benefits identified in the study.

[5] In 2011 the EU produced 3.7 million tonnes of ethanol (substitute for gasoline) and 9.4 million tonnes of biodiesel (substitute for diesel) (US Department of Agriculture, 2012). For comparison, Lithuania's only Mazeikiu Refinery produced 2.8 million tonnes of gasoline and 3.7 million tonnes of diesel in the same year (Statistics Lithuania, 2013).

[6] Fuel savings of 13 years were discounted at a rate of 3.5 per cent.

TABLE ES-1. OVERVIEW OF ECONOMIC AND NON-ECONOMIC COSTS AND BENEFITS.

IMPACT	DATE	KEY FIGURES RELATING TO 2010 – 2011 EU BIOFUEL CONSUMPTION LEVELS	POSITIVE OR NEGATIVE
Economic impacts			
Biofuel-related cash-flows in the EU		• See Figure 2	Neutral
Production costs and market size	2011	• Turnover EUR 14.7 billion • Wholesale value EUR 15.2 billion • EUR 13.6–16.8 billion	Neutral
EU subsidies to the biofuels sector	2011	• Total Subsidy Estimate: EUR 9.3 to 10.7 billion (GSI calculations) • USD 11 billion (IEA, 2012) See Tables 1 and 2 for breakdown of Total Subsidy Estimate • Subsidies to biofeedstock producers EUR 1 billion through the EU Common Agricultural Policy (CAP)	Neutral
Cost to EU biofuels industry from higher feedstock prices	2010 – 2011	• EUR 60 million – 2.2 billion	Negative
Additional costs to EU consumers from higher prices for vegetable oils	2010 – 2011	• Between EUR 100 million and EUR 3.6 billion a year for food	Negative
Impact on the EU's external trade and current account	2010 -2011	• US imports exceed EU exports by a factor of 10-20 (see Figure 16)	Negative
Tax payments generated by the biofuel industry	N/A	• No robust systematic data	Positive
Non-Economic Impacts			
Environmental impacts of EU biofuel policies	2011	• Water footprint - European water resource used for feedstock and biofuel production – 39 km^3	Negative
Employment and EU biofuel policies	2011	Direct, indirect and induced jobs • No robust verifiable jobs estimates	Positive
Reduced consumption of fossil fuels	2011 2020	• 2.7 billion liters of petrol • 8.5 billion liters of diesel • 3.7 billion liters of petrol • 11 billion liters of diesel	Positive
Imported biofeedstocks and biofuels to displace petrol and diesel consumption	2011	• Imports of biodiesel feedstocks – EUR 3-4 billion • Imports of biodiesel – EUR 2-3 billion • Imports of ethanol feedstocks – EUR 0.1 billion • Imports of ethanol – EUR 0.5 billion	Mixed
Technology and innovation spillovers	2007	• R&D Intensity estimated as 3.6-4.5 per cent	Positive
EU biofuel policies and greenhouse gas emissions	2020	Greenhouse gas savings under central ILUC factor: • 4.1 million tonnes of CO_2 eq (or 0.5 per cent of total EU-27 road transport emissions) in 2020 Carbon abatement cost of biofuels: • Ethanol: EUR 432 – 493 per tonne CO_2 avoided (Central ILUC factor) • Biodiesel: No abatement delivered (responsible for emissions increases) • Average biofuel (ethanol and biodiesel) abatement per tonne CO_2 avoided: EUR 2,248 – 2,583 per tonne	Mixed
Political benefits		N/A	
Energy Security	2010 - 2050	While biofuels scored 75 on a scale of 100 for energy security in 2010, Expected to drop to 42 out of 100 by 2050.	Positive

The recommendations that can be drawn from this study suggest that it is advisable for policy-makers at both the EU and national government levels to adopt the following:

- Subsidies to the EU biofuels sector are significant, and insufficiently targeted to support specific objectives.
- In the short term, governments should abstain from introducing new forms of government support to conventional biofuels and replace the rigid biofuel consumption mandates and targets with more flexible arrangements in order not to block interactions between the global markets of biofuels, food, animal-feed and related products during the periods when food supplies are endangered and there is a threat of food price hikes. The adoption of the 5 per cent cap would be a positive step in reducing the linkages between food and energy markets.
- In the middle term, governments should establish and implement a plan for removing national policies that support consumption or production of biofuels that (a) compete with food uses for the same feedstock crops and/or (b) have negative impacts on the environment. *The proposed 5 per cent cap is a step in the right direction, although remaining consumption of most food-based biofuels, in particular biodiesel, still represents significant costs that do not contribute in achieving key policy objectives.*
- In terms of greenhouse gas emission accounting, it is necessary for the European Union to include indirect land use change (ILUC) concerns in biofuel and other bioeconomy-based policies, in order to ensure that public money does not support biofuels that increase CO_2 emissions.
- A European Commission Agency is tasked to monitor and publish accurate data assessing the volume and origin of biofuel imports as well the end-use of key biofuel feedstock commodities such as vegetable oils. Also at the national level, Member States should be encouraged to make the information on the use and sustainability of biofuels publicly available and transparent.
- The European Commission should consider publishing official statistics through Eurostat on the number and types of jobs generated by the EU biofuels sector.
- Agricultural subsidies (in the form of Single Payment Scheme [SPS] payments) to energy crop producers are significant and should be considered as part of any EU consultation process or Impact Assessment to determine the effect of potential policy options.
- Accurate monitoring of changes in cropping patterns within the European Union should be improved to ensure the amount of land being used to grow feedstocks is published in a consistent time series. The European Commission provides greater clarity on the anticipated level of energy projected for road transport by publishing a revised official estimate.
- National Renewable Energy Action Plans (NREAPs) for estimated biofuel consumption should be revised to reflect the 5 per cent cap and to take into account negative impacts of certain biofuels.

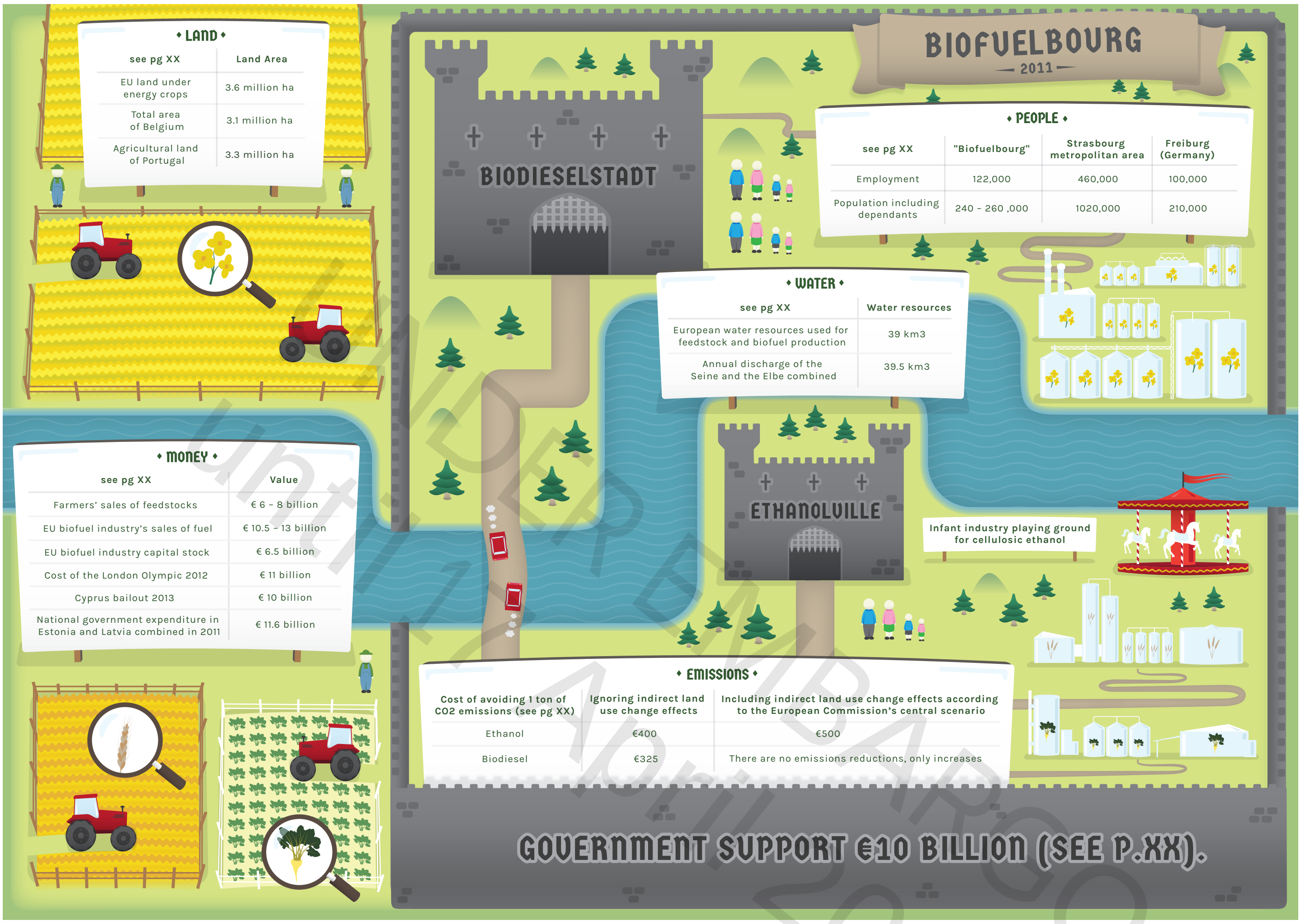


FIGURE 1: IF THE EU BIOFUEL INDUSTRY WERE A TOWN... [DIAGRAM OF BIOFUELBOURG TO BE ADDED]

2.0 Introduction

The unintended impacts of increased biofuel production and consumption are rapidly becoming better understood. Issues around rising food prices and changes in land-use patterns are now the subject of ongoing research, with the results guiding policy development. In response to the 2009 Renewable Energy Directive (Directive 2009/28/EC) (European Commission, 2009a), EU Member States will have to meet a 10 per cent target for renewable energy in transport. This target is now supported with a set of legally binding sustainability criteria for biofuels (in transport) and bioliquids (for heat and power) and a method to calculate the emission savings for different biofuels. However, the issue of ILUC has been a difficult one for the European Union to navigate. Increasing scientific evidence is highlighting the effects that EU biofuel production and consumption is having on land management patterns in the European Union and beyond. Also, in difficult economic times, a greater focus is being placed on the benefits of subsidy policies, with the costs and benefits of the EU biofuels sector subject to more scrutiny in order to ensure public funds are well spent.

The European Union's biofuel policy is at a crossroads, responding to concerns about indirect land use change (ILUC) and the impact of increasing demand for biofuels on prices for agricultural commodities and food products. The European Commission proposed on October 17, 2012, that food-based biofuels could only account for a maximum of 5 per cent of the European Union's 10 per cent target for renewable energy in transport (European Commission, 2012f). This means that food-based biofuels can only account for up to half of the target, as opposed to previously being unconstrained in contributing to the 10 per cent target under earlier arrangements. There is a vigorous ongoing debate over increasing or decreasing this cap.

The EU biofuels industry is predominantly policy-driven, relying on government support in order to secure a share of the road transport fuels market. Support is provided on the basis that biofuels can deliver a range of public goods. Its key policy objectives are (a) reducing greenhouse-gas emissions, (b) promoting the security of energy supply and (c) providing opportunities for employment and regional development, in particular in rural and isolated areas (European Commission, 2009a). To these objectives, one could add a fourth, non-official objective: supporting EU farmers (Sharman & Holmes, 2010). The effectiveness of the EU biofuels industry in meeting these objectives is increasingly being assessed, with additional issues raised such as the competition for food and whether biofuel delivers a sufficient energy return on energy invested ("EROEI") to ever be able to play more than a marginal role in energy supply. The use of government funding or policy to support the biofuels sector, at the same time, should be compared with alternative policy measures.

Strengthening existing policy options is on the table for consideration: the European Union's proposed standard promoting a reduction in CO_2 emissions from passenger cars may potentially deliver emission reductions at a cheaper cost, while potentially creating jobs and economic value and helping to reduce fossil-fuel consumption.

This study aims to help promote a better understanding of the cost-effectiveness of supporting the EU biofuels industry. The objectives of this study are:

- to provide a comprehensive overview of economic and non-economic costs and benefits of the EU biofuel policy and to quantify these costs and benefits where possible, using estimates available from public accounts and the state-of-the-art literature
- to estimate the cost-effectiveness of the EU biofuel policies as a means of achieving the European Union's stated policy objectives
- to compare the effectiveness of supporting the biofuels sector against other policy options
- to provide conclusions and recommendations in a form suitable for policy-makers

3.0 Methodological Section

There are two established analytical frameworks to support the review or revision of policy interventions within the economy: (a) cost-effectiveness analysis, and (b) cost-benefit analysis (CBA). Both techniques are used to rank alternative policy options. In case of cost-effectiveness studies, policy interventions are evaluated based on whether or not they have achieved, or could be expected to achieve the stated objectives at a given cost to the government (Independent Evaluation Group–World Bank, 2007). By contrast, CBA (also known as benefit-cost analysis) looks at the policy intervention's ultimate effect, including all benefits and all costs to all stakeholders, on the entire economy: in other words, a social welfare gain or loss (Dasgupta, Sen & Marglin, 1972). Thus, policy interventions can be compared and the most expedient option can be chosen.

Both techniques measure positive (beneficial) and negative (costly) consequences of a policy intervention in monetary terms. In cases where there are no market values for policy consequences such as, for instance, air pollution or energy-security benefits, a number of auxiliary estimates can be used to obtain a range of monetary values (non-market valuation techniques). The analysis should take into account the spread of costs and benefits over the lifetime of the policy or program and apply an appropriate discount rate. The obtained estimates and ratios of costs and benefits of a certain policy intervention can be compared with those under a scenario of no policy intervention or a different policy intervention. Such comparisons can thus inform a rational choice of the most appropriate policy. One of the most widely known examples of such analysis is the Stern review of costs and benefits of climate change and policy measures to mitigate it or adapt to it (Stern, 2006).

However, many costs and benefits that may be of interest to a particular analysis often lack hard data documentation. With respect to the biofuel policies specifically, data characterizing such phenomena as ILUC or trade in agricultural commodities and biofuels are highly spread and unsystematically reported. Further, it can be difficult to establish a cause-and-effect relationship between a policy intervention and certain positive or negative effects due to the large number of confounding factors. For instance, have new jobs been created or lost due to a policy in question or due to shifts in the structure of the economy?

In such cases, analysts resort to mathematical modelling of economic processes using input-output matrices and partial or general equilibrium models, as well as micro-econometric models. For instance, effects of biofuel policies such as ILUC, impact on prices for agricultural commodities and food products, or job creation need to be modelled, which approximates to reality with different margins of error.

Overall—and the Stern review is a prime example of this—policy evaluation results can almost always be criticized on the grounds of data inaccuracy, modelling deficiencies, inappropriate selection of multipliers, biased scoping of costs and benefits to be included in the analysis, etc. This has often been the case with respect to analysis of costs and benefits of biofuel policies in different parts of the world (EBB, ePure, COCERAL, CIBE, Copa-Cogeca, FEDIOL & EOA, 2012; Niemeyer, 2009). In particular, some studies (Urbanchuk, 2012) emphasize a much more important contribution of the biofuels industry to the economic output and job creation than others (Swenson, 2006).

But in reality, policy-makers do not typically make their decisions based only or even partly on considerations of the net impacts of given policies on the entire economy or social welfare (which can be explored through a classic CBA) or cost-effectiveness analysis of policies. Rather, their choices can be significantly influenced by the expected ensuing costs and benefits to their particular constituencies (Victor, 2009).

Therefore, the approach taken in this report looks at the costs and benefits to each of the constituencies, as presented in Figure 3. In particular, based on previous research (Gerasimchuk, Bridle, Charles & Moerenhout, *Cultivating Governance: Cautionary Tales for Biofuel Policy Reformers*, 2012), we have singled out stakeholder groups such as governments and policy-makers themselves on the one hand, and—on the other hand—their constituencies and interest groups: consumers of fuel (transport companies and private motorists), conventional biofuel producers, advanced biofuel producers, farmers, food and animal feed producers, producers of timber, producers of goods made from natural fibres and oils, fossil-fuel producers, manufacturers of cars and aircraft and other means of transport, renewable energy companies, commodity traders, food consumers, civil society organizations and academia.

Figure 3 uses the Precautionary Principle to interpret both literature and Interviews that IISD undertook from October 2012 to February 2013 to map key stakeholders affected by biofuel subsidies. The Precautionary Principle was applied in the sense that "when an activity raises threats of harm to human health or the environment," such threats and negative effects were given a higher weight than potential benefits even if some cause-and-effect relationships have not been fully established scientifically. The picture uses the colour yellow to designate stakeholders who are positively affected by measures of government support to biofuels and dark red to mark those who are negatively affected. Mixed colours stand for mixed impacts. Box 1, which follows Figure 3, provides a brief narrative explanation of the figure.

It is important to highlight that benefits to one group (e.g., income increases of farmers growing biofuel feedstocks and salaries of the biofuel industry employees) are costs for another (e.g., the biofuel companies and, ultimately, the motorists required to pay more to use biofuels, rather than conventional, petroleum-derived fuels). This idea is also explained in the input-output matrix below, which is broken down by the same stakeholder groups presented in Figure 3. The input-output matrix represents an **average** annual inflow **(per year)** and outflows (represented in EUR billions) for one year based on aggregated data developed as part of this study for 2010-2011 **(an average across both years)**.

INFLOWS TO AGENTS / OUTFLOWS FROM AGENTS	EU HOUSEHOLDS	GOVERNMENTS OF EU STATES	EU BIOFUEL PRODUCERS	EU FARMERS GROWING BIOFUEL FEEDSTOCKS	REST OF THE WORLD
EU HOUSEHOLDS		Not estimated	Wages for onsite employees at EU biofuel refineries = EUR 73–104 million (for comparison: wages for direct, indirect and induced jobs associated with the industry, which are an outflow from different economic agents, amount to EUR 2.4–3.5 billion)	Not estimated	Not estimated
GOVERNMENTS OF EU STATES	Not estimated		Tax revenues from the biofuel industry No quantified estimate	Not estimated	Revenues from the duties on biofuel imports EUR .26 billion Other flows not estimated
EU BIOFUEL PRODUCERS	Sales of EU-produced biofuels to EU consumers EUR 10.5–13 billion	Subsidies (budgetary transfers, tax breaks) EUR 3 billion		None	Not estimated as exports of biofuels from the EU are negligible
EU FARMERS GROWING BIOFUEL FEEDSTOCKS	Not estimated	Subsidies EUR 0.95 billion	Sales of EU-produced feedstock to the EU biofuel industry EUR 6 - 8 billion		Not estimated
REST OF THE WORLD	Sales of imported biofuels to EU consumers EUR 2.5–3.5 billion; a drop in sales of imported diesel by EUR 8.5 billion for diesel. Other flows not estimated	Not estimated	Sales of imported feedstock to EU biofuel producers EUR 3.1–4.1 billion Other flows not estimated	Not estimated as exports of biofuel feedstock from the EU are negligible	Increased value of sales of agricultural commodities to non-biofuel industry consumers – around EUR 2 billion; an increase in gasoline exports from the EU by EUR 2.5 billion due to replacement by ethanol on the EU market; other flows not estimated.

FIGURE 2: INPUT-OUTPUT MATRIX REPRESENTING OUTFLOWS AND INFLOWS FOR AGENTS.

Data, Country Focus and Target Years

This study assesses the biofuels sector at the European level while focusing on a selection of five key countries—France, Germany, Italy, Spain and the United Kingdom—selected due to the size and importance of their biofuel markets and domestic industry. For empirical data used in this study, discrepancies among different data sources have been frequent and even have occurred for yearly biofuel production and consumption figures. Data limitations are discussed in detail in the respective sections of the report. In all cases, the authors have compared different sources of data, paying particular attention to the most frequently cited ones. Eurostat data were generally neither the most readily available nor the most recent. On issues such as biofuel production, consumption and direct jobs, preference was given to the data compiled by the industry associations (EBB, ePure, FEDIOL) and also used by Ecofys and EurObserv'ER.[7]

Other sections of the report, especially those on second-tier employment effects, impacts on agricultural commodity prices, and ILUC, had to rely on modelling studies. In these cases, the authors have reviewed the most frequently cited and recent studies, looking at the range of available estimates of the best available science. When interpreting these estimates for policy, the authors were guided by the Precautionary Principle, which states that "when an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause-and-effect relationships are not fully established scientifically" (Wingspread Consensus Statement on the Precautionary Principle, 1998). This Principle is legally binding for the European Union and has taken the form of Article 191 of the Treaty on the Functioning of the European Union (Consolidated Version of the Treaty on the Functioning of the European Union, 2008).

The year 2011 has been chosen as a reference year for the study, and most of the calculations have been conducted for this year, excluding the cases where this has not been possible due to the lack of data or estimates. In order to convert values from the past years into 2011 money, the World Bank GDP deflator has been used (see Table 1, Technical Annex).

[7] Ecofys and EurObserv'ER are established European consultancies specializing in sustainable energy; they have executed a number of research projects on the EU biofuel policies commissioned by the European Commission, governments of the EU Member States and other stakeholders.

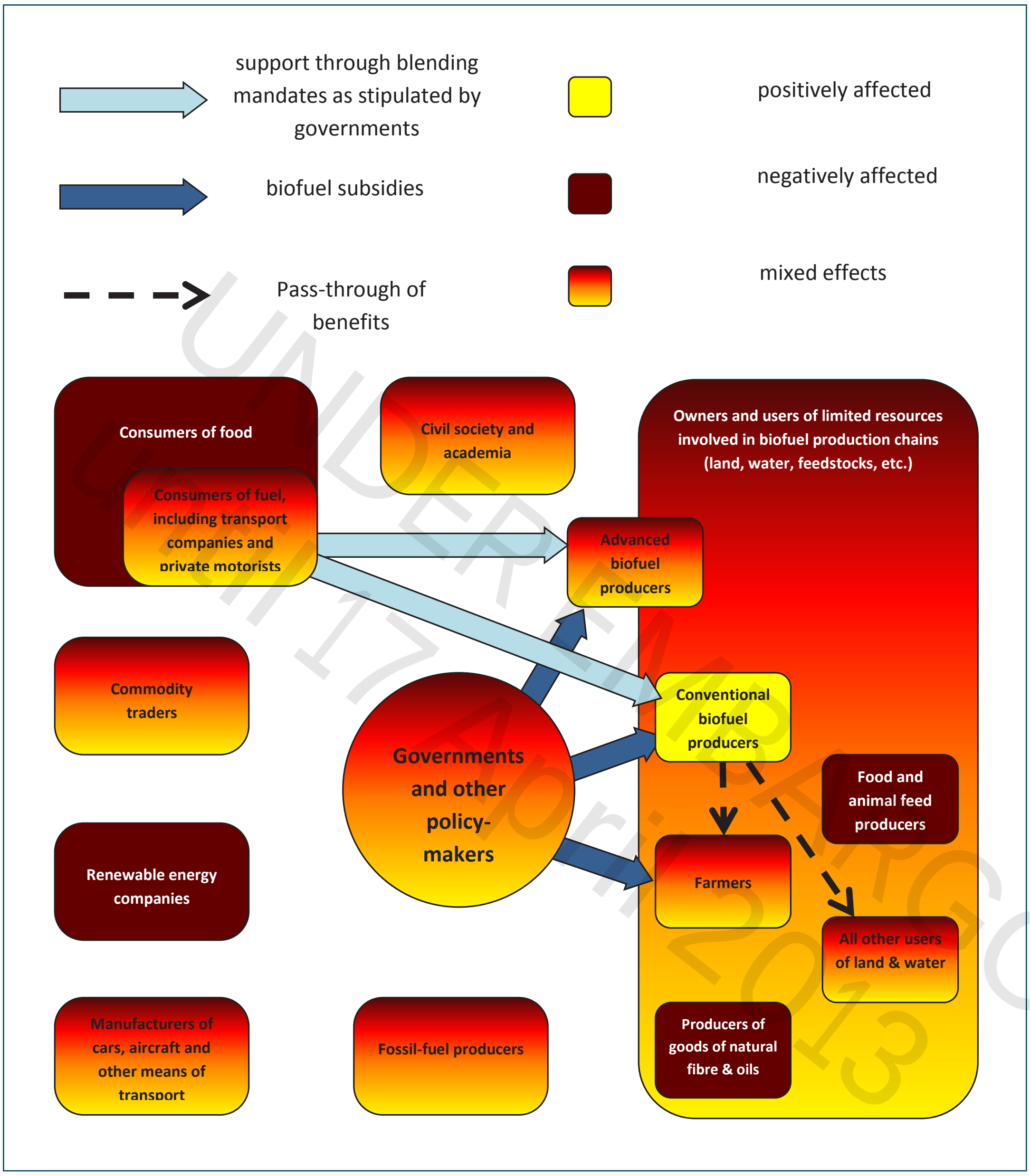


FIGURE 3: THE PRECAUTIONARY PRINCIPLE INTERPRETATION OF POSITIVE, NEGATIVE AND MIXED EFFECTS OF THE EU BIOFUEL POLICIES ON KEY STAKEHOLDERS.

Sources: IISD-GSI visualization based on various interviews (2012), Koplow (2009) and Sharman & Holmes (2010).

Box 1 describes each of the stakeholder groups in more detail.

BOX 1: KEY STAKEHOLDERS WHO ARE AFFECTED BY GOVERNMENT SUPPORT TO BIOFUELS IN POSITIVE, NEGATIVE OR MIXED WAYS.

Conventional (mainly "food-based") biofuel producers are the main intended beneficiaries of government support to biofuels.

Advanced biofuel producers, if not specifically singled out as a target group for biofuel subsidies, may fail to benefit from the measures of government support such as blending mandates, since these benefits will be mostly captured by the more cost-competitive, conventional biofuels, unless mandates are more sophisticated and differentiate between biofuels for example based on greenhouse gas performance.

Farmers benefit directly from biofuel subsidies if they grow biofeedstocks on their own land. In all other cases they may experience mixed impacts. As discussed below in more detail, rising prices for biofuel feedstocks may also trigger growth in prices for other agricultural commodities. However, the increased value of agricultural commodities triggers growth in costs of production factors such as land, fertilizers and water. Further, farmers who keep livestock may bear higher costs of unprocessed animal feed (for example, corn). In the meantime, high-protein processed animal feed such as oilmeals becomes increasingly available as a result of biofuel co-production processes.

Food and animal feed producers, as well as **producers of goods made of natural fibres and oils**, experience negative impacts due to higher costs of agricultural commodities driven by the biofuel market. This group excludes the biofuel companies themselves as these increasingly become producers of animal feed as a co-product of their processing technology.

All other users of land and agricultural production factors and owners of water rights may experience mixed impacts as biofuel subsidies become gradually capitalized in the value of these assets.

All EU citizens may incur some local benefits in terms of emission reductions. However, as consumers of food, they are negatively affected by the rising prices of agricultural commodities driven by the biofuel market. The higher the share of staple and minimally processed foods in their diet (generally, the poorer the consumer), the more severely they are affected.

Consumers of fuel, including transport companies and private motorists, bear the cost of meeting the biofuel mandatory blending requirements.

Producers of fossil (especially petroleum-based) fuels usually lose part of their market to biofuels due to subsidies. But they benefit from the biofuel subsidies' effect of conserving the existing mobility solutions such as private cars rather than innovative approaches such as car-sharing, extended use of bicycles and public transport, and teleconferencing.

Manufacturers of cars, aircraft and other means of transport experience mixed effects from biofuel subsidies, both for technological reasons[8] and depending on whether or not their products are oriented to liquid fuels.

In the eyes of policy-makers, **renewable energy companies** represent alternative recipients of government support aimed at low-carbon energy development. Thus, the more support the biofuel industry receives, the higher the opportunity cost of not supporting renewables.

Commodity traders can largely balance negative and positive price effects.

Governments and other policy-makers experience mixed effects depending on their policy objectives and the composition of their constituencies.

Civil society and academia are an important and very heterogeneous group of stakeholders in the debate. However, their status is quite different from that of other stakeholders, because many members of this group view themselves as representatives of stakeholders outside the European Union, particularly, the developing world's poor or the world's ecosystems. Further, some members of this group receive funding related to biofuel research and outreach work, which ideally should be unbiased, but in practice can also be influenced by other stakeholders.

Source: Gerasimchuk et al. (2012).

[8] For more details see, for instance, the European Automobile Manufacturers Association (2012).

Definitions and Biofuels

The term "biofuel," as used here, refers to liquid and gaseous fuels produced from biomass—organic matter derived from plants or animals. This report focuses on liquid biofuels used as motor fuels only. Its scope thus excludes other bio-energy types such as liquid biofuels and biogas used for electricity generation, and biogas used for motor vehicles.

There is considerable debate on how to classify biofuels depending on whether technology maturity, greenhouse gas emission balance or the feedstock is used to guide the distinction. The International Energy Agency (IEA) divides all biofuels into "conventional" and "advanced" (see Box 2 and Table 1); however, due to the insignificant volumes of advanced biofuels produced in the European Union at present, this report focuses on conventional biofuels only.

BOX 2: THE GENERATIONS OF BIOFUELS.

The IEA uses a definition based on the maturity of a technology, adopting the terms "conventional" and "advanced" for classification. It is important to bear in mind that, on a life-cycle basis, some advanced biofuels can generate higher levels of greenhouse gas emissions and have more negative impacts on land and water use—as well as on biodiversity and local livelihoods—than some conventional biofuels.

Conventional biofuel technologies include well-established processes that are already producing biofuels on a commercial scale. These biofuels, commonly referred to as first-generation technologies, include sugar- and starch-based ethanol, oil-crop-based biodiesel and biojet and straight vegetable oil, as well as biogas derived through anaerobic digestion. Typical feedstocks used in these processes include sugarcane and sugar beets, starch-bearing grains such as corn and wheat, oil crops like rapeseed (canola), soybean and oil palm and, in some cases, animal fats and used cooking oils. Hydrotreating vegetable oils or fats is also now a proven, although still quite an expensive, technology that has so far been used mainly to produce biojet fuel for use in commercial and military jet airplanes.

Advanced biofuel technologies are conversion technologies that are still in the R&D, pilot or demonstration phase, commonly referred to as second- or third-generation technologies. This category includes biofuels based on lignocellulosic biomass, such as cellulosic ethanol, biomass-to-liquids diesel and biosynthetic gas. The category also includes novel technologies that are mainly in the R&D and pilot stages, such as algae-based biofuels and the conversion of sugar into diesel-type biofuels using biological or chemical catalysts.

Sources: IEA (2011); IISD–GSI analysis.

TABLE 1: KEY CHARACTERISTICS OF CONVENTIONAL AND ADVANCED BIOFUELS.

	FEEDSTOCK-TO-FUEL CONVERSION PROCESSES	FEEDSTOCKS	CROPS	LAND USE IMPACTS	WATER RESOURCE IMPACTS
Conventional biofuels (First generation)	• Fermentation • Transesterification • Hydrogenation	• Sugars • Starch • Vegetable oils • Animal fats • Used cooking oil	For Ethanol: • Wheat • Corn • Potatoes • Beet • Sugar cane • Cassava For Biodiesel and biojet: • Palm oil • Soybean • Rapeseed (canola) • Sunflower • Jatropha curcus • Camelina sativa	• Direct use of agricultural land • Indirect land use change • No land take for waste-based biofuels	• Restriction of physical access to water • Reduction of water available • Impoundment of water courses • Change in groundwater depth • Less significant water take for waste-based biofuels
Advanced biofuels (Second/third generation)	• Biochemical • Thermochemical • Hybrid (biorefinery)	• Lignin • Cellulose • Hemi-cellulose	• Woody biomass • Grasses Agricultural by-products • Waste streams • Algae • Seaweed	• Direct use of agricultural land • Indirect land use change • Possible use of marginal / semi-arid land • No land take for waste-based biofuels and some algae and seaweed	• Restriction of physical access to water • Reduction of water available • Impoundment of water courses • Change in groundwater depth • Less significant water take for waste-based biofuels and some algae and seaweed

4.0 The Economics of the EU Biofuels: What Is At Stake?

Biofuel production in Europe has grown significantly since the early 2000s, primarily due to favourable legislation (subsidies and mandates) adopted by national and EU and Member State institutions. In 2010 biodiesel production reached 9,570,000 tonnes (10.8 billion litres) and ethanol production amounted to roughly one-third of that amount, or 3,223,565 tonnes (4.3 billion litres) (ePure, 2012; EBB, 2012). The biofuel industry has developed profound links with other sectors of the EU economy, which are explored further in this section.

Key Findings:

- The value of payments of the EU consumers for the use of biofuels is roughly estimated at EUR 13–16 billion per year over 2010–2011.
- Most of the biofuels purchased are produced in the European Union (however, a large proportion of the feedstock used is imported). In addition, EUR 2–3 billion worth of biodiesel and approximately EUR 0.5 billion worth of ethanol were purchased from outside the European Union.
- •Due to the purchasing of foreign biofuels and feedstocks, only about a half, of the value of biofuel sales in the EU market went to the EU farmers growing feedstock crops.

4.1 The EU Legislative Framework Concerning the Biofuels Industry

In order to promote the use of biofuels among its Member States, the European Union has established several Directives at the supranational level. Among the most important legislative measures regarding biofuels are the Renewable Energy Directive, or RED, 2003/30/EC (European Commission, 2003a); RED 2009/28/EC (European Commission, 2009a); the Energy Taxation Directive 2003/96/EC (European Commission, 2003b); and the Directive on the Quality of Petrol and Diesel Fuels (Fuel Quality Directive, or FQD, 2009/30/EC) (European Commission, 2009b).

On the issue of biofuels, the 2009 RED continued on—and repealed at the same time—the 2003 Biofuels Directive (European Commission, 2003a). Whereas the previous market-share targets for 2010 still remained in force, for 2020 the new Directive set an overall target of 20 per cent for the share of renewable energies among the European Union's final gross consumption and 10 per cent specifically in transport. This overall share of renewable energy varies between Member States but, depending on the current shares and other indicators (such as GDP), individual targets for each Member State have been set by the European Commission, while road energy transport targets are fixed at 10 per cent of renewable energy. Furthermore, the RED and FQD established so-called sustainability criteria for biofuels employed in the Member States. Biofuels not meeting the criteria cannot count toward calculating the share of biofuel or in measuring compliance with the set targets, and are ineligible for financial support.

The contribution from biofuels to the achievement of the 10 per cent transport target of the RED and the 6 per cent target of the FQD is expected to be significant. Biofuels must meet the sustainability criteria of the directives in order to receive support and be counted toward the targets. However, the 2012 Impact Assessment (European Commission, 2012d) showed that a large biofuel demand can lead to land displacement in other parts of the world. Logically, there is a risk that part of the additional demand for biofuels will be met through an increase of land used for agriculture, resulting in land-use change (by changing, e.g., forest into agricultural land) and an increase of greenhouse gas emissions due to land conversion occurring outside of the European Union. This is the so-called ILUC issue and is addressed later on in this paper. This being so, on October 17, 2012, the European Commission (2012f) published a proposal for a Directive amending the 2009 FQD and RED (European Commission, 2009a, 2009b) in order to limit global land conversion for biofuel production; in particular, the use of food-based biofuels to meet the 10 per cent target was proposed to be limited to 5 per cent. This means that, beyond 5 per cent, biofuels from food crops would not be counted toward the 10 per cent target. This means they will likely no longer receive public support, which makes them commercially non-viable in almost all cases.

4.2 Turnover and Market Value

The overall market size for biofuels is not well understood, given the extent of biofuel subsidies; therefore, the public interest in understanding the impact of these subsidies is high. Market size (the total value of transactions) can be estimated from measuring the total production or consumption of biofuels and some measure of the market price. Clean Edge[9] publishes estimates of the market value based on wholesale[10] pricing of ethanol and biodiesel (Pernick, Wilder & Winnie, 2012) at a global level. Estimates of market size from 2005-2011 are shown in Table 2. The data show a rapid increase in the global market, reaching USD 83 billion (EUR 59.3 billion) by 2011.

TABLE 2: GLOBAL MARKET SIZE AS BIOFUEL WHOLESALE MARKET VALUE

YEAR	GLOBAL BIOFUEL WHOLESALE MARKET VALUE (USD BILLION)	GLOBAL BIOFUEL WHOLESALE MARKET VALUE (EUR BILLION)
2005	15.7	12.6
2006	20.5	16.3
2007	25.4	18.5
2008	34.8	23.7
2009	44.9	32.1
2010	56.4	42.5
2011	83	59.6

Source: Pernick, Wilder & Winnie (2012).

Clean Edge does not provide a regional breakdown of their biofuel market estimate, but it is possible to calculate it using a similar approach. To provide a similar estimate of the value of the wholesale market in Europe, wholesale price data from Platts (2013b)[11] for ethanol and biofuels at the EU port of Rotterdam in The Netherlands and biofuels consumption data compiled from EurObserv'ER (2012a) were multiplied together. The results are shown in Table 3 below.

The data indicate a total wholesale biofuel market in Europe of approximately EUR 15.2 billion in 2011. This result is roughly in line with the European share of the global market based on the global estimate of approximately EUR 59.6 billion (see Table 2 above). In 2011 Europe accounted for approximately 19 per cent of global consumption (by volume) (EIA, 2013) and approximately 25 per cent of the value of the wholesale market. The difference in the two numbers may be explained by variations in regional prices.

[9] Clean Edge is a research and advisory firm specializing in the clean tech sector, and publisher of the annual "Clean Energy Trends" report.
[10] The wholesale price is a measure of the average price paid for bulk purchases, normally measured through observation of commodity markets.
[11] Platts is a global provider of energy, petrochemicals and metals information.

TABLE 3: ESTIMATES OF TURNOVER OF THE EU BIOFUELS INDUSTRY.

	2010 (EUR MILLION)			2011 (EUR MILLION)		
	ETHANOL	BIODIESEL	TOTAL	ETHANOL	BIODIESEL	TOTAL
Austria	55	350	405	64	401	465
Belgium	40	238	278	45	314	359
Bulgaria	0	14	14	0	0	0
Cyprus	0	13	13	0	18	18
Czech Republic	50	148	198	55	276	331
Denmark	18	1	18	127	5	132
Estonia	0	0	0	0	0	0
Finland	58	45	103	74	106	180
France	319	1,730	2,049	367	2,340	2,707
Germany	607	1,920	2,527	743	2,460	3,203
Greece	0	107	107	0	119	119
Hungary	46	100	146	51	126	177
Ireland	25	51	76	28	78	105
Italy	126	1,110	1,236	136	1,480	1,616
Latvia	7	16	23	7	39	46
Lithuania	8	30	38	9	41	49
Luxembourg	1	34	35	5	44	49
Malta	0	0	0	0	0	0
Netherlands	108	81	189	138	188	326
Poland	124	676	800	144	986	1,130
Portugal	0	279	279	0	352	352
Romania	58	108	166	67	145	212
Slovakia	32	104	136	37	142	179
Slovenia	2	36	38	4	36	40
Spain	189	1,020	1,209	215	1,660	1,875
Sweden	155	150	305	188	264	452
United Kingdom	256	709	965	306	837	1,143
Total, European Union	2,280	9,070	11,350	2,810	12,400	15,210

Sources: EurObserv'ER (2012a), pp. 48–49; Platts (2013b); author calculations.

Retail prices, the prices that consumers actually pay at the point of sale, are arrived at as a function of wholesale prices, retail costs, distribution costs, market dynamics, the effects of competition for market share and the impact of any subsidies. Due to additional costs and the need for retailers to extract a profit, retail prices are normally higher than wholesale prices. Sufficient data on retail prices were not available to produce an estimate of the value of the retail market.

In addition to the wholesale market for biofuels, a second measure of industry size is the turnover of the biofuel companies. EurObserv'ER publishes turnover estimates for the biofuels industry by country (EurObserv'ER, 2012b). These are shown in Table 4 below and are reported to be compiled from national estimates and EurObserv'ER calculations. Table 4 indicates that in all countries, with the exception of Italy, the market was either stable or rising between 2009 and 2011.

TABLE 4: ESTIMATES OF TURNOVER OF THE EUROPEAN BIOFUELS INDUSTRY.

	2009	2010	2011 *
Germany	2,950	3,050	3,670
France	1,172	2,110	2,450
Italy	1,500	1,318	1,350
Spain	750	950	1,600
United Kingdom	170	170	1,000
Other	5,010	5,683	4,615
European Union	11,552	13,281	14,685

** Note that the 2011 estimate of industry turnover has resulted in a significant change to turnover in the United Kingdom. It is not clear if this estimate reflects a true increase or a change in the calculation method.*

Sources: EurObserv'ER (2012b), EurObserv'ER (2013).

A further indicator that could be used to describe the size of the biofuel market includes the estimated cost of production of biodiesel and ethanol consumed in European countries. This indicator is discussed in more detail in Section 5.1.1.

To summarize the three measurements of market size discussed in this section, the biofuel market in the European Union in 2011 can be described by the following indicators:

a. EUR 14.7 billion by turnover (EurObserv'ER, 2012b)
b. EUR 15.2 billion by wholesale value (EurObserv'ER, 2012a, pp. 48-49; Platts, 2013b; author calculations)
c. EUR 13.6–16.8 billion by production cost (IEA, 2012; author calculations)

The turnover of the EU biofuels sector is estimated to be significantly lower than both the wind and solar photovoltaic (PV) industries. According to EurObserv'ER turnover estimates, including the main economic investment activities of the supply chain such as manufacturing, distribution and installation, but excluding electricity or heat sale, the EU solar PV industry has a turnover of around EUR 46 billion and the EU wind industry EUR 32 billion (EurObserv'ER, 2013). The overall renewable-energy sector activity including wind, PV, solar thermal, small hydropower, geothermal energy, biogas, biofuels, renewable municipal waste and solid biomass, is estimated to be EUR 137 billion. In terms of employment, according to EurObserv'ER, the biofuel sector creates employment for 109,150 FTE positions and is also considerably smaller than the solar PV (312,000) and the wind industry (270,000) (EurObserv'ER, 2013). The credibility of this estimate for the jobs associated with the EU biofuels industry is assessed further in Section 6.1.3, "Employment and EU Biofuel Policies."

4.3 Biofuel-Related Cash Flows in the European Union

In line with the estimates of the EU biofuel market above, the value of payments of EU consumers for the mandated use of biofuels can be roughly estimated at EUR 13 to 16 billion per year over 2010-2011 (representing about 4.5 per cent of EU road fuel use). Most of the biofuels purchased were produced in the European Union, although much of the feedstock is imported. In the meantime, EUR 2 to 3 billion worth of biodiesel and approximately EUR 0.5 billion worth of ethanol were purchased from outside the European Union. The proportions between imported and nationally produced biofuels vary considerably among EU-27 countries. For instance, in Spain the share of biodiesel imported from Argentina and Indonesia was estimated as 89 per cent of domestic consumption in 2011 (APPA Biocarburantes, 2012).

Further along the value chain, the EU biodiesel industry purchased around EUR 3.5 to 4.5 billion worth of crop feedstock from the EU farmers: approximately 80 to 90 per cent of this value was paid for rapeseed and the rest for sunflower seeds, soybeans and some other indigenous feedstocks. The biodiesel industry also uses recycled vegetable oil and tallow as feedstock—these and other feedstock costs of the industry could be approximated at EUR 0.5 billion a year. Importantly, the EU biodiesel industry also imported about EUR 3 to 4 billion worth of feedstock such as palm oil, soybean oils, and oilseeds.

The EU ethanol industry relied mostly on indigenous feedstock worth about EUR 2.5 to 3.5 billion. Sugar beet, wheat and maize each accounted for about quarter of this value. The European Union also imported approximately EUR 0.5 billion worth of ethanol feedstocks.

Thus, due to the purchasing of foreign biofuels and feedstocks, only about a half, if not less, of the value of biofuel sales in the EU market went to the EU farmers growing feedstock crops.

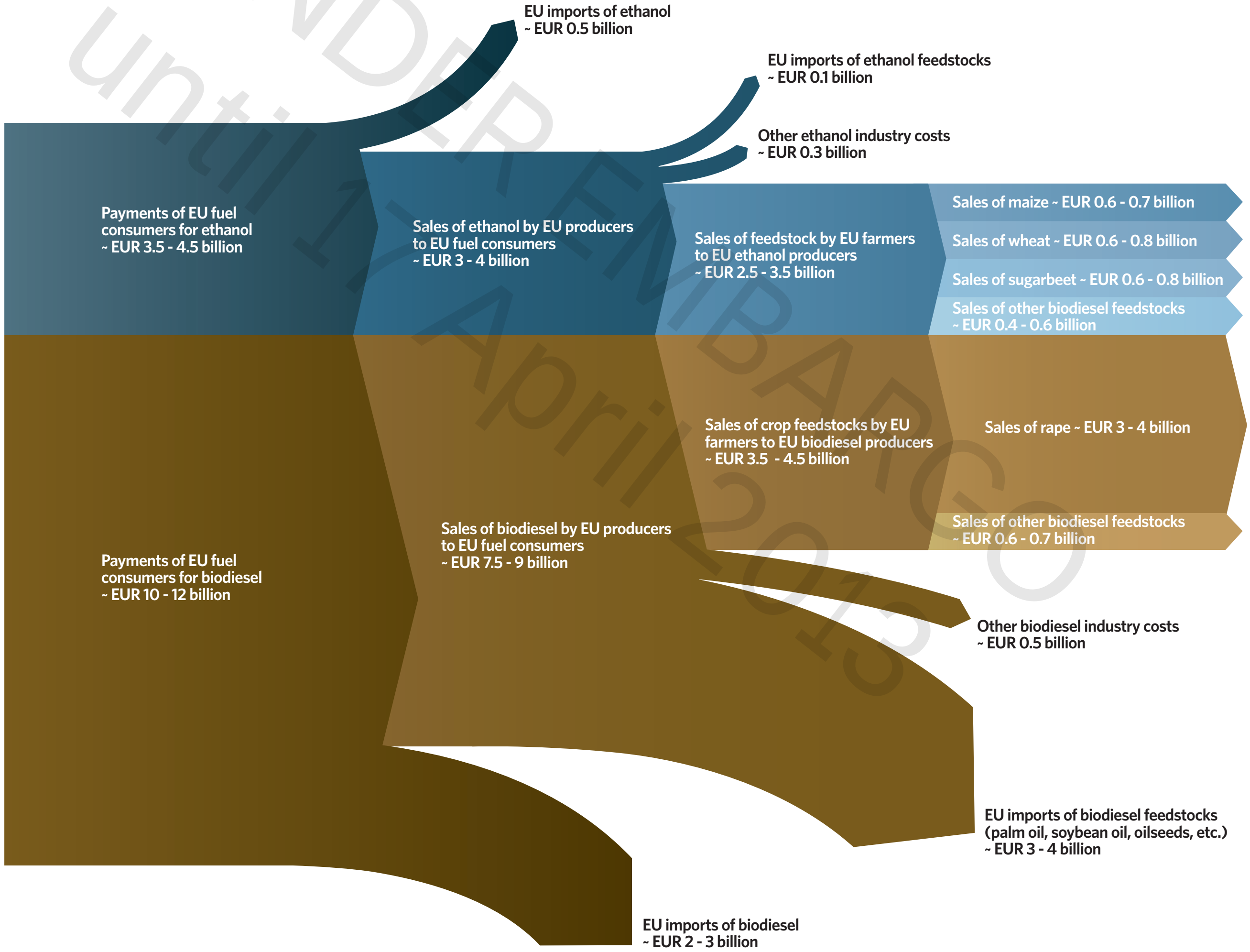


FIGURE 4: BIOFUEL-RELATED CASH FLOWS IN THE EUROPEAN UNION. THIS FIGURE EXPLORES BIOFUEL-RELATED CASH FLOWS AND THE EFFECT OF THE EU BIOFUEL POLICIES ON EU FARMERS. THE FIGURE COMPILES VARIOUS COST ESTIMATES DISCUSSED IN RESPECTIVE SECTIONS OF THIS REPORT.

Source: IISD-GSI estimates based on the discussion contained in this report.

4.4 Opportunity Cost: Foregone Opportunities of Funding Biofuel Subsidies

Like any form of expenditure, biofuel subsidies have an opportunity cost. Funds could instead have been used for other government priorities or taxes lowered to reduce government intervention in the economy.

The opportunity cost of providing a subsidy is not simply its value in euros. In the case of direct subsidies or tax expenditures, governments must raise funding from elsewhere, which imposes an additional cost. The government has three main options for funding the subsidy. It can borrow (internationally or national borrowing), raise additional revenue or reduce spending elsewhere. If the money is borrowed, costs include interest and the effect of drawing savings away from alternative economic uses, or increasing foreign debt. If additional revenue is raised, the main cost is the effect of taxation on society.

The marginal cost of public funds (MCF) measures the loss incurred by society in raising additional revenues to finance government spending (Dahlby, 2008). Estimates of MCF vary widely depending on the way that additional revenue is raised (such as taxes on personal or corporate income on energy), the overall tax burden in the economy and the existence of structural rigidities that may exacerbate distortionary effects (European Commission, 2012h). The cost of EU biofuel subsidies, taking into account MCF, will depend on how funds are raised to pay for them, given a significant amount of support is provided through mandates resulting in the cost of subsidizing biofuels being met by motorists.

5.0 Costs

5.1 Economic Costs

The following sections explore a range of economic costs and a combination of accounting costs, which can be explicitly measured, involving time and other resources and implicit costs. Opportunity cost is also important, recognizing that within an economy investment or economic output could have been generated by using funds and other resources dedicated to action on some other policy objective.

5.1.1 Production Costs

There a great deal of literature estimating the engineering cost of producing biodiesel and bioethanol. The estimates show significant variation in the production cost of biofuels, reflecting the uncertainty of modelling approaches and the wide range of production processes and feedstocks. A summary of studies that have estimated biodiesel production costs is available in the Technical Annex's Table 2, "International Estimates for Production Costs for Biofuels."

The production costs of biofuels include a number of main items. These can be divided into operational costs (OPEX) including raw materials, utilities, labour, supplies and general works (adapted from Haas, McAloon, Yee & Foglia, 2006), and capital costs (CAPEX). In general, for conventional biofuels the cost of servicing the capital costs accounts for a relatively small proportion of total production cost. An illustrative example of the cost of capital as a proportion of production cost is given in Table 6. The table is based on costs per unit of capacity from the GSI survey of biofuel production facilities, an illustrative discount rate and typical global production cost data from the IEA World Energy Outlook (IEA, 2012).

The total production costs of the biofuel consumed in the European Union and in the five countries included in this study are shown in Table 5. To estimate the total production cost of the biofuels consumed in the European Union, typical global values for unit production costs from the IEA World Energy Outlook (IEA, 2012) for conventional biodiesel and ethanol were multiplied by EU consumption figures (EurObserv'ER, 2012a, pp. 48-49).

TABLE 5: PRODUCTION COSTS OF BIOFUELS CONSUMED IN EUROPE.

	ESTIMATED COST OF PRODUCING BIOFUEL FOR THE EU MARKET IN 2011 (EUR MILLION)					
	BIODIESEL		ETHANOL		TOTAL	
	Low	High	Low	High	Low	High
France	2,030	2,220	368	644	2,400	2,870
Germany	2,140	2,340	746	1,310	2,890	3,650
Italy	1,280	1,410	137	239	1,420	1,650
Spain	1,440	1,580	215	377	1,660	1,950
United Kingdom	728	797	307	537	1,030	1,330
EU	10,800	11,900	2,820	4,930	13,600	16,800

	ESTIMATED COST OF PRODUCING BIOFUEL FOR THE EU MARKET IN 2010 (EUR MILLION)					
	BIODIESEL		ETHANOL		TOTAL	
	Low	High	Low	High	Low	High
France	2,020	2,210	370	647	2,390	2,860
Germany	2,230	2,440	705	1,230	2,940	3,680
Italy	1,290	1,420	146	256	1,440	1,670
Spain	1,180	1,300	219	383	1,400	1,680
United Kingdom	825	904	297	520	1,120	1,420
EU	10,600	11,600	2,650	4,640	13,200	16,200

Sources: IEA (2012), author calculations.

The total cost of producing biofuel to meet European consumption in 2011 is estimated to have been between EUR 10.8 and 16.8 billion. This annual production supports the investment in assets, the operational costs (including employment) and the purchase of raw materials.

TABLE 6: PRODUCTION COSTS OF BIOFUELS AND THE COST OF CAPITAL.

	TOTAL PRODUCTION COST (IEA *WORLD ENERGY OUTLOOK*, DATA FOR 2011)		COST PER UNIT OF CAPACITY	ANNUALIZED COST OF CAPITAL	PROPORTION OF PRODUCTION COST AS CAPEX	
	Low	High		10 per cent discount rate	Low	High
	(EUR/litre)		(EUR/litre)		%	
Conventional Ethanol	0.453456	0.793548	0.73	0.06	7.73	13.53
Conventional Biodiesel	0.793548	0.869124	0.25	0.03	2.95	3.23

Sources: IEA (2012), GSI biofuel production facility survey, author calculations.

The finding that a relatively small proportion of the production cost is required to service capital is reflected in the literature. Data obtained following a freedom of information request to the UK Department for Transport (DfT), referring to a model used to estimate the costs of implementing the Fuel Quality Directive, provided an estimate of annualized CAPEX charges as approximately 4 per cent for biodiesel plants and 10 per cent for ethanol plants of operational plants under central fuel-price scenarios. One study (Haas et al., 2006) reviewed the construction and operating costs for a 38 million litres (10 x 106 [million] gallon) scale soybean-based biodiesel plant. The study found a total installed cost of USD 11.4 million (USD 0.30 per litre of capacity) and an overall production cost of USD 0.52/litre, of which just USD 0.03 was required to service capital. Servicing capital costs thus accounted for just 6 per cent of total operating costs. The discount rate used in the above example is a measure of the cost of capital and the risk profile of the project. Projects viewed have higher risk, perhaps due to the likelihood of a forthcoming policy change, and may raise capital at higher a cost, effectively increasing the discount rate and therefore the annualized cost of capital.

The results indicate that the cost of servicing CAPEX investments is not the major cost of production of conventional biofuels. Rather, raw materials by far account for the major cost of biofuel production for both ethanol and biodiesel.

Capital Expenditure (CAPEX)

An expansion in biofuels production requires CAPEX right across the supply chain. The supply chain can be divided into three areas: (1) upstream (feedstock) production and logistics, (2) biofuel production, and (3) downstream distribution and consumption (Vimmerstedt, Bush & Peterson, 2012).

In the upstream area (biofuel feedstock), producers are free to choose to engage with the biofuel market or not. Any specialized equipment may be internalized in the production costs of the feedstocks. The production of biofuels does require new investment for processing the feedstock into fuel, however; this investment cost is discussed below. Finally, upgrades to the downstream infrastructure are required to distribute biofuels, especially ethanol. Where mandates are in place, the cost of additional infrastructure is imposed on the liquid fuels suppliers and reflected in the price charged to consumers. The costs of downstream infrastructure are discussed later in this section.

The expansion of conventional biofuels demand has led to a significant expansion of production capacity in Europe. Biodiesel capacity in Europe has increased from 119 biodiesel plants with a total capacity of 5,806 million tonnes in 2006 to a projected 257 plants with an annual capacity of 24,345 million tonnes in 2012 (US Department of Agriculture, 2012). Advanced biofuel production in Europe is still in its infancy, by comparison. The United States Department of Agriculture (USDA) reports no "advanced" biodiesel production and only three advanced ethanol production facilities, representing 10 million annual litres of installed capacity (US Department of Agriculture, 2012).

The increase in conventional capacity has been made possible by capital investments across Europe. If the European Union wavers in its support for biofuels, it is possible that some of this production capacity may risk becoming "stranded" assets. To understand how much has been invested in biofuel production facilities, the CAPEX per unit of production and the installed capacity were considered.

The sources for estimates of plant CAPEX in the literature can be divided into two types. The first type is derived from engineering estimates for theoretical plants, in which basic plant characteristics are defined and data are obtained from vendors and consultants to estimate the costs of a theoretical plant. Second, surveys can be used to review the actual contract values and published costs from real projects. Table 7 includes projects from a range of sources. It shows a relatively wide spread of CAPEX estimates and indicates that, in general, biodiesel plants require lower capital investment than ethanol plants.

In the literature the range of CAPEX for biodiesel plants was (0.08 - 0.5 EUR/litre) with a mean value of 0.3 EUR/litre and for ethanol plants was (0.41 - 1.05 EUR/litre) with a median value of 0.7 EUR/litre. The range of capital costs found in the literature may be explained by a range of factors, including the availability of finance the contracting structure adopted, the scope (battery limits[12]) of the plant, the complexity of the process and prevailing local market conditions for construction and technology suppliers. A full review of the available literature on the CAPEX costs is available in Table 3 of the Technical Annex.

In addition to the information available in the literature, the Global Subsidies Initiative (GSI) surveyed operational projects in December 2012. The survey reviewed biodiesel and ethanol projects in five of the largest markets in Europe (France, Germany, Italy, Spain and the United Kingdom) to identify sources for CAPEX. The information collected took the form of press releases, information from company websites and direct communications with biofuel producers. Eighty-eight commercial-scale projects, biofuel refining facilities, were identified—of which CAPEX information for 50 plants was located (16 ethanol and 34 biodiesel)—and were reviewed across the five countries that are the focus

[12] Battery limits are the physical limits or interface points of a plant, used for defining the extent of a project or portion of a project.

of this study. In some countries CAPEX information was located for the majority of plants identified, such as Spain and the United Kingdom, while limited information was obtained for Italian refining plants identified (only four of fifteen plants). A map showing the geographic location of the plants identified is shown in Figure 5. The detailed information on the findings from the review is presented in the Technical Annex's Section 5.

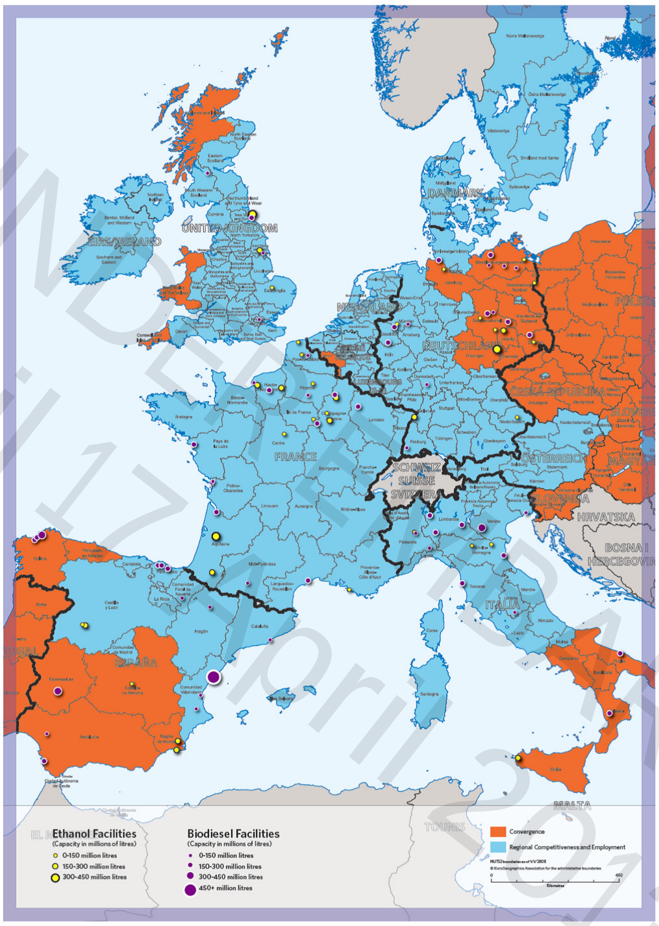


FIGURE 5: BIODIESEL AND ETHANOL PLANTS IN STUDY COUNTRIES.

Source: Global Subsidies Initiative data collection and analysis, European Union.

The locations of biodiesel and ethanol plants in Figure 5 are shown in relation to the European designations for Convergence Regions (where per capita GDP is less than 75 per cent of the European average) and Competitiveness and Development Regions. A variety of factors affect the selection of biofuel refining plants, such as the local road network and employment specialization in the local region. The siting of plants in Convergence areas could potentially indicate that the plants are creating employment in economically disadvantaged areas, providing an additional benefit. It is possible that the agricultural Italian south produces raw feedstocks and the industrial north is where the biofuel is processed, although it is likely agricultural jobs are located near biofuel plants, as feedstocks are sourced locally. In general, there is not a high degree of correlation between the Convergence Regions and the locations of plants, with the exception of Germany, where plants are generally located in the northeast of the country.

A full breakdown of the plants, their locations, installed capacity, year of first operation and CAPEX is contained in Table 4 of the Technical Annex. Further discussion of this is provided in the section on employment (Section 6.1.3). In a number of countries, most notably the United Kingdom, plants are predominantly located at port locations providing direct access to imported feedstocks and export markets.

The survey recorded exclusively the published costs, mainly engineering, procurement and construction (EPC) contract values retrieved from direct communication with the plant operators and press releases from equipment vendors and project developers. The survey reinforced the finding that ethanol plants are more expensive, at least in terms of CAPEX, than biodiesel plants. The CAPEX costs found in the survey are generally higher than those found in the literature; this may be due in part to optimism bias[13] (HM Treasury, 2002), as well as the technologies, regulations and types of feedstock that are prominent in European markets. The study also indicated that within Europe CAPEX costs may vary by country, with generally lower costs observed in Spain and Germany and high costs in France, Italy and the United Kingdom.

TABLE 7: RESULTS OF A SURVEY OF BIOFUEL PRODUCTION PLANTS IN THE EUROPEAN UNION

COUNTRY	TOTAL FACILITIES IDENTIFIED	FACILITIES WITH CAPEX IDENTIFIED (NUMBER)	INSTALLED CAPACITY IDENTIFIED (MILLION LITRES)		TOTAL INVESTMENT IDENTIFIED (EUR MILLION)		COST PER UNIT OF CAPACITY (EUR/LITRE)	
			BIODIESEL	ETHANOL	BIODIESEL	ETHANOL	BIODIESEL	ETHANOL
France	25	9	525.26	1,150.00	184.00	1,068.50	0.35	0.93
Germany	23	16	1,779.50	323.00	392.00	185.90	0.22	0.58
Italy	15	4	849.00		120.00		0.14	
Spain	19	15	3,012.30	259.40	796.00	43.00	0.26	0.17
United Kingdom	6	6	334.17	659.00	105.40	442.00	0.32	0.67
Total	88	50	6,500.23	2,391.40	1,597.40	1,739.40	0.25	0.73

Source: GSI survey of various news media and direction communications with producers.

Installed Capacity

Over the last 10 years the European Union's installed biofuel production capacity has risen from a low base to the 2013 levels of biodiesel (24,265 million litres) and ethanol (8,450 million litres) (US Department of Agriculture, 2012). Increase in production capacity between 2004 and 2008 was generally in excess of demand at that time, with investment driven by EU policy-makers supporting the development of the industry and the 10 per cent renewable-energy-in-transport target formulated by the RED. From 2008, the increase in capacity has slowed significantly and in some cases there has been a drop in capacity as producers cease production in economically infeasible production facilities. Closure or suspension of production of biofuel plants has been reported in Germany (Reuters, 2012), the United Kingdom (Biofuels Digest, 2012) and Spain (Reuters, 2011).

Data for the installed capacity of biofuels were available at national levels for each fuel from the biofuels trade associations (EBB, 2012; ePure, 2012), at national levels for aggregated fuels (Eurostat, 2013b) and at a European level for biodiesel and ethanol (US Department of Agriculture, 2012). National level data were not available by year for ethanol in the figure below (Figure 6); rather, these data from the producer survey are used.

[13] The systematic tendency for project appraisers to be overly optimistic.

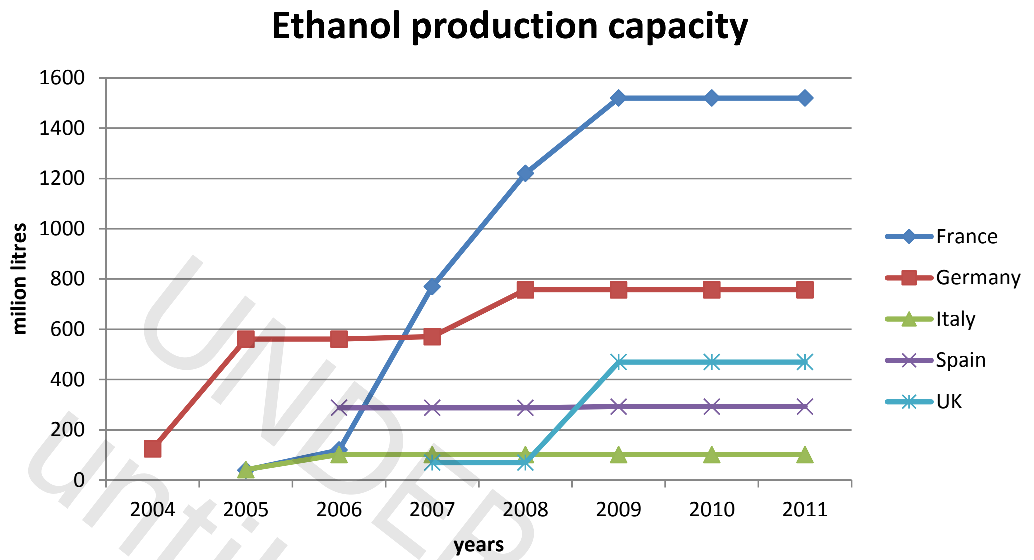


FIGURE 6: CUMULATIVE ETHANOL PRODUCTION CAPACITY IN THE EUROPEAN UNION.

Source: Author's calculations.

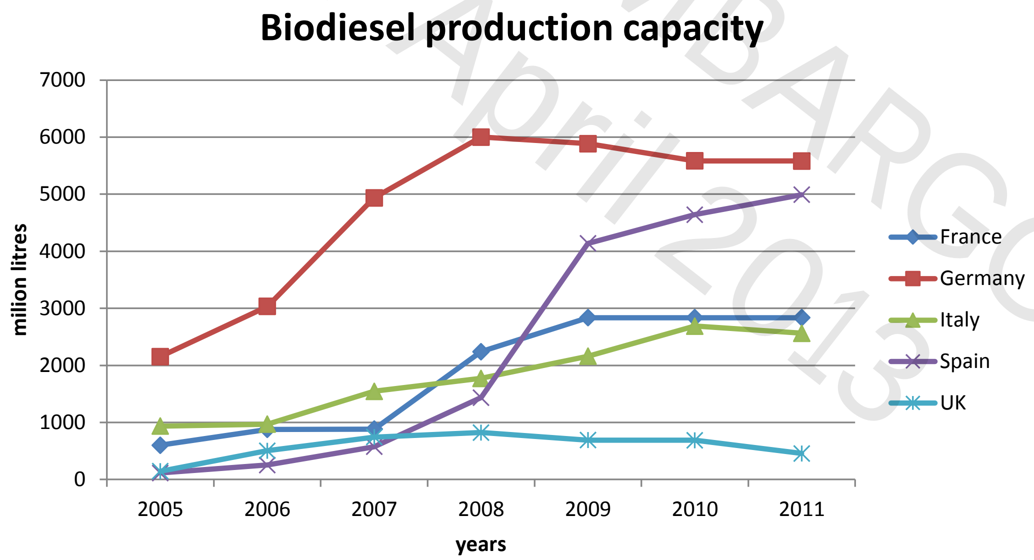


FIGURE 7: CUMULATIVE BIODIESEL PRODUCTION CAPACITY IN THE EUROPEAN UNION.

Source: EBB (2012).

The data presented in Figure 9 show that the rate of capacity installation of biodiesel was highest in Germany in 2007 and in Spain in 2009. By 2009, increases gave way to decreases in Germany and the United Kingdom. In 2011 capacity was also seen to fall in Italy. The data for ethanol are less complete, as they are the result of the survey undertaken by the project team rather than official figures from a trade association.

Investment

An estimate of overall investment (CAPEX) was calculated from the average values for installed cost per unit of capacity, calculated from the project survey (see Technical Annex) and the installed capacity by year (Table 4 in the Technical Annex). Where reported falls in capacity generated negative values of investment, these were ignored. The overall investment in the European Union was found to be EUR 6.5 billion (authors' calculations).

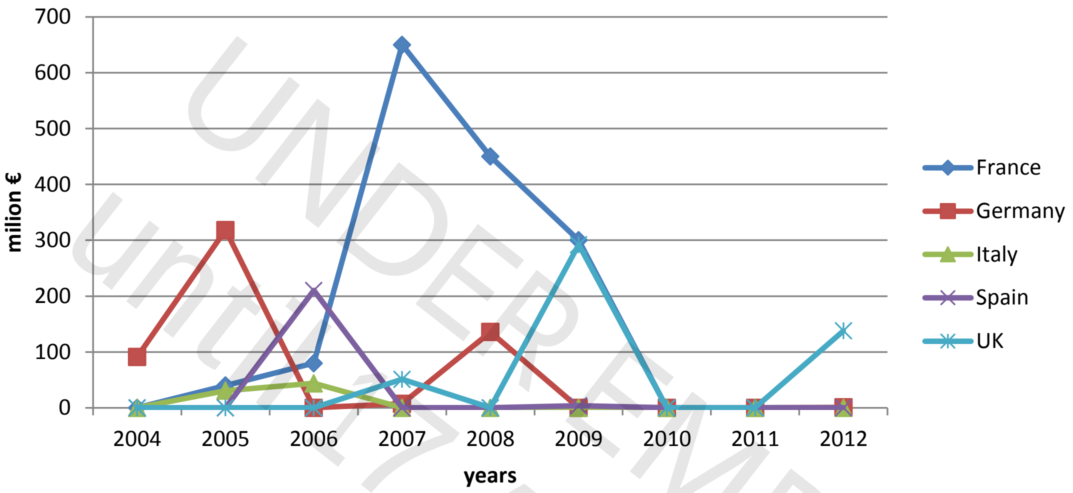


FIGURE 8: ESTIMATED ANNUAL INVESTMENT IN ETHANOL PRODUCTION FACILITIES.

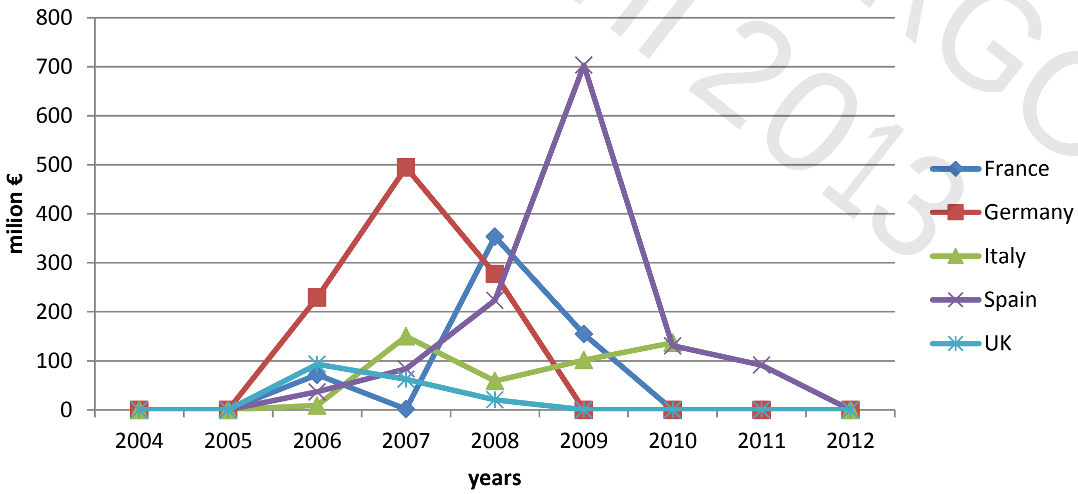


FIGURE 9: ESTIMATED ANNUAL INVESTMENT IN BIODIESEL PRODUCTION FACILITIES.

Discussion of "stranded assets," production facilities that can no longer be operated economically, often involves call from the industry to support demand to ensure that investors are able to receive a return on investment. In addition, a further complication arises in the biofuels industry due to a grandfathering clause, stating that if EU policy is changed by including measures that limit the impacts of indirect land use change (ILUC), support will, with some conditions, continue for operational plants (Ecofys, 2012).

It is by no means clear whether investors in production facilities should be compensated for losses resulting from a lack of competitiveness against imports and changes to support mechanisms. It could be argued that investors are expected to factor business risks into their activities and to act accordingly. Leaving aside for a moment a discussion of whether investments should be protected, it is worthwhile to consider the practicalities of protecting investments. In a recent examination of grandfathering of biofuels investments by Ecofys (2012), a period of cost recovery of approximately 5 to 10 years is suggested. In the cost-recovery period a drop in demand or prices could render production economically infeasible, creating a risk of "stranded assets." However, the actual period of cost recovery depends on the financial structure and financing period of the project. In some cases, projects are refinanced several times, reflecting the value of the underlying business rather than the original capital value of the assets. The notion of cost recovery, where investors and lenders invest at the beginning of a project and wait to recoup their investment, does not reflect the complexity and structure investment in large production facilities.

As discussed in earlier in the paper, serving the debt incurred by an investment in biofuels production facilities represents a relatively small fraction of overall operating costs and, consequently, the cost to the consumer. If the goal of continuing biofuel subsidies is to protect investments, then the continued mandates for biofuel may be an expensive mechanism for protecting a comparatively small quantity of investment. In fact, it would be far cheaper to compensate investors directly than to continue to provide a guaranteed market for the biofuels produced from the facilities.

Plant Utilization Factors

The degree to which the fixed costs and variable costs influence the overall cost of production is influenced by the utilization rate of the plant. Plants with lower utilization rates will see proportionally greater fixed costs. The increase in biofuel production has coincided with a reduction in average plant utilization rates. Plant utilization rates vary across countries given different market conditions. Ethanol plant utilization is reported to have fallen from 89 per cent in 2006 to 61 per cent in 2010 (US Department of Agriculture, 2012). The utilization rate is projected to bounce back slightly to 65 per cent in 2013. Similar falls can be observed in biodiesel utilization, from 55 per cent in 2006 to 47 per cent in 2009. Some countries have seen even lower utilization rates. The rate in Spain was reported to be as low as 14 per cent in 2011, while imports from Argentina alone accounted for nearly 60 per cent of the country's total consumption, prompting Spain to briefly introduce a quota system in order to reduce the imports of biodiesel (US Department of Agriculture, 2012). Across Europe, there may also be differences in utilization rates between Eastern and Western Europe, reflecting the current economics of the industry in these regions. The fall in utilization has been attributed to slackening demand and competitive imports (US Department of Agriculture, 2012). Lower utilization rates indicate declining competitiveness and over-capacity. The reasons for the decline in competitiveness are complex, but since the largest component of operational expenditures (OPEX) is the cost of the raw material (see below), variations in the costs of available feedstocks play a role in production competitiveness. The presence of import tariffs and other duties further influences competitiveness.

Operating and Raw Material Costs

Operational costs include feedstock, maintenance, services, labour, miscellaneous chemicals and working capital (Duncan, 2003). Costs vary according to the plant process, scale and location. The main component of operating cost of conventional, first generation biofuels is the cost of the feedstock itself. Feedstock costs vary depending on type and origin. The majority of biodiesel consumption (58 per cent) and ethanol production (76 per cent) were produced from feedstocks that originated within the European Union in 2008 (Ecofys, 2012).

Recent estimates place the raw material cost at approximately 90 per cent for biodiesel and between 70 and 80 per cent for bioethanol (Table 8).

TABLE 8: RAW MATERIAL COST OF BIOFUEL AND COST OF CAPITAL.

ECOFYS	Biodiesel plant	90%
	Ethanol plant	70-80%
UK DFT FQD model	Biodiesel plant	92%
	Ethanol plant	80%

Source: Ecofys (2012); author calculations.

The high raw material costs and low CAPEX and non-fuel OPEX costs render the biofuel production industry extremely sensitive to changes in feedstock price. As the overall OPEX costs are driven by variable input costs, an increase in feedstock costs or a fall in sale prices can cause production facilities to cease production (Ecofys, 2012).

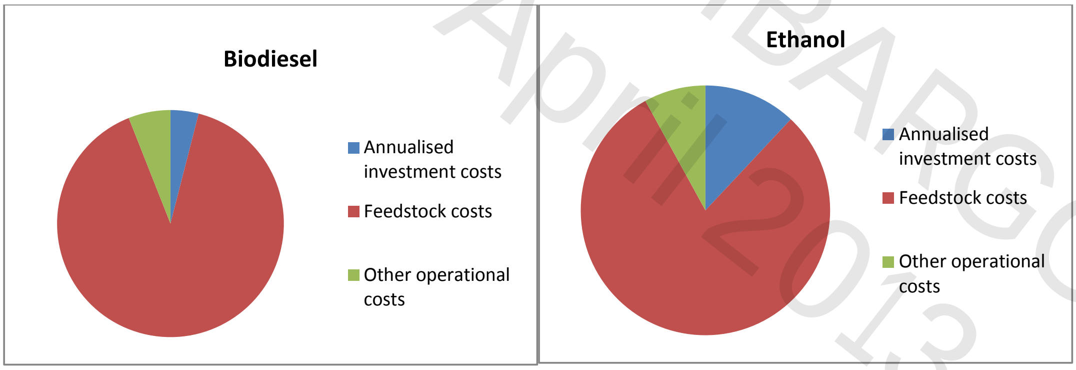


FIGURE 10: INDICATIVE BREAKDOWN OF OPERATING COSTS OF BIOFUEL PRODUCTION FACILITIES.

Investments in Infrastructure Supporting the Distribution and Sale of Biofuels

Increased consumption of biofuels in the European Union will require additional investment in supporting infrastructure to handle the importation and the distribution of both imported and domestically produced biofuels internally within the EU-27 countries. The need for indirect infrastructure (other than biofuel production plants) is an area requiring investigation in order to identify the scale of potential costs and those stakeholders expected to bear them. Additional or modified infrastructure (import terminals, petroleum refineries, storage tanks, etc.) will have to support the distribution of (a) finished biofuels or (b) unfinished product and processing of biofuel feedstocks (AEA, 2011).

With expanded use of biofuels in the European Union, some infrastructure may require new development or modified facilities:

1. **Sites from which biofuels will originate:** for import facilities, an increase in biofuels usage may result in a roughly comparable fall in fossil-fuel volume, so total or excess capacity may not be the most effective indicator. However, import terminals, oil refineries and depots could require costly technical modifications in order to handle biofuels.
2. **Intermediate storage sites (coastal areas or inland):** additional storage tanks will be required depending on where the final grade biofuel is blended, while additional tankage may be required for the blend feedstock or the finished product. In situations where the blend is carried out at a refinery, such as is the current trend for FAME, tanks for feedstock and finished product would be required at the refinery with additional product tanks required at storage terminals, despite there being no increase in overall product throughput.
3. **Transportation and supply-related infrastructure (such as rail, marine and road use)**: some tankers may require that their seals and linings be modified.
4. **Downstream retail fuel supply infrastructure (such as service stations)**: for filling stations to sell four fuel types (diesel, petroleum, bioethanol and biodiesel) there may be a number of additional handling charges, including service station owners installing additional tanks and fuel pumps (Charles & Wooders, 2011).

There are few estimates for the additional cost of this infrastructure at the European level; however, the following estimates for specific countries were available:

» United Kingdom: one off cost of EUR 367 million (GBP 315 million in 2010 prices[14]) to upgrade the UK refinery infrastructure. Costs to be met by the private sector (DfT, 2011a).

» Germany: introducing E10 to German filling stations in 2011 was estimated to have involved one off cost of EUR 133 million.

Key Findings

- In 2011, the annual market value of biofuel production was of the order of EUR 14.7 billion as measured by turnover (EurObserv'ER, 2012b), EUR 15.2 billion by wholesale value (EurObserv'ER, 2012a; Platts, 2013b; author calculations) and EUR 13.6 – 16.8 billion by production cost (IEA, 2012; author calculations).
- The economic activity generated by EUR 6.5 billion of investment capital (the amounted invested to building production facilities) in the European Union is estimated in an earlier section at EUR 10.8 – EUR 16.8 billion in 2011. The GSI estimates the amount of subsidy provided to the EU biofuels sector at EUR 9.3 to 10.7 billion in 2011, while the size of the capital base is estimated at EUR 6.5 billion for the European Union.
- The cost of the biomass feedstock represents approximately 80 to 90 per cent of biofuel production cost. High raw material costs and low CAPEX and non-fuel OPEX costs render the biofuel production industry extremely sensitive to changes in feedstock price.
- Existing infrastructure may have some unused capacity to accommodate some additional biofuels. However, due to the physical characteristics of biofuels, distribution infrastructure (infrastructure other than refining facilities) will require some modification in order to handle higher volumes. The additional costs of this infrastructure are poorly estimated, and the costs will likely need to be met by the private sector and not the government.

[14] Based on average exchange rate for 2010: 1 GBP = 1.1652 EUR (http://www.oanda.com).

- There is pressure to increase or maintain consumption, in part to protect an investment of approximately EUR 6.5 billion in ethanol and biodiesel production facilities in the European Union. In the cost-recovery period a drop in demand or prices could render production economically infeasible, creating a risk of stranded assets. However, the actual period of cost recovery depends on the financial structure and financing period of the project. In some cases projects are refinanced several times, reflecting the value of the underlying business rather than the original capital value of the assets.

5.1.2 EU Subsidies to the Biofuels Sector

Biofuels—both ethanol and biodiesel—benefit from high levels of financial support in almost all EU Member States. This section provides two estimates of subsidies to the sector. The first one, which the majority of the section is dedicated to, involves a bottom-up assessment of all subsidy programs whether or not they have an effect on end-user prices. This approach has been used to measure subsidies by the GSI for years 2010 and 2011. The quantified estimate follows GSI's methodological approach applied previously in studies by Kutas, Linderberg and Steenblik (2007) and Jung, Dörrenberg, Rauch and Thöne (2010). The second estimate is provided by the IEA in its 2012 World Energy Outlook adopting a method that "multiplies the volumes of biofuels consumed by the difference of their cost to the reference price of comparable petroleum-based products" and following a price gap approach estimating the gap between domestic energy prices (IEA, 2012, p. 234).

In 2011, global subsidies to renewable energy (excluding large hydro) were estimated by the IEA at USD 88 billion: solar PV (electricity generation) receiving USD 25 billion and biofuels USD 24 billion, followed by wind energy (USD 21 billion), bio-energy (USD 15 billion), and USD 3 billion to other sources. Based on IEA subsidy figures of USD 11 billion (EUR 8.4 billion[15]) for 2011, the EU biofuel subsidies received 46 per cent of the global subsidies to biofuels and 13 per cent of global subsidies for all forms of renewable energy (IEA, 2012, pp. 234-235).

BOX 3: CONTEXTUALIZING THE NUMBERS—SUBSIDIES TO BIOFUELS COMPARED TO SUBSIDIES TO OTHER ENERGY SOURCES.

All energy sources in the world are subsidized. Historically, the most subsidized energy source is fossil fuels. The International Energy Agency (IEA) estimates that fossil-fuel consumer subsidies in non-OECD [Organisation for Economic Co-operation and Development] countries amounted to USD 523 billion in 2011 (IEA, 2012), while IISD's Global Subsidies Initiative estimates fossil-fuel producer subsidies worldwide at USD 100 billion (APEC Energy Working Group, 2012). These estimates of fossil-fuel subsidy value do not include the non-internalized environmental externalities, first of all the cost of greenhouse gas emissions to the society.

Hence, many countries introduced subsidies to biofuels and renewables aiming to create public goods in the form of carbon emission reductions and to level the "playing field" already distorted by subsidies to fossil fuels. However, as discussed in detail in this report, subsidies to biofuels have only partially delivered against their stated policy objectives, including emissions savings.

Figure 11 below provides existing estimates of the values of subsidies to different energy sources.

[15] Based on average exchange rate for 2011: 1 USD = 0.7661 EUR (http://www.oanda.com).

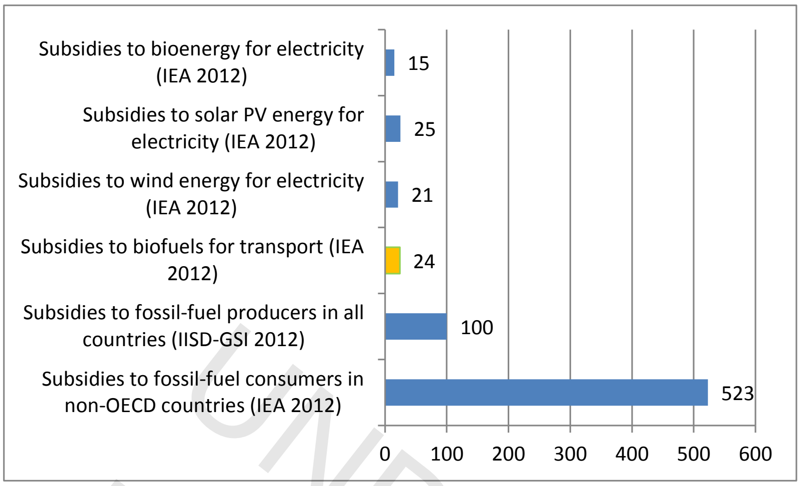


FIGURE 11: ESTIMATES OF SUBSIDIES TO DIFFERENT ENERGY TYPES IN 2011.

Sources: IEA (2012), APEC Energy Working Group (2012).

EU Biofuel Subsidies

The method used by the IEA to calculate the monetary value of government support to the EU biofuels sector estimates the gap between domestic energy prices (for example, oil products such as petrol and diesel) within an economy and world reference prices (or the price for which the energy would be sold without government support programs). The IEA estimates the EU biofuel subsidies to have been at USD 11 billion (EUR 8.4 billion) in 2011 (IEA, 2012, p. 235). This figure varies from the GSI estimate, which is based on valuing individual subsidy programs and a bottom-up approach. The IEA approach is less resource intensive and looks at the overall level of consumption in the EU market, focusing on consumption data and reference prices for biofuels and comparable petroleum based substitutes. The IEA and GSI estimates are not comparable as a result, but are illustrative of the range of estimates that can be developed.

Identifying and measuring the various subsidies is a complex challenge. Often the necessary data are not available, either because Member States do not report on their measures or because official statistical data—for example on trade volumes—are not available. As a result, most figures in this section are under-estimates.

The GSI estimates that in 2010, total transfers in support of biofuels associated with policies of the European Union and Member States amounted to between EUR 6.7 and 7.7 billion. In 2011, the total transfer was approximately between EUR 9.3 and 10.7 billion. This represented an increase from EUR 3 billion estimated in 2008 as presented in the GSI report, *Biofuels—At What Cost? Government Support for Ethanol and Biodiesel in the European Union—2010 Update* (Jung et al., 2010). One reason for the increase in the level of subsidy study in 2010 and 2011, compared to 2008, was the inclusion of a market price support estimate for biodiesel. The quantification of support provided by EU biodiesel consumption mandates and increasing consumption resulted in a higher subsidy estimate.

Based on the estimation methods developed by the Global Subsidies Initiative,[16] the report assessed the following support elements to estimate aggregated measures of support:

- market transfers
- budgetary support linked to the volume produced or consumed
- support for R&D

[16]Compare with Kutas et al. (2007) and Jung et al. (2010).

TABLE 9: TOTAL SUPPORT ESTIMATE FOR ETHANOL

SUPPORT ELEMENT	2010	2011
Market transfers	484 - 751	318 - 736
Market price support (production)	353 - 548	225 - 520
Other market transfers (imports)	130 - 203	93 - 216
Budgetary support (reductions in, or exemptions from, fuel excise tax on volumes produced or consumed)	2,421	2,610
Support for R&D	23	26
Total Support Estimate (TSE)	2,928 – 3,195	2,954 – 3,372
Support per litre consumed (EUR/litre)	0.50 - 0.55	0.48 - 0.54
Consumption (millions of litres)	5,844	6,214

Sources: GSI calculations; Production figures from ePure (2012); World ethanol prices from OECD/FAO (2011); Tax exemptions figures from EU State Aid database and EU Excise Duty Tables, 2011; Support to research and development from FP7 and IEE databases; Consumption figures from EurObserv'ER (2012a).

TABLE 10: TOTAL SUPPORT ESTIMATE FOR BIODIESEL

SUPPORT ELEMENT	2010	2011
Market transfers	215 – 898	3,097 – 4,060
Market price support (production)	146 - 699	2,114 - 2,772
Other market transfers (imports)	69 - 199	983 - 1,288
Budgetary support (Reductions in or exemptions from fuel excise tax on volumes produced or consumed)	3,591	3,194
Support for research and development	23	26
Total Support Estimate (TSE)	3,829 – 4,513	6,317 – 7,280
Support per litre consumed (EUR/litre)	0.27 - 0.33	0.44 - 0.51
Consumption (millions of litres)	13,925	14,272

Sources: GSI calculations; Production figures from EBB (2012); World biodiesel prices from author calculations based on EU Member States Reports; Tax exemptions figures from EU State Aid database and EU Excise Duty Tables, 2011; Support to research and development from FP7 and IEE databases; Consumption figures from EurObserv'ER (2012a).

The following table summarizes subsidies to ethanol and biodiesel for 2010 and 2011.

TABLE 11: SUMMARY OF EU BIOFUEL SUBSIDIES FOR 2010 AND 2011

TOTAL, EUROPEAN UNION	UNITS	2010	2011
Subsidy to Ethanol	€ millions	2,928 - 3,195	2,954 - 3,372
Subsidy to Biodiesel	€ millions	3,829 - 4,513	6,317 - 7,280
Total Subsidy	**€ millions**	**6,757 - 7,707**	**9,271 - 10,652**

Source: Author calculations.

Market transfers: Market price support measures the intervention affecting both consumer and producer prices by artificially elevating the price of biofuels. In the European Union, among the most important instruments are mandatory blending rates and border protection through tariffs. At the moment, Member States are heavily using consumption mandates in order to promote biofuels (European Commission, 2011a). The former establishes mandatory requirements for the share of biofuels in transport fuels sold, whereas the latter aims at protecting European production of biofuels through tariffs on biofuel imports. The value of these measures was EUR 484 to 751 million for ethanol and EUR 215 to 898 million for biodiesel in 2010, and EUR 318 to 736 million for ethanol and EUR 3.1 to 4.1 billion for biodiesel in 2011.

BOX 4: METHODOLOGICAL NOTE ON ESTIMATING THE SUPPORT PROVIDED BY MEMBER STATE CONSUMPTION MANDATES.

Valuing the benefit or subsidy provided to the producer of biofuels from mandates is challenging. A mandate allows biofuel producers to overcome technical or other barriers imposed by primary fuel suppliers, who may object to the use of biofuels, while also providing long(er)-term targets, thus enhancing the predictability of market developments and reducing investment risks. This Box aims to explain the subsidy provided by the consumption mandates from the view point of a theoretical producer of ethanol (whether located inside our outside of the EU region). An ethanol producer will identify the best market to sell their product based on range of factors but principally it will be determined by the price they are able to secure. Prices in the European Union for ethanol (and biodiesel) are higher than average world prices; hence, an ethanol producer will factor in transport costs for their product, and then estimate the profit they could make from selling into the EU market. The higher price for ethanol in the European Union represents demand (and supply) forces and reflects the value of the biofuel consumption mandates introduced by Member States (the consumption mandates help establish a market for biofuels). In previous GSI studies estimating subsidies to the EU biofuels sector (Kutas et al. 2007; Jung, et al. 2010), the value of market price support or "market transfers" to EU ethanol producers was measured (using a price for Brazilian ethanol as a world reference price). The value of consumption mandates implemented by EU Member States in support of ethanol consumption was estimated as the difference between the EU price for ethanol and a world reference price. The value of the mandates is in pushing upwards EU wholesale market prices, hence the benefit to EU biofuel producers. The Total Support Estimate (TSE) for biodiesel in 2010 and 2011 developed for this study now includes an estimate for "market price support" thereby contributing to a significant increase in the overall level of subsidy estimated earlier in 2008 by GSI (EUR 3 billion) (Jung, et al., 2010). In calculating market support in 2011, biodiesel production of 10,710 million litres (EBB, 2012) was multiplied by the price gap of 22 to 28 euro cents per litre (the difference between the EU biodiesel wholesale average price of 90 euro cents per litre[17] [with a sensitivity of minus 7.5 per cent for the reference price, creating a lower bound reference price of 83 euro cents per litre] and the world biodiesel average price of 62 euro cents per litre),[18] minus a small adjustment for freight costs of 4 euro cents per litre for shipping ethanol from Brazil to Europe (personal communications with Brazilian ethanol expert, 2013). The 2011 market price support estimate is significantly more than 2010 due to the spread of the price gap between the EU biodiesel prices and world reference price. Market price support was calculated for ethanol by multiplying 2011 EU production of 4,392 million litres[19] by a price gap of 5 to 12 euro cents per litre (the difference between EU ethanol wholesale average price of 63 euro cents per litre[20] [with a sensitivity of minus 7.5 per cent, creating a lower bound reference price of 58 euro cents per litre] and the world ethanol average price of 47 euro cents per litre[21]). The amount of subsidy estimated is very sensitive to changes in either world or EU reference prices. The higher the EU price (or lower the world reference price) for ethanol or biodiesel, the higher the subsidy provided via consumption mandates.

[17] Source: Platts figures for ethanol and biodiesel traded prices for Rotterdam port (Platts, 2013b).

[18] Source: Assumed international biodiesel price of: 0.8222 USD/litre (converted into 0.62 EUR/litre using the conversion exchange rate of 1 USD = 0.7486 EUR, as of February 15, 2013), retrieved from http://www.ecofys.com/en/publication/international-biodiesel-markets/, Table 3, p. 11.

[19] Source: ePure (2012).

[20] Source: OECD/FAO (2011), variable: "Producer price, local currency/t."

[21] Source: OECD/FAO (2011), variable: "World Price, USD/t"; original price of 0.64 USD/litres converted into 0.47 EUR/litre using the conversion exchange rate of 1 USD = 0.77511 EUR, as of December 10, 2012.

Budgetary support linked to volume produced or consumed: Among all support measures for biofuels, tax exemptions and reductions by far account for the largest share of all support and amounted to around EUR 6 billion in 2010 and EUR 5.8 billion in 2011. One can distinguish between systems without a quota, as employed in most countries, and systems with a quota, as applied in only a few countries—Belgium (European Commission, 2008a), France (European Commission, 2010a), Ireland (European Commission, 2008b), and Italy (European Commission, 2010b). In the latter case, exemptions and reductions are only granted up to a certain level of production. In systems without such a quota, an unlimited amount of consumption benefits from tax exemptions or reductions and thus foregone tax revenue depends highly on the level of consumption.

BOX 5: THE MECHANICS OF BIOFUEL SUBSIDIES IN EUROPE.

The term "subsidy" – with respect to biofuels, other energy types, or any other goods and services – has several definitions and therefore needs an explanation in the context of this report. In layman's terms, the word "subsidy" is often thought to refer only to a direct transfer of funds from a government to a private actor. In contrast, in policy circles the notion of subsidy includes a wide range of preferential treatment—financial and otherwise— that governments provide to consumers and producers on various grounds. Subsidies are often justified as being designed to supply public goods that the market fails to create or as being temporary measures to enable maturation of new technologies and to create a larger market for subsidized products with the objective of reducing their cost and increasing their competitiveness over time (OECD, 1996).

One of the most authoritative "subsidy" definitions is formulated in Article 1 of the Agreement on Subsidies and Countervailing Measures (ASCM), which has been agreed by 155 members of the World Trade Organization (WTO) and covers direct and indirect transfer of funds and liabilities, various forms of tax relief, provision of access to capital, land, water and public infrastructure at below-market rates, as well as market and price support. Importantly, in order to be considered a subsidy, such preferential treatment has to be specific to a company, or industry, compared to other economic agents.

Importantly for the subject matter of this report, the ASCM definition does not include market price support induced through tariffs or mandates. Meanwhile, consumption mandates have become the main policy providing government support to biofuels in many countries.

Therefore, a number of stakeholders and experts, including the International Energy Agency and the Global Subsidies Initiative, consider the market price support enabled by consumption mandates to be a subsidy (Lang, 2010; IEA, 2011). Mandates act in the same way as other subsidy forms, driving up market clearing prices, setting the demand floor and thereby improving competitiveness of biofuel producers (Koplow, 2009).

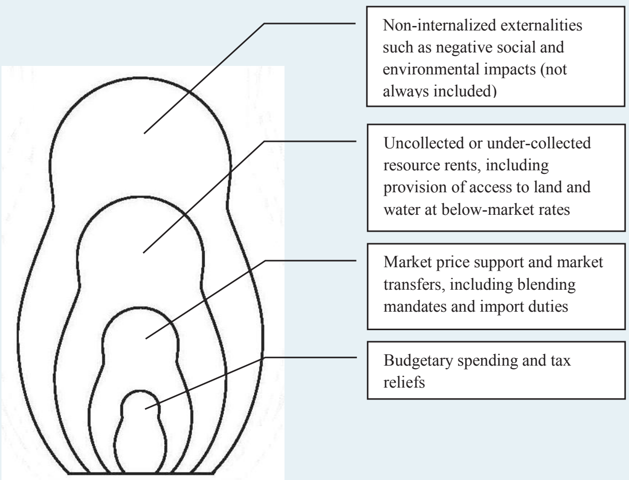


FIGURE 12: THE "NESTING DOLL" OF SUBSIDY DEFINITIONS

Source of Figure 12: IISD-GSI interpretation using OECD (2010).

To summarize, the term "subsidy" can be visualized as a matryoshka nesting doll—at the centre of the definition are ideas that everyone agrees on, but as the definition expands to include other layers, it becomes more complicated and more controversial (see Figure 12).

At the industry facility level though, individual biofuel plants in Europe may be benefitting from different "sets" of government support measures, which may provide more or less preferential treatment vis-à-vis their peers.

The management of Ethanol Europe Renewables (and its subsidiary Pannonia Ethanol) invited the authors of this report to a site visit to their plant in Dunaföldvár, Hungary, in February 2013.

Pannonia Ethanol is the 8th largest ethanol producer in Europe (Sievers & Zubarev, 2012). This case study can be used to illustrate the application of the discussion of the subsidy definition above to the biofuel industry. While the economics of the company is profitable, the success of their operations will rely on the policy-driven demand for biofuel in Europe.

Budgetary spending and tax reliefs.

The ethanol plant in Dunaföldvár has not received any budgetary transfers, such as, for instance, R&D grants. Neither has it received any biofuel industry-specific tax reliefs. Investment into the plant amounted to EUR 152 million raised in market-rate loans from the US Export-Import Bank (Ex-Im Bank), the US Overseas Private Investment Corporation (OPIC) and Cordiant Capital (Chemicals-technology.com). The taxation regime for the plant is very favourable, but this treatment is not specific to the Pannonia plant or the biofuel industry, and thus does not fall under the WTO definition of subsidy. In particular, the local business tax is set at 2 per cent only (as determined by local authorities in accordance with Act C of 1990 on Local Taxes). The plant is also eligible for a Development Tax Benefit (form of state aid) as it is situated in the assisted regions of Hungary. The European Commission authorized the authorities of Hungary to grant EUR 37.2 million (present value) tax relief to Pannonia Ethanol for setting up a plant in Dunaföldvár. The amount of the aid is to be deducted between 2012- 2021 from the corporate income tax (European Commission, 2011b). Pannonia Ethanol does not sell ethanol within Hungary; all fuel is exported to other EU countries. In many European countries ethanol is benefiting from exemptions from excise duties on sales as compared with petrol.

Market price support.

The plant benefits from market price support mechanisms of the country in which the product is sold, such as blending mandates and import duties. It should be noted that both ethanol and gasoline prices in Europe are volatile, and over the past few years ethanol prices in Europe have been both higher and lower than gasoline prices (though ethanol has a lower energy content than gasoline, and price comparisons require a corresponding adjustment). In other words, ethanol has been at times price-competitive with gasoline in Europe (Platts, 2013a). This development has the potential to make government support to ethanol through blending mandates and excise relief (see above) excessive, but there is also another important circumstance: the EU produces more gasoline than it consumes. Thus the EU refineries may need an additional incentive to blend ethanol and gasoline.

Uncollected or under-collected resource rents.

Pannonia Ethanol utilizes land and water on the same conditions as other private industry enterprises in Hungary, thus no subsidy is conferred.

Non-externalized externalities.

Pannonia Ethanol's profile in terms of ILUC is sounder than that of a number of biofuel businesses in Europe (see Section 6.2.2, "EU Biofuel Policies and Greenhouse Gas Emissions"). The plant procures 100 per cent of its feedstock in the form of locally produced corn. At present, corn yields in Hungary are among the lowest in Europe, hence the potential to improve yields is high, which has been one of the major considerations for locating the plant in Hungary. In the future, if yields improve, more corn can be supplied for processing into ethanol without inducing any land change (Sievers & Zubarev, 2012). As a new business unit emitting greenhouse gases, Pannonia Ethanol is also part of the European Emissions Trading Scheme (European Commission, n.d.).

Support for research and development: The European Union and Member States have continued to foster research and development activities in the biofuel field via various programs. Special focus has been on projects concerning second-generation biofuels that, in contrast to first-generation biofuels, are made from non-edible feedstocks such as wood and straw. Total funding was estimated to be at least EUR 46 million for ethanol and biodiesel in 2010 and EUR 52 million in 2011 (source: author's calculations). These rates of support show a sharp decrease compared with 2007 and 2008, but this is mainly due to the fact that the EU support programs (FP7 and IIE II) started in 2007 and will last until 2013 and the majority of them have already run out.

Support related to distribution and consumption: Many Member States have established incentives for supporting the consumption of biofuels other than tax exemptions. Among the most important are: reduced registration fees for high-blend biofuel-compatible cars, free parking, subsidies for filling stations that provide high biofuel blends or pure biofuels, or singular premiums for the purchase of "green" cars. What is more, many governments also try to set "good examples" and make their public car fleets or public transportation vehicles accessible for high blends of biofuels. In addition, a special reduction in reported CO_2 emissions was instituted in the CO_2 and cars Regulation (Article 6) for E85 compatible cars (European Commission, 2012e). These forms of support were not quantified.

Increased consumption and subsidization: The level of support to biofuels derived from many of the key subsidy mechanisms are linked to the volume of biofuels produced and consumed in the European Union. Unless countries implement quota systems that limit the level of foregone revenue or tax exemptions up to a cap, the level of support provided by excise-tax exemptions will rise with the level of consumption in the country. The following scenarios illustrate, using current EU support policies, and assuming biofuels generate 5 per cent energy in road transport, the relative costs of subsidies if biofuel consumption in 2020 were to increase to (a) 7 per cent of energy in EU road transport, and (b) 10 per cent of energy in road transport, by 2020. The business-as-usual scenarios assume linear growth for both ethanol and biodiesel consumption, constant policies, and trade dynamics, and are illustrative of potential future costs as opposed to specific cost projections.

TABLE 12: SUBSIDIES TO ETHANOL AND BIODIESEL ASSUME A LINEAR INCREASE IN ETHANOL CONSUMPTION FROM 2012 FIGURES, SO ETHANOL AND BIODIESEL REPRESENT 7 PER CENT OF ENERGY CONTENT IN ROAD TRANSPORT BY 2020

	2011	2015	2020
Support element Ethanol (all numbers in EUR million)	range	range	range
Market transfers	318-736	459-1,064	636-1,473
Market price support	225-520	325-752	450-1,041
Other market transfers	93-216	134-312	186-432
Budgetary support (Reductions in or exemptions from fuel excise tax on volumes produced or consumed)	2,610	3,770	5,221
Support for research and development	26	38	52
Total Support Estimate Ethanol (TSE)	2,954-3,373	4,267-4,872	5,910-6,745
Support element Biodiesel (all numbers in EUR million)			
Market transfers	3,097-4,060	3,372-4,421	3,716-4,872
Market price support	2,114-3,047	2,302-3,318	2,537-3,656
Other market transfers	983-1,013	1,070-1,103	1,180-1,216
Budgetary support (Reductions in or exemptions from fuel excise tax on volumes produced or consumed)	3,194	3,477	3,832
Support for research and development	26	29	32
Total Support Estimate Biodiesel (TSE)	6,317-7,280	6,879-7,927	7,580-8,736
Total Support to Ethanol and Biodiesel (EUR million per year)	9,272-10,653	11,147-13,335	13,488-15,482
Annual Savings: Not increasing consumption from 5 to 7 per cent		1,875-2,682	4,216-4,829

Notes:

**Assumes ethanol and biodiesel consumption in 2012 equal to 5 per cent in energy content in road transport.*

**Assumes a linear growth for biodiesel and ethanol through to 2020.*

**Key assumptions in measuring Market Transfers are that levels of biofuel imports and exports will remain relatively constant from 2011 onwards. And that average EU biofuel prices and the average Brazilian ethanol price (used as a reference price) and average world Biodiesel price (used as a reference price) will remain constant over time, hence given fluctuations in prices these estimates are subject to significant uncertainty.*

**Key assumptions in measuring and Support linked to volumes produced or consumed are that tax exemption policies implemented in Member States will remain unchanged from 2011 through to 2020. Given excise tax policies can be reviewed annually, and Member States have been amending biofuel excise taxation policies, these estimates are subject to significant uncertainty.*

Assuming biofuels currently contribute 5 per cent of energy in road transport and applying a linear growth of ethanol and biodiesel through to 2020 to meet 7 per cent of energy road transport, the amount of subsidy would increase from EUR 9.3–10.7 billion in 2011, to EUR 13.5–15.5 billion. Capping the conventional biofuels at current levels would save the European Union nearly EUR 4.2–4.8 billion per year in 2020.

TABLE 13: SUBSIDIES TO ETHANOL BIODIESEL ASSUME A LINEAR INCREASE IN ETHANOL CONSUMPTION FROM 2012 FIGURES, SO ETHANOL AND BIODIESEL REPRESENT 10 PER CENT OF ENERGY CONTENT IN ROAD TRANSPORT BY 2020

	2011	2015	2020
Support element Ethanol (all numbers in EUR million)	range	range	range
Market transfers	318-736	459-1,064	636-1,473
Market price support	225-520	325-752	450-1,041
Other market transfers	93-216	134-312	186-432
Budgetary support (Reductions in or exemptions from fuel excise tax on volumes produced or consumed)	2,610	3,770	5,221
Support for research and development	26	38	52
Total Support Estimate (TSE)	2,954-3,373	4,267-4,872	6,545-6,745
Support element Biodiesel (all numbers in EUR million)			
Market transfers	3,097-4,060	4,473-5,865	6,194-8,121
Market price support	2,114-3,047	3,054-4,401	4,228-6,094
Other market transfers	983-1,013	1,420-1,464	1,966-2,027
Budgetary support (Reductions in or exemptions from fuel excise tax on volumes produced or consumed)	3,194	4,613	6,387
Support for research and development	26	38	53
Total Support Estimate Biodiesel (TSE)	6,317-7,280	9,125-10,516	12,634-14,561
Total Support to Ethanol and Biodiesel (EUR million per year)	9,272-10,653	13,393-15,388	18,544-21,306
Annual Savings: Not increasing consumption from 5 to 10 per cent		4,121-4,735	9,272-10,653[a]

[a] Differences in figures to previous estimates may be due to rounding.

Notes:

**Assumes ethanol and biodiesel consumption in 2012 equal to 5 per cent in energy content in road transport.*

**Assumes a linear growth for biodiesel and ethanol through to 2020.*

**Key assumptions in measuring Market Transfers are that levels of biofuel imports and exports will remain relatively constant from 2011 onwards. And that average EU biofuel prices and the average Brazilian ethanol price (used as a reference price) and average world Biodiesel price (used as a reference price) will remain constant over time, hence given fluctuations in prices these estimates are subject to significant uncertainty.*

**Key assumptions in measuring and Support linked to volumes produced or consumed are that tax exemption policies implemented in Member States will remain unchanged from 2011 through to 2020. Given excise tax policies can be reviewed annually, and Member States have been amending biofuel excise taxation policies, these estimates are subject to significant uncertainty.*

Assuming biofuels currently contribute 5 per cent of energy in road transport and applying a linear growth of ethanol and biodiesel through to 2020 to meet 10 per cent of energy road transport, the amount of subsidy would increase from between EUR 9.3 and 10.7 billion in 2011, to between EUR 18.5 and 21.3 billion. Capping the conventional biofuels at current levels would save the EU nearly **EUR 9.3 to 10.7 billion per year in 2020.**

Key Findings

- The Global Subsidies Initiative estimates subsidies at between EUR 6.7 and 7.7 billion in 2010. In 2011, the total transfer was between EUR 9.3 and 10.7 billion.
- The Global Subsidies Initiative has estimated that foregone revenue in the form of tax exemptions is one of the key support mechanisms for both ethanol and biodiesel, with ethanol receiving EUR 2.6 billion in 2011 and biodiesel receiving EUR 3.2 billion that same year.
- The Global Subsidies Initiative has estimated that support provided through consumption mandates came to between EUR 318 and 736 million in 2011 for ethanol; biodiesel received between EUR 3 and 4 billion that same year.
- Based on the IEA's estimate (IEA, 2012) the EU biofuel sector received a significant share of sectorial and global subsidy allocations: 46 per cent of global biofuel subsidies and 13 per cent of all global renewable energy subsidies.
- On a per litre basis, in 2011 ethanol received between EUR 0.48 - 0.54 per litre and biodiesel received EUR 0.44 - 0.51 per litre.
- If 2012 consumption levels for ethanol and biodiesel produced from food based crops were to increase to (these calculations are based on 2011 subsidy policies and trade flows remaining constant over time, hence they are subject to significant uncertainty):
    - 7 per cent of energy content in road transport, the cost to the EU for subsidizing ethanol and biodiesel would theoretically increase from EUR 9.3 to 10.7 billion as estimated by GSI for 2011 to EUR 13.5 - 15.5 billion. The additional cost of not capping current levels of conventional biofuels would be EUR 4.2 - 4.8 billion in 2020.
    - 10 per cent of energy content in road transport, the cost to the EU for subsidizing ethanol and biodiesel would theoretically increase from EUR 9.3 to 10.7 billion as estimated by GSI for 2011 to around EUR 18.5 to 21.3 billion. The additional cost of not capping current levels of conventional biofuels would be EUR 9.3 - 10.7 billion in 2020.

5.1.3 EU Agricultural Subsidies and Biofuel Feedstock Production

The area of the European land used to grow biofuel feedstocks is larger than the area of Belgium or the total agricultural land area of Portugal.[22] Producers of feedstock for biofuels within the European Union are supported indirectly through the Single Payment Scheme (SPS) of the EU Common Agricultural Policy (CAP). In this analysis, SPS payments are considered to include both the Single Farm Payment Scheme (operated by 17 member states) and the transitional Single Area Payment Scheme (used by the other 10 member states). Both schemes provide payments to farmers based on the land used and have been decoupled from production since 2003 (European Parliament, 2010).

Under the SPS scheme, there is thus no direct support in the form of payments to biofuel feedstock, but the areas cultivated for biofuel feedstocks are, like those for food crops, eligible for SPS payments. If there would be no biofuel feedstock production in Europe, it is not certain that overall SPS payments would be lower, as most of the land being used would instead produce crops for feed or food. However, in this case, the subsidy would eventually primarily benefit the food market, while it is now divided between the food market and the bio-energy market. Therefore the Global Subsidies Initiative (GSI) considered it necessary to calculate the share of SPS payments benefiting biofuel feedstock production.

In a similar fashion, it could also be put forward that if the SPS payments would be removed, some decrease in overall agricultural production (food and biofuels) would be observed (contrary to the opinion that mainly expects a decrease in the market value of farmland, or that expects an increase in efficiency to maintain levels of production). In this regard, the SPS payments would currently be benefiting, through monetary support per hectare cultivated, the biofuels industry. For example, one of the reasons for incentivizing biofuel production at the EU level was originally to create a new market for farmers in response to CAP reforms (Gerasimchuk et al., 2012).

The payments provided to biofuel feedstock production are calculated here using the following simple formula:

Hectares used for biofeedstock production per annum x SPS per hectare rate =

SPS payments for biofeedstock production per annum

While hectares used for biofeedstock production are derived from a variety of sources, the average SPS per hectare rates are all taken from the European Parliament (see Table 14; European Parliament, 2010). This source estimates the per-hectare flat rate for each Member State and for the European Union as a whole for the year 2013 (after a number of CAP reforms have been implemented). The number of hectares of arable land used for biofeedstock production may be underestimated in certain cases as a result of a lack of data. Especially for the EU as a whole and for France, data on land use is only available for, respectively, 2008 and 2009. On the other hand, the SPS payments may be overestimated as this calculation does not take account of co-products, as a result of a lack of data.

[22] Biofuels consumed in the EU in 2008 have been produced from feedstock growing on land area of approximately 3.6 million hectares in the EU and 3.3 million hectares in other parts of the world (Ecofys, 2012).The area of Belgium is 3.1 million hectares and the total agricultural land area of Portugal is 3.3 million hectares (Eurostat, n.d.).

TABLE 14: TOTAL SPS PAYMENTS TO AREAS USED FOR BIOFEEDSTOCK PRODUCTION

COUNTRY	HA FEEDSTOCK	YEAR (HA)	AVERAGE (EUR/HA)6	TOTAL (EUR MILLION)
European Union	3,600,000[1]	2008	266	958
France	826,100[2]	2009	310	256
Germany	1,180,000[3]	2010	346	408
Italy	100,000[4]	2010	343	34
United Kingdom	72,918[5]	2010	247	18

Sources: 1. Ecofys, Agra CEAS, Chalmers University, IIASA & Winrock (2011), 2. In Numeri (2012), 3. Government of Federal Republic of Germany (2011), 4. Government of Italy (2011), 5. Government of the United Kingdom (2011), 6. European Parliament (2010).

GSI identified EUR 1 billion in SPS payments to land used for growing biofeedstock in the European Union, based on land-use data from 2008. Of the five countries investigated in this analysis, Germany had the highest SPS payments. In total, almost EUR 410 million was provided to biofeedstock producers, of which most went to rapeseed for biodiesel (940,000 hectares in 2010) (GSI, 2012a). France came in second with support of over EUR 250 million. Other countries, like Spain, Italy and the United Kingdom, have more modest SPS payments (GSI, 2012b). These countries often rely on biofuel or feedstock imports. Some countries, such as the UK since 2008, however, have seen a significant increase in land used for biofeedstock production (GSI, 2012b).

It is well understood that it is controversial to include SPS payments to land used for biofeedstock production as biofuel subsidies. Caution is warranted and consistency required. For example, biofuel interest groups cannot take credit for agricultural jobs while at the same time objecting that SPS payments to biofuel feedstock producers represent biofuel subsidies. In this report, which is critical toward the claim that farmers producing biofeedstock are to be counted toward "biofuel employment," SPS subsidies have not been included in the total support estimate for biofuels.

Key Findings

- An estimated 3.6 million hectares of EU land is used for growing biofuel feedstock in the European Union (Ecofys, Agra CEAS, Chalmers University, IIASA & Winrock, 2011), with approximately EUR 1 billion annually provided to farmers producing biofeedstock.
- Of this EUR 1 billion, around EUR 400 million went to German farmers and EUR 250 million to French farmers. This support is provided to land on which feedstock is grown, an area linked to environmental and trade issues resulting from land-use changes and impacts on food prices.
- While farm payments come directly from the EU budget, the EU does not measure the amount of the EU budget used under the SPS related to biofeedstock production, nor does it consistently collect land-use data. More information collected and made publically available by the EC would be beneficial given the importance of understanding the effect of the CAP on agricultural activities in and outside of the EU. It would also be of assistance in estimating ILUC in different Member States.

5.1.4 Government Revenue Foregone Due to Tax Breaks for Biofuels

Excise Tax Exemptions

Governments can grant specific goods lower duties or tax exemptions as part of a country's fiscal policy system. In the European Union, transport fuels such as petroleum and diesel are charged an excise tax, or duty on their sale. The producer or seller who pays the tax to the government is generally expected to try to recover any increase in the tax (though this will depend on the relative price elasticity of demand and supply) by raising the price of the product. The subsidy provided to biofuel producers through reduced tax rates or excise exemptions is estimated as the amount of excise tax exempted on a per-litre basis in relation to their equivalent products. For ethanol it is petroleum and for biodiesel it is diesel. The policy benefits the biofuels industry, in that their product is made more affordable than cheaper fossil fuels, motorists in that they have access to the fuel at a cheaper price, while it is a cost to government and society (including those not using biofuels) through reduced tax revenues that could be used within the economy on other government priorities.

In the European Union there has been a general trend for countries to phase out excise tax exemptions for biofuels, bringing the level of the tax up to the level charged on petrol and diesel. Please refer to Table 5 in the Technical Annex, "Excise Tax Rates in EU Member States," for a full list of tax exemptions.

Tax exemptions are often cited as way to help reduce the price of biofuels relative to fossil fuels and overcome consumer resistance to their use however when there is a mandatory blending requirement this is unnecessary. Regarding the design of excise-tax exemptions, it is possible to distinguish between systems with and without production quotas. Systems with so-called production quotas grant tax relief on specified volumes. Quotas are intended to limit the amount of foregone tax revenue and hence limit the burden on taxpayers. In systems without a quota, an unlimited amount of consumption is exempted from taxation, meaning the cost to the government increases (Jung et al., 2010).

Assessing the Cost of Excise Tax Exemptions

In order to highlight the burden of tax exemptions on government coffers, the GSI undertook a number of hypothetical calculations to estimate the amount of foregone tax revenue by the Member States if existing tax exemptions for biofuels were maintained through to 2020. There are several caveats, in that tax exemptions may need to be reviewed annually as part of government budget assessments, meaning that Member States could phase out exemptions. They could also look to introduce quota systems in order to limit foregone revenue. Conversely, Member States currently not using tax exemptions for biofuels could decide to introduce them between now and 2020. The following table highlights the costs of maintaining current policy through 2015.

TABLE 15: FOREGONE REVENUE FROM TAX EXEMPTIONS BASED ON CURRENT PRODUCTION LEVELS

	2011	2012	2013	2014	2015	TOTAL
Ethanol (EUR millions)	2,610	2,610	2,610	2,610	2,610	13,052
Biodiesel (EUR millions)	3,194	3,194	3,194	3,194	3,194	15,968
Total (EUR millions)	5,804	5,804	5,804	5,804	5,804	29,020

Source: Author's calculations based on the following. For Ethanol: Consumption figures from EurObserv'ER (2012a), European Commission-DG Taxation and Custom Union (tax duties), EU State-Aid database and Member States reports (tax exemptions); for Biodiesel: Consumption figures from EurObserv'ER (2012a), European Commission-DG Taxation and Custom Union (tax duties), EU State-Aid database and Member States reports (tax exemptions).

**Assumes ethanol and biodiesel consumption in 2012 equal to 5 per cent in energy content in road transport*

Key assumptions in measuring and* ***Support linked to volumes produced or consumed* *are that tax exemption policies implemented in Member States will remain unchanged from 2011 through to 2020. Given excise tax policies can be reviewed annually, and Member States have been amending biofuel excise taxation policies, these* ***estimates are subject to significant uncertainty.***

Key Findings

- Excise-tax exemptions help to reduce the end price differential between biofuels and petroleum products paid by the end consumer. Pre-tax biofuel products cost more than petroleum counterparts. Tax exemptions for biofuels were introduced to overcome that disadvantage and ensure biofuels a more stable market (Transport and Travel Research Ltd., 2009).
- Many EU countries have phased out tax exemptions. Some large producing and/or consuming countries like Finland, France, Germany, Italy, The Netherlands, Spain and the United Kingdom still have differential excise tax rates in place for ethanol, biodiesel or—most often—both. These excise tax exemptions are expensive to government budgets.
- The costs to Member States of maintaining current excise tax exemptions for biofuels (assuming tax exemptions are maintained at 2011 rates and EU consumption levels remains constant) are estimated to be EUR 5.8 billion per year until 2015. The cumulative cost of the policy by 2020 could be EUR 29 billion in foregone revenue. It should be noted there are significant uncertainties regarding this estimate given it assumes a static policy environment and levels of biofuel consumption.

5.1.5 Biofuel Prices and the Additional Costs to Motorists

Biofuels are currently more expensive to produce than fossil fuels, a fact which may result in additional costs at the pump being borne by consumers as consumption mandates lead to (more expensive) biofuels replacing fossil fuels. Though recently, there has been some price parity (on a per litre basis) observed for ethanol and gasoline in Europe. The negative externalities resulting from the use of fossil fuels, such as the environmental damage resulting from their extraction or carbon emissions emitted during their consumption are negative externalities borne by society and generally not reflected in their market price.

This section illustrates the relative costs to motorists of using petrol, diesel, ethanol and biodiesel, the principal transport fuels within the European Union. This is achieved by multiplying the anticipated volumes of biofuels projected to meet future targets (under a range of scenarios) and biofuel production costs, generating estimates of the additional costs of biofuel production, albeit with some important caveats.

BOX 6: COMPARING THE CALORIFIC VALUES OF BIOFUELS AND PETROLEUM PRODUCTS.

The relative calorific values of ethanol and biodiesel against petrol and diesel are as shown in the table below.

FUEL	CALORIFIC VALUE (CV) (MJ/LITRE)	CV AS FRACTION OF PETROLEUM PRODUCT (%)	SHARE OF BIOFUEL REQUIRED TO MEET 10 PER CENT OF PETROLEUM PRODUCT ENERGY CONTENT (%)
Ethanol	21.28	64.8	14.6
Biodiesel	33.10	90.5	10.9

Source of table: Second and third columns from DfT (May, 2011); fourth column, author calculations.

Based on volume, 14.6 per cent of ethanol is required for it to represent 10 per cent of the energy in a blend with petrol. A biodiesel volume of 10.9 per cent is required for it to represent 10 per cent of the energy in a blend with diesel. In both cases, the blended fuel has a lower calorific value per litre than the pure petroleum product, and thus a higher volume of fuel will be required in order for the blended fuel to meet the equivalent energy content. A consequence of the lower calorific value is that, if tax per litre is equal for petroleum products and biofuels, the tax per unit of energy garnered by governments is higher for biofuels (Charles & Wooders, 2011).

Assessing a Range of Biofuel Scenarios

The demand for petroleum products in the European Union has been roughly stable over the past decade, with the European Commission projecting a small decrease in energy used by private cars and motorcycles through to 2030 (European Commission, 2009c, p. 125). This trend will be combined with a steady swift from petroleum- to diesel-powered vehicles (European Automobile Manufacturers Association, 2012). The European Union's 10 per cent renewable-energy-in transport target (by energy) could be met by a range of technologies, with a combination of ethanol and biodiesel included in the mix. Just relying on biofuels to achieve the required targets could theoretically involve 10 per cent by energy for petrol and diesel approximately being met by E15 (i.e., a blend of petrol with 15 per cent ethanol) and B11 (a blend of diesel with 11 per cent biodiesel). Current blends hover around 5.2 per cent (EsseCommunity, 2013).

To explore the potential costs of different combinations of biofuels in response to EU biofuel policies the following scenarios were adopted by the GSI in this study:

- Scenario A: biofuel consumption remaining at current levels of around 5 per cent energy content in transport through until 2020 (EurObserv'ER, 2012a).
- Scenario B: starting from current consumption levels following projected biofuel consumption outlined in the EC Impact Assessment projecting increases to 10 per cent energy content in transport through 2020.

Biofuel and Petroleum Price Assumptions

The future costs of biofuels and petroleum products out to 2020 were drawn from a model used (as an internal tool) by the United Kingdom's Department for Transport (DfT)[23] for assessing the impacts[24] of biofuels in implementing the EU's Fuel Quality Directive for the years 2010 to 2020. The projected biofuel prices used are anticipated wholesale market-based prices (as applied to final retail prices paid by consumers) applied to EU consumption estimates. Based on the model's central biofuel (and petroleum products) scenario:

- in 2013, bioethanol is projected to be EUR 0.16[25] per litre more expensive than the petrol it displaces, becoming cheaper out to 2020 with the price differential closing to EUR 0.06 per litre.
- in 2013, biodiesel is projected to be EUR 0.37 per litre more expensive than the diesel it displaces, with the price differential reducing slightly to EUR 0.34 per litre in 2020.[26]

The models projections need to be balanced against the intrinsic challenges in expecting long term changes in prices, price responses and technology or the development of society, whether in response to international commodity or fuel markets (see Charles [2013] for a critique of the model's assumptions). While the underlying macroeconomic assumptions of the model (such as feedstock costs, future prices for oil) can vary over time the projected fuel prices allow for a comparison of the additional costs paid by motorists from using biofuels in the European Union.

[23] The DfT supplied IISD, under the terms of the Environmental Information Regulations 2004, with a copy of a model it used to estimate the impacts of implementing the Fuel Quality Directive (DfT, 2011b; referred to in this report as the "FQD Model").

[24] The DfT's 2009 Impact Assessment notes that it has been biodiesel that has met the majority of the United Kingdom's biofuel demand to date, but expects that ethanol will become cheaper going forward.

[25] Conversion rate (February, 2013): 1 GBP = 1.18 EURs

[26] The projections made by the United Kingdom's DfT implicitly assume perfect market conditions, notably that there will be feedstock available to scale up biofuel production within and for the United Kingdom and for all other countries across the world, and that investors will be sufficiently attracted to build new biofuel production facilities in the quantities required.

The following table sets out the projected wholesale prices modelled by the United Kingdom's DfT FQD model[27] from 2013 to 2020, for ethanol, petrol, biodiesel and diesel. The rows labelled "price differential per litre" represent the difference in price per litre between ethanol and petrol, and biodiesel and diesel. The price differential per litre (in euro cents) represents the additional cost per litre of consuming ethanol and biodiesel, instead of petrol and diesel. The values are not adjusted for energy and are on a per-litre basis, they do not include final taxes or duties, and it is assumed the additional costs of biofuels are passed through to the consumers in a competitive fuels markets.

TABLE 16: PROJECTED WHOLESALE PRICES MODELLED BY THE UK'S DEPARTMENT FOR TRANSPORTS FQD MODEL[28] FROM 2013 TO 2020, FOR ETHANOL, PETROL, BIODIESEL AND DIESEL.

CENTRAL SCENARIO – WHOLESALE PRICE PROJECTIONS FOR ETHANOL, PETROL, BIODIESEL AND DIESEL									
		2013	2014	2015	2016	2017	2018	2019	2020
Central Petrol Price Scenario	(euro cents per litre)	43	44	44	45	45	46	46	47
Central Ethanol Price Scenario	(euro cents per litre)	59	60	60	58	56	55	53	52
Price differential per litre	(euro cents per litre)	16	17	16	13	11	09	07	06
Central Diesel Price Scenario	(euro cents per litre)	47	48	48	49	49	50	50	51
Central Biodiesel Price Scenario	(euro cents per litre)	85	84	84	84	83	84	83	85
Price differential per litre	(euro cents per litre)	37	36	36	35	33	34	33	34

Source: FQD model provided to IISD (DfT, 2011b).

In the following table, the wholesale "price differentials per litre" (for ethanol versus gasoline, and biodiesel versus diesel) are multiplied across a number of biofuel transport fuel consumption scenarios through 2020. It should be noted, both the cost of biofuels, fossil-fuels, and consumption patterns are projected into the future based on a range factors with the real outcome likely to differ. The calculations in Table 17 do not account for different excise-tax regimes applied to the petrol, diesel, ethanol or biodiesel, and don't reflect final retail prices paid by motorists.[29]

[27] Biofuel retail prices for years 2010 (starting January) to 2012 (November) from the DfT's (2011b) FQD model: The FQD model provides price projections across a range of price scenarios—Low, Central, High, and High High—based on a range of cost assumption for inputs such as fossil fuels and biofeedstocks.

[28] Biofuel retail prices for years 2010 (starting January) to 2012 (November) from the DfT's FQD model: The FQD model provides price projections across a range of price scenarios—Low, Central, High, and High High—based on a range of cost assumption for inputs such as fossil fuels and biofeedstocks.

[29] Retail market price data for biofuels is difficult to obtain; final retail prices will vary across Member States depending on duties or taxes. Retail prices also represent a complex mix of transport costs (distributing biofuels from a wholesale point of distribution, such as an EU port, to the point of retail such as a service station) and individual company profit margins.

TABLE 17: THE COSTS OF BIOFUELS TO MOTORISTS UNDER A NUMBER OF CONSUMPTION SCENARIOS (BASED ON WHOLESALE PRICES WITH NO TAXES APPLIED)

YEARS		2013	2014	2015	2016	2017	2018	2019	2020
Current Production level 2011 (5 per cent)	Ethanol (EUR million)	1,011	1,040	995	827	690	573	452	362
	Biodiesel (EUR million)	5,349	5,160	5,076	4,975	4,778	4,802	4,678	4,870
	Total (EUR million)	6,360	6,200	6,071	5,801	5,468	5,376	5,130	5,232
EC Impact Assessment to 2020	Ethanol (EUR million)	1,167	1,360	1,455	1,335	1,220	1,102	938	808
	Biodiesel (EUR million)	5,902	6,226	6,648	7,030	7,245	7,778	8,059	8,893
	Total	7,068	,586	8,103	8,365	8,466	8,880	8,998	9,701

Notes:

**Scenario A is based on 2011 consumption figures remaining constant through to 2020.*

**Scenario B is based on projected biofuel consumption developed as part of the European Commission's Impact Assessment.*

** Diesel and petrol price projections (based on the UK's Department for Energy and Climate Changes oil price projections) published in 2009.*

** Given the complexity of calculating the final retail price to consumers, the prices used as part of the projections are wholesale prices, and do not take into account the costs of moving refined products to the point of sale, profit margins, excise taxes, or other duties.*

There are a number of important caveats affecting future prices. More generally, they can include economies of scale for products and technological progress and efficiency improvements that will modify the estimates identified in Table 17 above. Petroleum products are used as an input to the biofuel production process, and will also affect the costs of other inputs such as feedstock and transport services. A higher oil price will therefore lead to a higher production cost for biofuels, noting that the relationship is not as strong as for petroleum products, which are almost entirely linked to the oil price. As the oil price rises, the cost of producing a litre of biofuel can be expected to decline relative to the cost of producing a litre of petroleum products, as long as feedstock prices don't change. But all indications are that these are now linked to the price of oil, so increasing oil prices are unlikely to help much the competitiveness of conventional biofuels. As biofuel production increases demand for biofeedstocks will drive up by the increased demand—especially if oil prices increase. This is due to higher petrol and diesel prices resulting in additional costs biofuel mandates impose on consumers reducing as the gap between the pump price for fossil-fuels and biofuels closes as fossil-fuel prices rise relative to the more expensive biofuels.

Key Findings

Multiplying the required volumes and production costs described above gives us an estimate of the additional costs of biofuel productions, albeit with some important caveats.

- The additional costs of ethanol (based on wholesale market prices as opposed to retail prices which would result in the cost to consumers likely being higher) to EU motorists could be in the range of EUR 1 to 1.2 billion in 2013, decreasing to around EUR 362 million to EUR 808 million in 2020, assuming ethanol is able to achieve reductions in production costs. The additional costs of biodiesel to EU motorists could be in the range of EUR 5.3 to EUR 5.9 billion in 2013, increasing to around EUR 4.8 billion to EUR 8.9 billion in 2020. If petrol and diesel prices increase in the future it will mean the additional costs of biofuel mandates imposed on consumers is reduced as the gap between the pump price for fossil-fuels and biofuels closes as fossil-fuel prices rise relative to the more expensive biofuels.[30]

[30] These projections are dependent on the underlying assumptions, relating to the amount of biofuels which will be consumed in the EU, and how biofuel and fossil-fuel costs pan out.

- While the variations in prices differentiates among ethanol, biodiesel, petrol and diesel, may seem relatively small, when these price differences are multiplied across the volumes of transport fuels used in the European Union there are a number of knock-on effects. These can include additional costs borne by consumers from using more expensive biofuels and lower or higher than expected excise tax revenue from changes in the volumes of petrol and diesel sold.
- The insights generated by projections undertaken here need to be balanced against the intrinsic challenges in forecasting long-term changes in prices, price responses and technology or the development of society, whether in response to international commodity or fuel markets or specific to European policies and doubtful assumptions about feedstock price not being affected by oil price.

5.1.6 Costs to the Consumers of Agricultural Commodities and Food

The extra costs that consumers of agricultural commodities and, ultimately, consumers of food incur as a result of the impact of biofuel policies on feedstock prices are very important from the policy-making perspective. There are two aspects of this relationship: the upward trend of prices for agricultural commodities and food and the increased market volatility of these prices. In both cases, the biofuel policy-driven demand for feedstocks has been cited as one of the causes in recent years (Lee et al., 2012).

The debate over the impact of subsidized biofuel-production on the food-price spikes of 2006–2008 when, in spite of worldwide record crop yields, global prices for traded food commodities, such as staple cereals and sugars, reached record highs . These hikes in food prices corresponded with the introduction of biofuel consumption mandates in the U.S., Europe and some other countries and the rapid increases in global biofuel production (Mitchell, 2008) (FAO, IFAD, IMF, OECD, UNCTAD, WFP, World Bank, . . . UN HLTF., 2011) (da Silva, 2012) (Tilman, et al., 2009) (Jung et al., 2010). Food prices decreased in 2009, but then resumed their growth through 2010–2011 (see Figure 13).

In 2011, a group of key international organizations released a report entitled "Price Volatility in Food and Agricultural Markets" (FAO et al., 2011) that stressed that government-imposed consumption mandates aggravate the price inelasticity of demand that contributes to the volatility in agricultural prices. The report recommended that G-20 governments should "remove provisions of current national policies that subsidize (or mandate) biofuels production or consumption" (FAO et al., 2011).

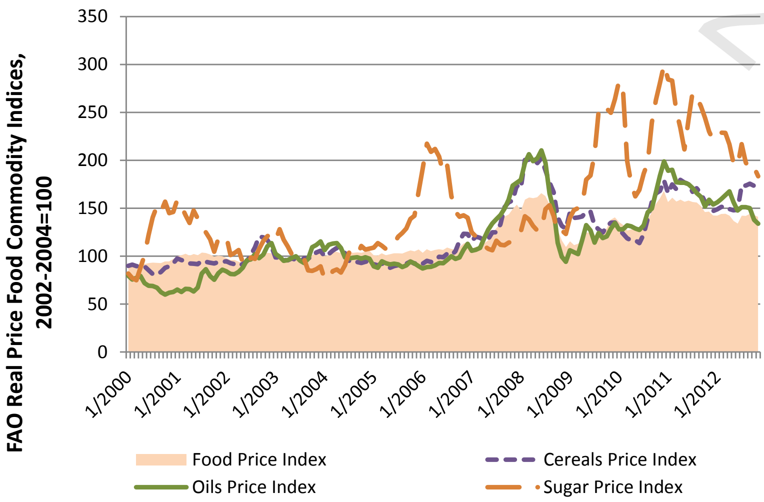


FIGURE 13: FAO REAL FOOD COMMODITY PRICE INDICES (2002-2004=100).

Source: Plotted using FAO data.

Food price increases contribute to inflation and are felt by everybody. In terms of their political significance they affect different groups of consumers differently, most notably:

A politically significant subpopulation of poorer households that are vulnerable to food price shocks. The poorer the households, the larger share of their income they spend on staple foods and, hence, the more negatively they are affected by food-price increases. In many cases, rises in food-prices may contribute to political unrest. In particular, rising food prices have been viewed as drivers of the "tortilla riots" in Mexico in 2007 (ActionAid, 2012), street riots in Haiti in 2008 (Busicchia, 2012) and the Arab Spring in 2011 (Lee et al., 2012).

Food and animal feed processors. In particular, a number of large food and beverages companies, including Nestlé and Unilever, have on many occasions requested the EU and other governments to release the pressure on tight food markets by phasing out support to biofuels (Perri, 2008) (Ruitenberg, 2013).

A concentrated group of livestock producers with a pronounced political agenda. In particular, rising prices for animal feed (which ultimately contribute to higher prices for meat and poultry) eat into the profit margins of farmers growing livestock and have been cited as one of the causes of the EU farmers' protests in late 2012 (Sekularac & Hunt, 2012).

Other users of agricultural feedstocks, e.g., biochemical and healthcare companies. In particular, the oleochemical industries in the European Union are likely to be negatively impacted by the intense competition created for their key feedstock of waste animal fat.

Importantly, all these groups include stakeholders both within and outside the EU's boundaries. For understandable reasons though, the EU policy-makers offer more consideration to concerns of the EU-based constituents. However, the poorest households that are most vulnerable to food price hikes are mostly located in developing and least developed countries.

Understanding the costs of the EU biofuel policy to each of these stakeholder groups is a key prerequisite for its sound reform. However, any estimation of effects on agricultural commodity prices requires a long series of assumptions and caveats, and produces a very wide range of numbers. The discussion and some estimates below illustrate these challenges. In the meantime, it is the order of magnitude rather than exact numbers that may matter most when analyzing this issue.

Methodological Challenges and Caveats

The challenges that a priori stipulate a large margin of mistake in estimating the impacts of policy-driven demand for biofuels on prices for agricultural commodities and food include, but are not limited to:

- inconsistent and disaggregated data on prices, origin and end-uses of feedstocks throughout value chains, including data on relevant exports, imports, re-exports and re-imports (Ecofys et al., 2011)
- a significant dispersion of market prices for agricultural commodities and, especially, food products depending on their uses and quality nomenclature (numerous varieties of industrial feedstocks, animal feeds, staple foods for human consumption, processed foods, etc.) and geographical markets;
- the complexity of relationships among markets for individual feedstocks as well as their complementary or substitute goods, especially petroleum (including insufficient data on elasticities of demand for such goods with respect to price and consumer income);

- the abundance of other factors influencing food prices such as: population growth, income growth and associated changes in diets, especially in emerging economies; weather conditions and plant diseases; changing climate; technological advances, especially those enabling productivity gains and reduction of waste; exchange-rate movements; changes in the stock levels of agricultural commodities; trade restrictions such as export quotas and bans; speculation and, more generally, financial market activity (Kretschmer, Bowyer & Buckwell, 2012); and agricultural subsidies and changes in the use of production factors such as land, labour, water and petroleum products.

In view of such significant challenges of using empirical data, most studies have to rely on general or partial-equilibrium models that approximate projected real-world conditions on a theoretical basis (this approach is used for modelling food price impacts, but also ILUC impacts, employment effects, etc.). Examples of the most reputable and widely employed models that, with varying degrees of calibration and adaptation, have been used to estimate the impact of the EU biofuel policies on prices of agricultural commodities and food include: AGLINK-COSIMO developed by the OECD and the FAO (e.g., applied by OECD, 2008; Blanco Fonseca et al., 2010; Durham, Davies & Bhattacharyya, 2012; Davies 2012), European Simulation Model (ESIM) used by the European Commission (e.g., applied by Blanco Fonseca et al., 2010), MIRAGE, developed by the International Food Policy Research Institute (IFPRI) (e.g., applied by Laborde, 2011) and IIASA's world food system (WFS) model (e.g., applied by Fischer et al., 2009 and Ecofys et al., 2011). Most of these models run simulations until 2020 that somehow refer to the EU 10 per cent of renewable-energy-in transport target. But it is noticeable that the ranges of biofuel policies' impacts on commodity and food price are mostly similar for all years.

While having their own plusses and minuses, each of the aforementioned models simplify reality and have therefore been criticized (e.g., see EBB et al., 2012). A lot of criticism has to do with different assumptions about the potential to raise agricultural yields, the successes of co-production of animal feed as a result of biofuel feedstock processing and some other factors.

Table 18 below has been drawn from a recent literature review of modelling exercises by Kretschmer et al. (2012). The table demonstrates the wide ranges of estimates for specific groups of agricultural commodities that have been obtained in two cases: (a) modelling the impacts of the EU biofuel policies only and (b) modelling the impacts of biofuel policies from across the world, most notably including the EU, but also a number of developing countries which have stimulated demand for biofuels such as Brazil, China, and Thailand. The range of estimates is very wide, which can be explained by different models' varying assumptions about short, medium and long terms reactions of commodity producers to increased demand and higher prices. For instance, alternative assumptions about options to increase yields on existing farmlands may lead to quite different modelling results.

Not surprisingly, most modelling exercises validate that the EU policies have the biggest impact on world prices of oilseeds and vegetable oils, which are feedstocks for biodiesel. Indeed, the EU is a leading consumer of biodiesel while its consumption of ethanol is not so significant on the global scale. In the meantime, on the markets of wheat, maize, sugarcane and sugar beet, which are feedstocks for ethanol, it is the US policies that matter most, since the United States is the world's leading consumer of ethanol.

TABLE 18: SUMMARY OF SELECTED MODELLING ESTIMATES OF BIOFUEL POLICY EFFECTS ON FEEDSTOCK PRICES BY COMMODITY

FEEDSTOCK (GROUP)	STUDIES THAT FOCUS ON THE EFFECTS OF EU BIOFUEL POLICY	STUDIES THAT ANALYZE THE IMPACTS OF GLOBAL OR MULTI-REGIONAL BIOFUEL MANDATES
Oilseeds	8 – 20%	2 – 7%
Vegetable oils	1 – 36%	35%
Cereals or maize	1 – 22%	1 – 35%
Wheat	1 – 13%	1 – 8%
Sugar (cane and beet)	1 – 21%	~ 10%

Source: Kretschmer et al. (2012, p. 6).

It is possible to illustrate the cost of the EU biofuel policies to consumers of agricultural feedstocks with the following example. The prevailing biofuel in the European Union is biodiesel (delivering 77.3 per cent of the energy content provided by biofuels in 2010, or 10,785 TOE according to EurObserv'ER (2012a, p. 65) produced from different vegetable oils, mainly: rapeseed oil (55 per cent), soybean oil (19 per cent) and palm oil (16 per cent) (all estimates are for 2008 based on calculations by Ecofys et. al, 2011, p. 42). These feedstocks – both domestically produced and imported – also have other uses.

In Table 19 below, the Federation of the EU Vegetable Oil and Protein Meal Industry (FEDIOL) estimated the biodiesel use of all – both domestically produced and imported – vegetable oils in EU-27 at 31 per cent in 2010 and 32 per cent in 2011 (FEDIOL, 2012). There exist other estimates as well, for instance, the AGLINK-COSIMO model estimates biodiesel production in the European Union absorbed 40 per cent of all vegetable oils in the 2009-2011 period (European Commission, DG AGRI, 2011, p. 49; OECD/FAO, 2012, p. 138).

TABLE 19: SPLIT OF END-USE (CONSUMPTION) OF ALL EU-27 VEGETABLE OILS IN 2010 AND 2011

TYPE OF END-USE (CONSUMPTION)	2010			2011		
	Physical volume, thousand tonnes	Share of the total end use (%)	Market value at a price of USD 1,233 (EUR 930) per tonne, billion EUR*	Physical volume, thousand tonnes	Share of the total end use (%)	Market value at a price of USD 1,085 (EUR 779) per tonne, billion EUR*
TOTAL	24,575 (incl. 2050 olive oil)	100	22.9	23,766 (including 2045 olive oil)	100	18.5
Food	13,189	54	12.3**	12,814	54	10.0
Biodiesel	7636	31	7.1***	7,680	32	6.0
Non-energy technical	1,729	7	1.6	1,730	7	1.3
Animal feed	1,000	4	0.9	942	4	0.7
Direct energy (electricity)	800	3	0.7	500	2	0.4
Direct fuel	220	1	0.2	100	0	0.1

** The sum of disaggregated market values may exceed the total due to rounding.*

Source: Calculations by IISD-GSI based on the current prices (OECD/FAO, 2012, p. 135) and industry end-use data (FEDIOL, 2012).

Combining the estimates of price effects of the EU biofuel policies (Table 18) and the estimates of the value of the EU markets of vegetable oils (Table 19) produces **an extremely wide range of estimates (with a factor of 36!) for the extra costs that the EU consumers had to incur: between EUR 100 million and EUR 4 billion a year for food and animal feed end uses of vegetable oils, while the biofuel industry itself had to pay between EUR 60 million and 2.2 billion a year over 2010 – 2011** (see Table 20 for more detail). This wide range is again accounted for different assumptions in cause-and-effect relationships on both demand and supply sides of the agricultural commodities' markets. Although different models also have different central scenarios, it can be intuitively assumed that the true value of extra costs incurred by the European consumers due to increased biofuel production are somewhere closer to the middle of these wide ranges, i.e., around EUR 2 billion per year.

TABLE 20: ESTIMATED ADDITIONAL COSTS ANNUALLY INCURRED BY EU CONSUMERS OVER 2010 - 2011 AS A RESULT OF POLICY-DRIVEN HIKES OF PRICES FOR VEGETABLE OILS (CURRENT PRICES)

TYPE OF END-USE (CONSUMPTION)	LOW-END ESTIMATE (PRICE EFFECTS AT 1 PER CENT), MILLION EUR	HIGH-END ESTIMATE (PRICE EFFECTS AT 36 PER CENT), MILLION EUR
Food	100	3594
Biodiesel	60	2153
Non-energy technical	14	485
Animal feed	7	264
Direct energy (electricity)	4	140
Direct fuel	1	28

Source: IISD-GSI calculations based on estimates contained in Tables 18 and 19.

However, even in terms of the biodiesel market's impacts on prices for vegetable oils, this example tells only part of the story. It is not just the costs of oilseeds and vegetable oils that go up as a result of the growing demand from the biodiesel industry. Similarly, it is not just prices for cereals and sugar that increase as a result of pressure from the ethanol manufacturers. A spike in prices for these commodities often has a domino effect on other commodity and food markets due to the substitutability of these commodities (Busicchia, 2012).

Many cereals, sugars and vegetable oils are inputs into processed foods, but they are also used as feed for livestock. Thus demand for biofuels may also be contributing to rising prices for meat, poultry, eggs, dairy and other products of animal farming. As Professor B. Babcock, one of the world's leading agricultural economists, explained in The Colbert Report on American TV, "Eggs are about seventy per cent corn. You feed the chickens a heavy ration of corn, out comes an egg, so there's a heavy concentration of corn in that egg. So when the price of corn goes up, the cost of producing that egg goes up immediately" (Polsdofer, 2012).

A complicated factor is that, many of the co-products of biofuel feedstock processing, e.g., oilseed cakes (a co-product of biodiesel) and distiller's dried grains with solubles (DDGS, a co-product of ethanol), can be used as valuable high-protein animal-feed. Many experts predict that these co-products of the biofuel industry will increasingly replace the unprocessed animal feeds such as common corn or wheat (E-Energy Market , 2010) (Ziggers, 2007). Figure 14 below demonstrates an extremely strong positive correlation among the volumes of rapeseed crushed, biodiesel produced, and rapeseed oil meal production and consumption in the European Union – 2007 in 2006 – 2011.

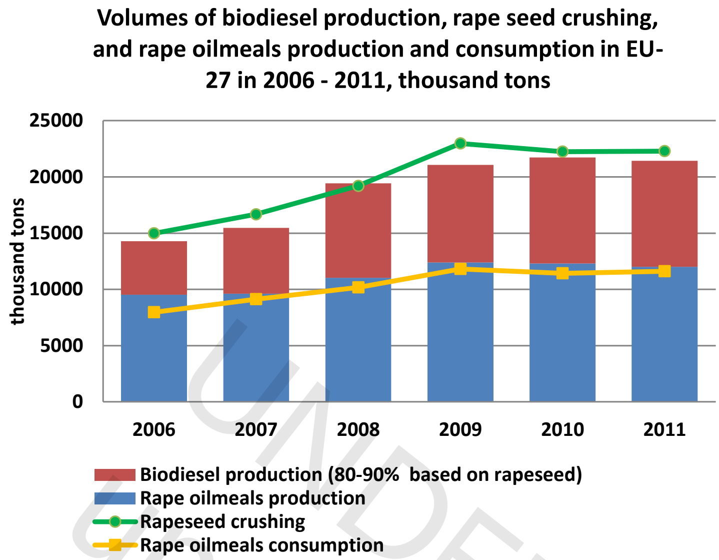


FIGURE 14: VOLUMES OF BIODIESEL PRODUCTION, RAPE SEED CRUSHING, AND RAPE OILMEALS PRODUCTION AND CONSUMPTION IN EU-27 IN 2006-2011, THOUSAND TONNES

Source: Plotted by IISD-GSI using USDA data for biodiesel production (US Department of Agriculture, 2012) and FEDIOL data for rapeseed crushing and rape oatmeal production and consumption (FEDIOL, 2012).

More generally, biofuel feedstocks compete with all other crops for production factors such as labour, land, water, energy, fertilizers, etc. This means that prices for these production factors increase and eat into the margins of producers of "non-energy" crops, who often either have to pass them further down the value chain onto consumers or switch to growing biofuel feedstocks as well, which increase the equilibrium price of all commodities in the market.

The most recent AGLINK-COSIMO modelling exercise undertaken by the European Commission's Directorate-General for Agriculture and Rural Development (DG AGRI) (European Commission, DG AGRI, 2012) has considered three EU biofuel policy scenarios for the future and their impact on agricultural commodity prices. Table 21 below summarizes the results, which fall within the ranges of the estimates discussed above.

TABLE 21. FUTURE PROJECTIONS OF DIFFERENT EU BIOFUEL POLICY OPTIONS ON PRICES OF SELECTED AGRICULTURAL COMMODITIES.

Scenario	Projected impacts on agricultural commodity prices compared to the baseline (i.e., current EU policy, under which the 10 percent of renewable-energy-in-transport target will not be reached and biofuels will account to 8.6 per cent of the transport energy in the European Union by 2020 (of which conventional biofuels will account for 6.7 per cent)
1. **Implementation of the European Commission's proposal** of 17 October 2012: conventional biofuels contributing to no more than 5 per cent of energy in transport	Vegetable oil prices drop by 10 per cent, cereals prices drop by -2.5 per cent, sugar prices drop by 1 per cent (compared to baseline of 6.7 per cent of 1st gen)
2. **Additional measures** to reach the 10 per cent renewable-energy-in-transport target by 2020 (of which conventional biofuels will account for 8.2 per cent).	Vegetable oil prices increase by 4 per cent, no estimates on prices of cereals and sugar

Source: IISD-GSI summary of European Commission, DG AGRI (2012).

Depending on the scale and nature of their operations, food companies may or may not be able to absorb the rising prices of their inputs throughout the value chain (Lucas, 2011). But overall the more value is added to food products, the less impact commodity costs have on their end-price. That is why the impacts of food price hikes in 2006-2011 were much less felt in Europe than in the developing world. In Europe consumers are both richer and more reliant on processed foods in their diets. In contrast, in developing and least developed countries the share of staple foods in diets is much higher, hence the higher vulnerability to food-price increases.

Thus, the efforts to quantify the costs of the EU biofuel policies to consumers of agricultural commodities and food estimates are within a very wide range. Improvements in models and data inputs will certainly help to narrow the range. However, there are irreducible uncertainties, and there always may be many valid results of such quantifications, but no ultimate truths. Therefore, in their decision-making process policy-makers should be guided by the Precautionary Principle.

A number of organizations, for instance UN FAO, Oxfam and ActionAid, have voiced concerns about the impacts of these trends on food security and poverty (Schmidhuber, 2007; ActionAid, 2012; Oxfam, 2012).The FAO defines food security as a "situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO, 2002). In this sense, the security of the EU food supply of citizens is hardly endangered (Schmidhuber, 2009) (EU Food Security), and major negative impacts can be felt in developing countries.

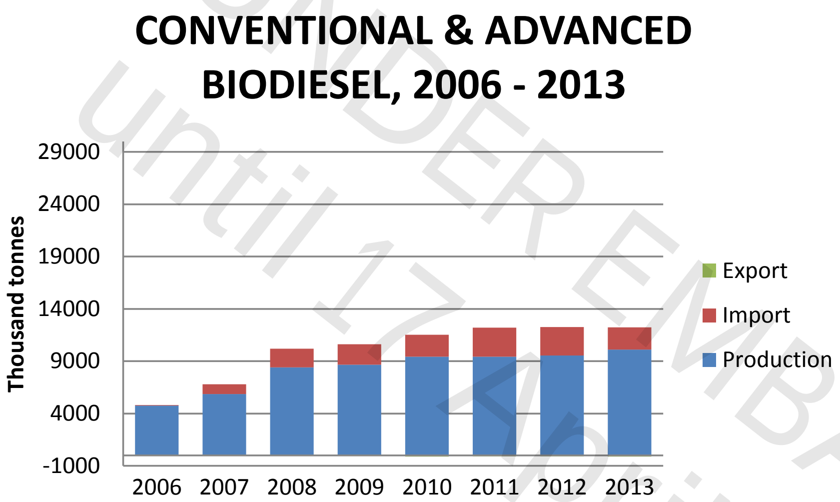
The world's poor already spend a disproportionately high share of their income on food (International Bank for Reconstruction and Development, 2008). Second, there are very different patterns of interaction of biofuel expansion policies, with food markets depending on the commodity and locality in question. In this respect, world-average prices for internationally traded commodities may not tell the full story (Hossain & Green, 2011). Many rural families in developing countries depend on locally grown foods, and many of the local markets are not fully aligned with global trends due to undeveloped transport networks and other factors (Keats et al., 2010).

Key Findings:

- Most modelling exercises validate that the EU's policies have had the biggest impact on world prices of oilseeds and vegetable oils, the feedstocks for biodiesel. Indeed, the EU is a leading consumer of biodiesel while its consumption of ethanol is not so significant on the global scale.
- Regarding markets for wheat, maize, sugarcane and sugar beet, the feedstocks for ethanol, it is the US policies that matter most, since the United States is the world's leading consumer of ethanol.
- Combining the estimates of the price effects of the EU biofuel policies and the estimates of the value of the EU markets of vegetable oils produces an extremely wide range of estimates (with a factor of 36!) for the extra costs that the EU consumers had to incur: between EUR 100 million and EUR 4 billion a year for food and animal feed-end uses of vegetable oils, while the biofuel industry itself had to pay between EUR 60 million and 2.2 billion extra a year over the period 2010 to 2011.
- EU biofuel policies may be a major contributor to food price hikes, but they hardly endanger food security of the average EU citizen. The negative effects on the poor will be mostly felt in developing countries in the strata of the society that spend a disproportionately high share of their income on food.

5.1.7 Impact on the European Union's External Trade and Current Account

Discussion of the EU biofuel policies on its trade balance is an area where quantification is unreliable and a lot of assumptions have to be made. As mentioned above, Harmonised System trade codes do not always distinguish between feedstocks and other commodities being imported or exported for biofuel or other purposes (for instance, ethanol is also used for technical purposes other than road transport fuels and in the beverages industry). Further, biofuels can also be traded as blends with fossil fuels, and trade statistics do not always make a clear distinction of pure and blended products. Further, data need to be adjusted for re-export and re-import. To illustrate, according to the US International Trade Commission, the US data on non-beverage ethanol export to the European Union and the EU data on import from the United States differ by the factor of 10 to 20 for 2010-2011 (Figures 15 and 16).



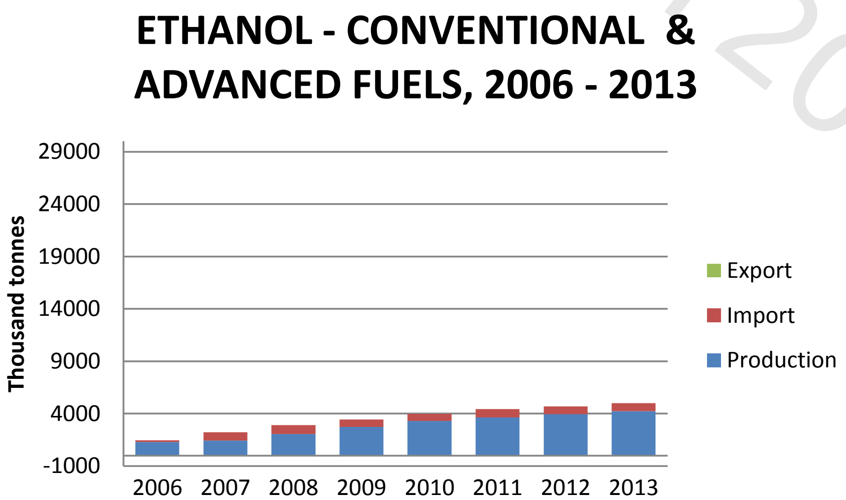


FIGURE 15: VOLUMETRIC ESTIMATES OF PRODUCTION, IMPORT AND EXPORT OF BIOFUELS IN THE EU-27, THOUSAND TONNES.

Source: IISD-GSI compilation based on estimates of US Department of Agriculture (2012) for biofuels.

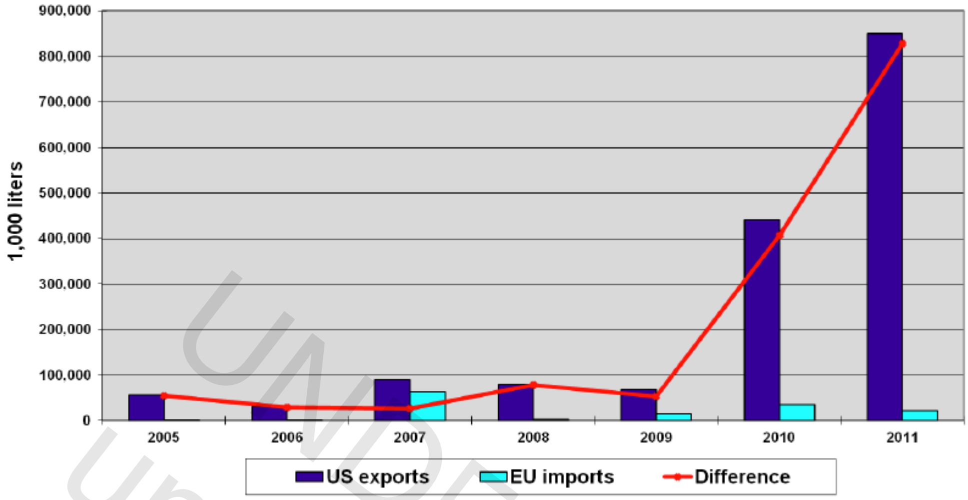


FIGURE 16: DATA DISCREPANCY IN US-EU TRADE IN NON-BEVERAGE ETHANOL, 2005–2011.

Sources: Illustration courtesy of the US International Trade Commission (2013). Note: Figure 16 uses estimates of extra-EU trade in biofuels with all countries, not just from the United States (US Department of Agriculture, 2012).

Consequently, a number of assumptions have to be made to estimate the EU biofuel policies' impact on international trade and these impacts can only be modelled, most notably under complex exercises such as studies by Laborde (2011) or (Birur, Hertel & Tyner, 2008).

Modelling results also differ considerably depending on whether or not the selected scenario assumes trade liberalization, as at the moment a lot of restrictions apply to trade in biofuels. In particular, the EU and its individual members have undertaken several attempts to protect the national feedstock and biofuel industry from foreign competition and to re-target cash flows to domestic agriculture. For example, in August 2012, Spain attempted to protect its domestic market from imports of biofuels but this restriction had the potential to be in violation of the WTO rules, and had to be withdrawn (Sapp, 2012; Argentina, EU in Confrontation over Biodiesel Imports, 2012). In January 2013 the European Commission proposed an anti-dumping duty on all US producers of bioethanol, which is likely to result in another WTO dispute (Reuters, 2013).

Impact on the EU External Trade in Agricultural Commodities

Overall, a review of the literature suggests the following trade trends driven by the policy-stimulated demand for biofuels in the European Union as compared with a "no-biofuels scenario":

- increased imports of biodiesel and ethanol
- increased imports of feedstocks such as rapeseed, soybeans, wheat and corn in the European Union
- increased imports of vegetable oils, especially palm oil and soybean oil, in the European Union

A recent analysis by the International Council for Clean Transportation, ICCT (Malins, 2013) shows that as rapeseed oil and biodiesel production were rising over the recent years, the EU was reducing its vegetable oil exports and increasing its imports. Indeed, from 2000 to 2010, as biodiesel consumption increased by 11 million tonnes, the EU's net imports of vegetable oil increased from about 1.5 million tonnes to 7.5 million tonnes, a change of 6 million tonnes (see Figure 17).

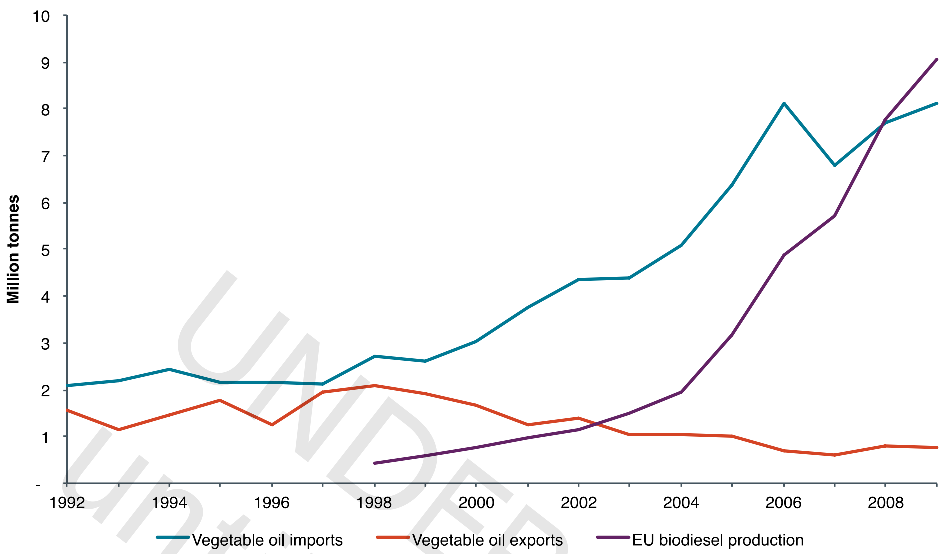


FIGURE 17: EU VEGETABLE OIL IMPORTS, EXPORTS AND BIODIESEL PRODUCTION

Source: ICCT based on data from FAOStat and EBB. Vegetable oils included: sunflower, rapeseed, soy, palm, palm kernel

A notable commodity among others is palm oil, a biodiesel feedstock that the EU imports mainly from Indonesia and Malaysia and which is traditionally the cheapest among other vegetable oils. Palm oil thus plays the role of the EU's "marginal oil," i.e., its import and consumption increases or drops as the EU changes its demand for other vegetable oils. In the recent years, the EU's increasing deficit in vegetable oil trade involved a shift from being a net exporter of rapeseed and sunflower oil to being a substantial importer of these, as well as of palm oil (Figure 18).

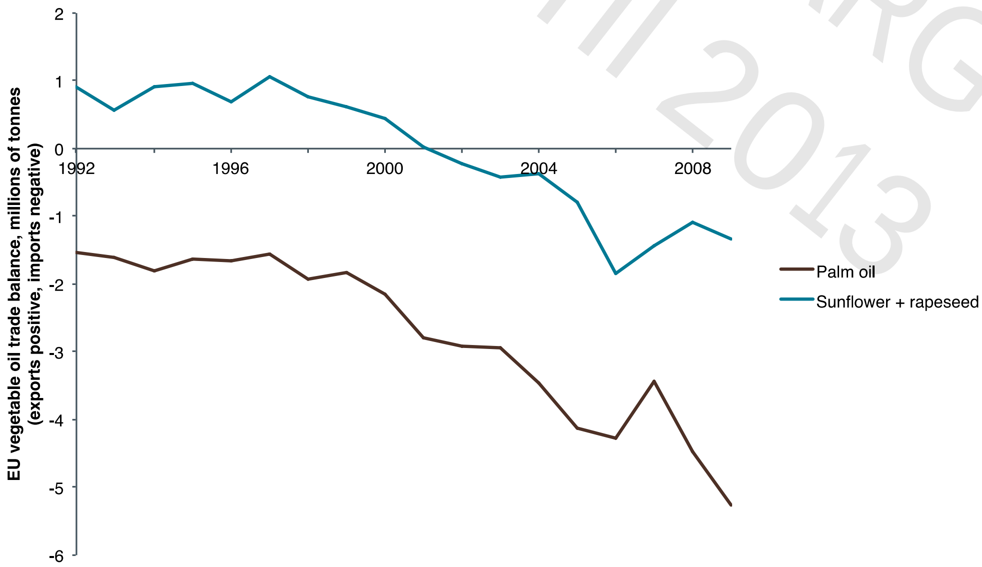


FIGURE 18: EUROPEAN TRADE BALANCE FOR KEY OILS.

Source: ICCT based on data from FAOStat.

5.2 Non-Economic Costs

5.2.1 Environmental impacts of EU Biofuel policies

Like emissions, the environmental impacts of biofuels are associated with changing patterns in land use and intensity of farming as a result of biofuels policies (Joint Research Centre, 2010). The Joint Research Centre (JRC) (2010) lists a number of environmental impacts from increased production of biofeedstocks and biofuel refining, such as:

- higher rates of nitrate and phosphate leaching into surface and ground water
- pesticide contamination
- soil degradation
- loss of biodiversity
- deterioration of landscape amenity

Many of these effects are related to agricultural production, in which fertilizers are used to enhance crop yields and pesticides to prevent pest related damage (such as insecticides to prevent insect-related damage and herbicides to kill off weeds).

The same JRC study also points to the fact that environmental drawbacks of biofuels are often site- and crop-specific, and therefore aggregate impacts are difficult to model. Especially for biodiversity loss and landscape deterioration, data are often unavailable and negative environmental impacts difficult to measure. This makes overall quantification of environmental impacts very difficult and reliance on more small-scale or localized evidence necessary (Joint Research Centre, 2010).

EMPA et al. (2012) offer the most comprehensive study assessing the overall environmental impacts of biofuels. Even though the study is performed specifically in relation to biofuels in Switzerland, the assessment of environmental indicators is most relevant to the EU as it does not give specific nominal values, but rather assesses the performance of different biofuels against fossil-fuel use. In addition, their model specifies, the origin of the feedstock, making the results more relevant to the EU as environmental performance is linked to feedstock origin. While recognizing modelling uncertainties and a lack of data, the study concludes that on many environmental impact indicators, biofuel value chains have higher values than the fossil-fuel reference indicator, in particular when assessing agricultural processes contributing to environmental problems, such as eutrophication, acidification, water depletion, and ecotoxicity. In terms of particulate matter formation[31], biofuels also have a higher impact than fossil fuels, in particular as a result of ammonia emissions due to fertilizer utilization in agricultural processes and the transformation of forest into agricultural land for feedstock production (EMPA, ART, PSI and Doka Ökobilanzen, 2012).

Certain biofuels can provide greenhouse gas emission reductions relative to fossil fuels (EMPA, ART, PSI and Doka Ökobilanzen, 2012). However, updated estimates of ILUC emissions (*see above*) can strongly reduce the emission reduction benefits of biofuels, in particular biodiesel. In addition, greenhouse gas benefits may be exaggerated through being credited with the benefit of reduced food consumption and because possible Indirect Fuel Use Change is often ignored. This leaves ozone depletion as the only indicator against which biofuels generally have an advantage over petrol and diesel derived from conventional crude oil, which, as it is often found in conjunction with natural gas, emits methane during production, refinement, transportation and storage (EPA, 2013). However, this can be undermined

[31] Particulate matter (PM) is a mixture of small particles and liquid droplets that can cause heart and lung problems through inhalation. In particular those with a diameter of below 10 micrometers can cause a negative impact on human health (EPA, 2013).

where higher vapour pressure limits for ethanol blended with petrol are permitted in the European Union. These higher vapour pressure limits result in greater VOC emissions which are a precursor of ground level ozone. There is considerable evidence that wood-based biofuels emit ground-level ozone, which is a pollutant causing reductions in crop yields, loss of biodiversity and excess health related deaths (Transport & Environment, 2008).

Nitrous Oxide Emissions

The study by EMPA et al. (2012) also points to the need for more specific modelling of nitrous oxide (N2O) linked to agricultural production, and warns that uncertainty related to such emissions should "lead to general caution when promoting biofuels" (EMPA at al., 2012, p I). One of the reasons for these nitrous oxide emissions is nitrate leaching into ground water from fertilizer use. When this water eventually becomes surface water, N2O is released. Such emissions have 300 times the global warming potential of CO_2 emissions (FAO, 2008). Already in 2008, atmospheric chemist and Nobel laureate Crutzen and colleagues concluded that the production of biofuels depending on nitrate fertilizer has an equal or larger amount of global warming potential from N2O emissions as its cooling potential from displacing fossil fuel. This analysis did ignore the benefits from co-products generated by biofuels, as well as fossil-fuel emissions on farms and for fertilizer and pesticide production (Crutzen, Mosier, Smith, & Winiwarter, 2008).

Like ILUC emissions, there is considerable uncertainty in estimating N2O emissions. The model used by the Joint Research Centre found values lower than Crutzen et al., but equally came to the conclusion that nitrous oxide emissions have the potential to negate greenhouse gas savings from biofuels (Joint Research Centre, 2008). A Swedish case study found that crops grown on nitrate-intensive soils will fail the EU's target of 35 per cent greenhouse gas savings threshold with a probability of higher than 50 per cent (Klemedtsson & Smith, 2011).

The environmental impacts of EU biofuels compared with fossil-fuel usage

As previously mentioned, aggregate results for countries or regions are difficult to estimate. The most relevant European-level modelling study that can be used to indicate the environmental harm or benefit of EU biofuel policies is the ReCiPe model. This is a model used to calculate life-cycle impact category indicators. It first uses mid-point level impact categories such as, among others, freshwater eutrophication, human toxicity and water resource depletion. These midpoint categories are then converted and aggregated into endpoint categories such as damage to human health, ecosystem diversity and resource availability (see below) (Goedkoop, Heijungs, Huijbregts, De Schryver, Struijs, & van Zelm, 2012).

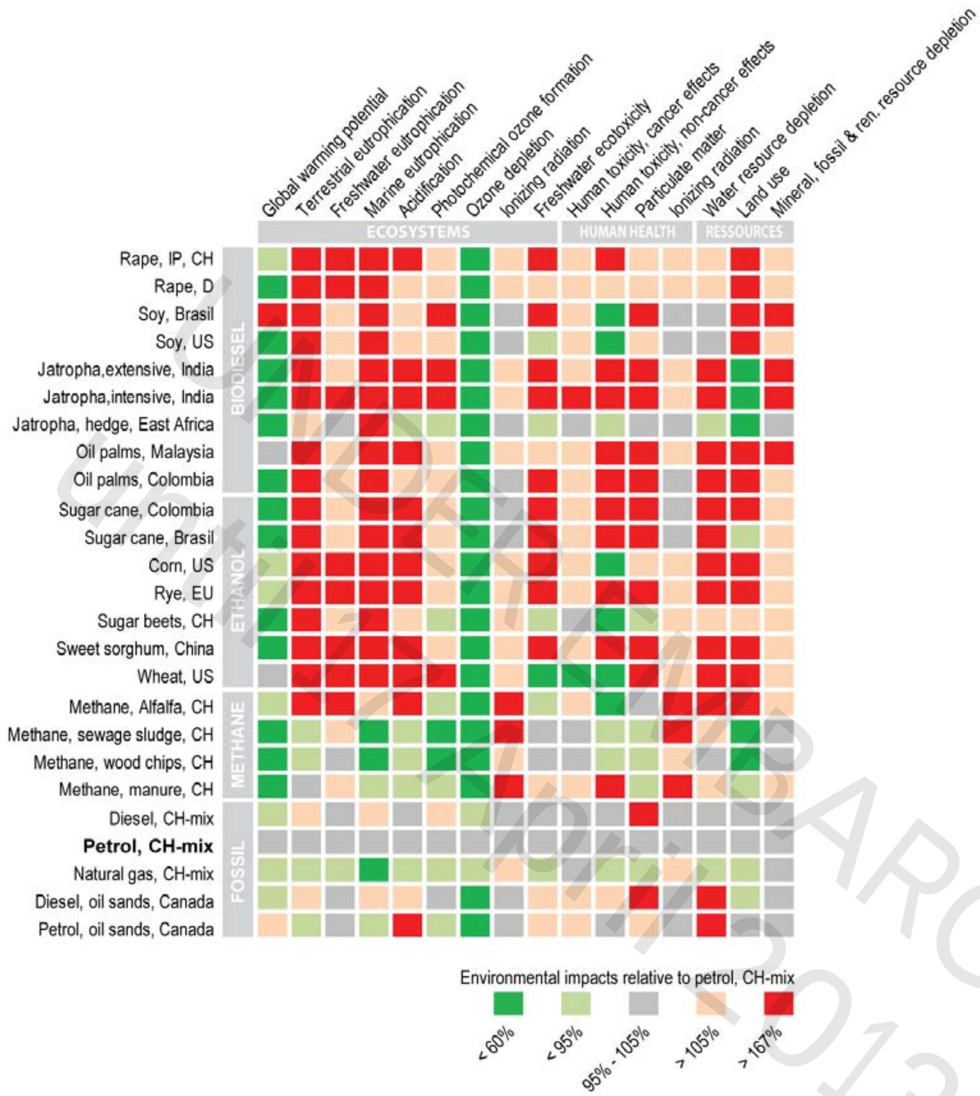


FIGURE 19: OVERVIEW OF THE DIVERSITY OF ENVIRONMENTAL EFFECTS (INTERNATIONAL REFERENCE LIFE CYCLE DATA SYSTEM (ILCD) ENVIRONMENTAL INDICATORS)

Source: (EMPA, 2012)

The endpoint results of the ReCiPe model for Europe show that environmental impacts from biofuels are in most cases higher than or roughly equal to the fossil-fuel reference figure. This is mostly as a result of the significant impacts of biofeedstocks at the cultivation stage. In particular, the occupation of agricultural land and the transformation of natural land are categories that score highly as negatively impacting the environment. Nitrogen emissions and pesticides also contribute significantly to environmental harm (EMPA, ART, PSI and Doka Ökobilanzen, 2012).

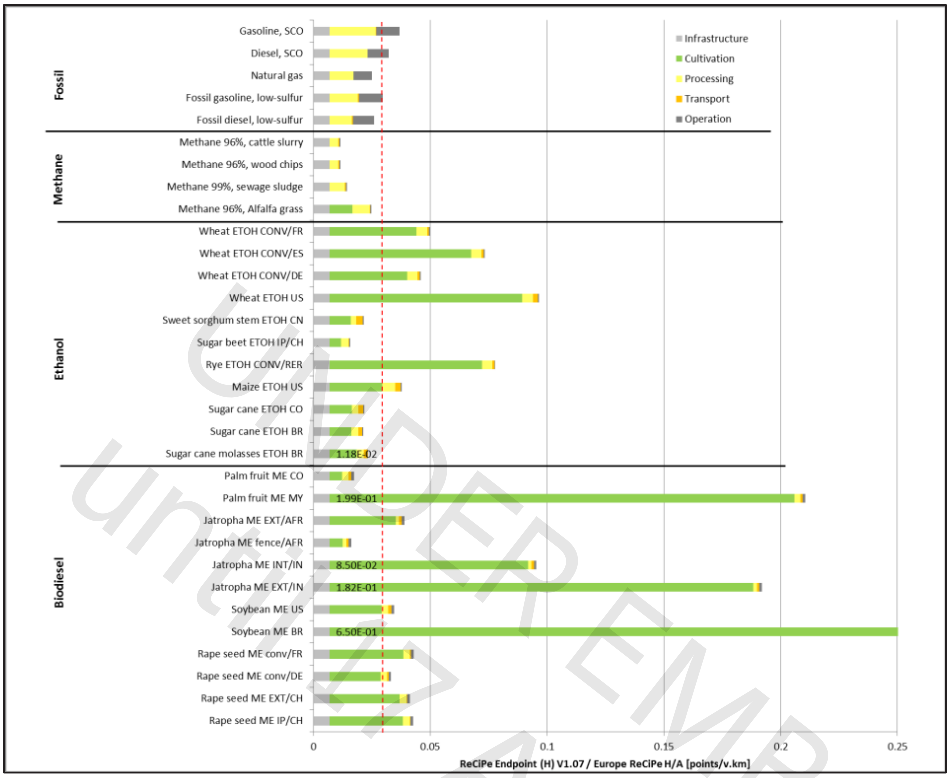


FIGURE 20: RECIPE EUROPE ENDPOINT RESULTS (POINTS PER VEHICLE KM), BY IMPACT CATEGORY (WATER DEPLETION NOT INCLUDED)

Source: (EMPA, ART, PSI and Doka Ökobilanzen, 2012, p. 89)

Water depletion as a result of biofuels

An increase in water demand for biofuel feedstock production is a particularly problematic issue (Joint Research Centre, 2010). Water resources are scarce and used in a variety of important sectors, most naturally for growing food. Irrigated crops such as wheat and maize, sweet sorghum, sugar cane, palm fruit and jatropha, have the highest water depletion impacts, around 17 litres/per kg (for extensive jatropha production) and 110 litres/per kg (for intensive jatropha production). Apart from feedstock production, biorefineries and fertilizers used to grow feedstock can also contribute to water depletion (EMPA, ART, PSI and Doka Ökobilanzen, 2012). Overall water use in biorefineries is much less than for growing biofeedstocks. Biodiesel refineries are generally less water intensive than ethanol refineries (National Research Council of the National Academies, 2008).

Irrigation water supporting the growth of these crops is often subsidized in European countries, as well via the second pillar of the CAP. Due to a lack of data, the share of irrigation subsidies going to biofeedstock production is difficult to quantify.

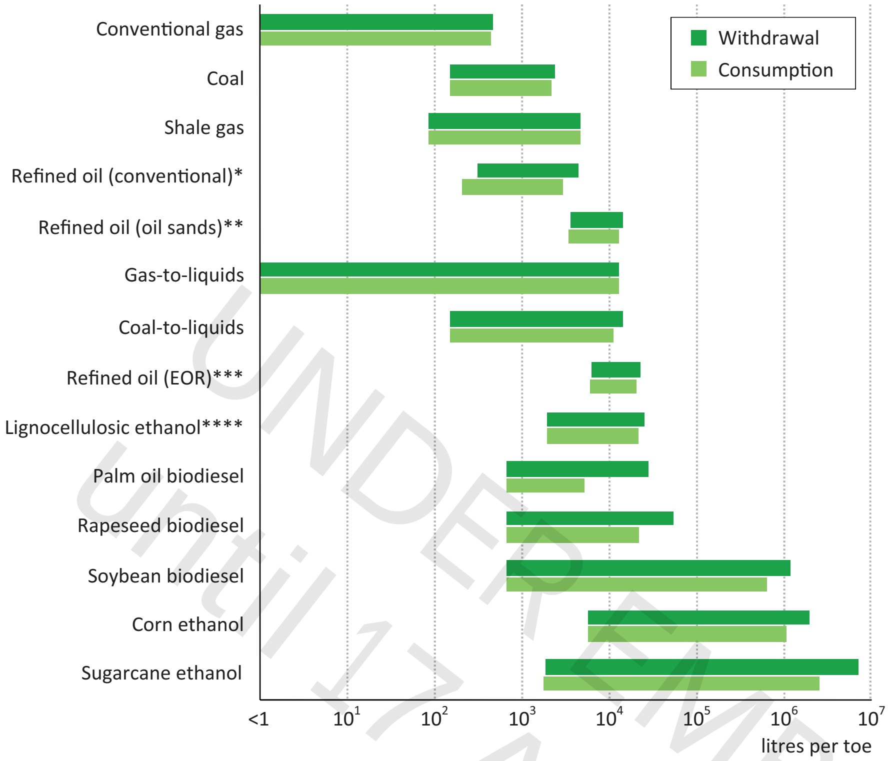


FIGURE 21: WATER USE FOR ENERGY PRODUCTION.

Source: IEA (2012), figure 17.3, p. 507.

**The minimum is for primary recovery; the maximum is for secondary recovery.*

***The minimum is for in-situ production; the maximum is for surface mining.*

****Includes CO_2 injection, steam injection and alkaline injection and in-situ combustion.*

*****Excludes water use for crop residues allocated to food production.*

Notes: Ranges shown are for "source-to-carrier" primary energy production, which includes withdrawals and consumption for extraction, processing and transport. Water use for biofuels production varies considerably because of differences in irrigation needs among regions and crops; the minimum for each crop represents non-irrigated crops whose only water requirements are for processing into fuels. EOR = enhanced oil recovery. For numeric ranges, see http://www.worldenergyoutlook.org.

Water intensity is, like other environmental factors, often difficult to observe (Ecofys et al., 2011). Assessments on a watershed basis would be more useful for identifying water stress. However, the data required to undertake such assessments of biofuel feedstock cultivation are unavailable in the European Union (Ecofys et. al, 2011).

In a case study on Germany, (Ayres, 2012) found that previous studies have underestimated domestic and international water depletion caused by increased biofuel production at home and abroad. The study finds that the largest producers are not necessarily those with the largest water footprints. While water use is not only dependent on crops, but also on site-specific characteristics, the study gives an average water footprint by type of biofuel in which it is clear that imported biofuels generally have higher water footprints. This begs an international perspective on water depletion concerns as a result of EU biofuel policies, which is beyond the scope of this study.

Based on these numbers and EU biofuel consumption and importation figures from the Impact Assessment accompanying the October 2012 proposal (European Commission, 2012d), it is possible to calculate a rough estimate of the EU water footprint. As mentioned, since water use is also specific to each watershed, this estimate is imperfect and mainly gives an indication of the rough magnitude of EU water use. In this calculation, it is further assumed that all sunflower production is European (while it is in reality shared between European and imported feedstock) and that the water footprint of soy from the United States and Argentina is equal to the reported one from Brazil.

TABLE 23: EU WATER FOOTPRINT

BIOFUEL	CONSUMPTION (TJ)	WATER FOOTPRINT (M^3/GJ)	WATER FOOTPRINT (KM^3)
Domestic			
Bioethanol	86,772	54	4.7
Biodiesel or Plant Oil	322,312	106	34.2
Imported			
Bioethanol (Br-Sugarcane)	40,242	58	2.3
Biodiesel or Plant Oil (Br-Soy)	108,951	351	38.2
Biodiesel Plant Oil (Palm oil from Malaysia or Indonesia)	22,698	130	2.9
EU Total	580,975		82.4

Source: Author calculations; average water footprint from (Ayres, 2012)

Notes: Second column, Footprint (m^3/GJ) based on research (Ayres, 2012)

This estimate of around 82 km^3 is comparable to the 2010 EU water footprint estimated by Melkko in 2008 who estimated an EU total water footprint associated with biofuels of between 44 and 88 km^3, depending on the crops used and assuming that the share of biofuels in every country would have reached 5.75 per cent of transport fuel consumption in 2010. Melkko also finds that the water footprint compared with renewable water resources varies significantly between EU countries (Melkko, 2008). Of the 82 km^3, around 39 km^3 is water consumed from European water resources.

To put these numbers in perspective, total annual freshwater resources in Germany (Europe's largest country and the one with the highest freshwater resources) is around 188 km^3 (Eurostat, 2012), and 39 km^3 is roughly equal to the annual discharge of the Seine (15.8 km3) and Elbe (23.7 km^3) combined (Kempe, Pettine & Cauwet, 1991). One can conclude that the water footprint of EU biofuels is significant. Even though biorefineries use less water relative to feedstock production, the effect on local communities can be very significant. Water depletion within the EU as a result of biofeedstock growth and biorefineries is a serious risk and dependent on specifics related to location, watersheds and crop type. This study strongly urges more quantitative research on this topic.

Loss of biodiversity as a result of biofuels

Closely related to environmental degradation and water depletion, certain biofuel production also has an impact on biodiversity. For example, in Germany, an increase in feedstock production for bio-energy has led to the destruction of grassland habitats. It is estimated that between 2003 and 2009, at least 55,000 ha of grassland were lost as a result of conversion to maize (European Environmental Bureau et al. 2011). Under certain circumstances, traditional and small-scale farming management methods can be beneficial to biodiversity, if they are themselves not used in mass scale (European Environmental Bureau et al. 2011). However, feedstock production for biofuels is nearly always produced on large-scale holdings and associated with land-use change. The Joint Research Centre (JRC) of the European Commission estimated biodiversity loss as a result of changing land patterns due to biofuel production. It found that the transformation of pastures to croplands on average will lead to an 85.3 per cent decrease in those areas of the Mean Species Abundance (MSA) index, which is an indicator for biodiversity. The JRC therefore comes to the conclusion that "the extensive use of bio-energy crops will increase the rate in loss of biodiversity" (Marelli, Ramos, Hiederer, & Koeble, 2011).

Similarly, the Convention on Biological Diversity found that land- use change from biofuel production "exacerbates the risk of losing biodiversity and ecosystem services". The effect is the largest when undisturbed natural vegetation is transformed to land for feedstock cultivation. There is also a large effect when disturbed natural vegetation is converted to land for feedstock production (Convention on Biological Diversity, 2012).

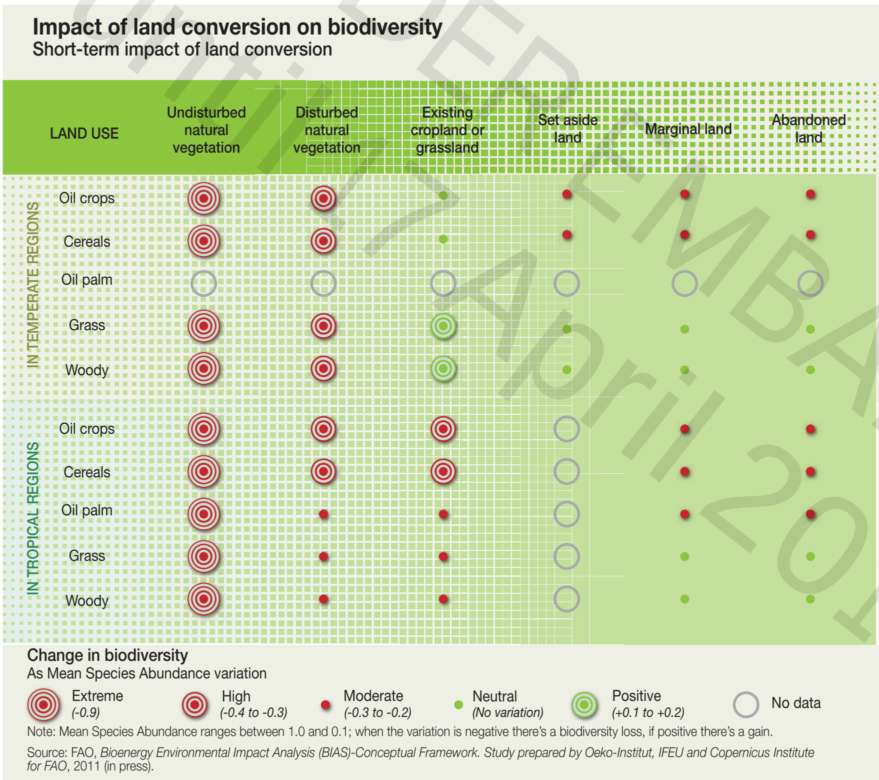


FIGURE 22: SHORT TERM-IMPACT OF LAND CONVERSION ON BIODIVERSITY

Source: (Convention on Biological Diversity, 2012)

Key findings

- Many negative environmental impacts are related to agricultural production, in which fertilizers are used to enhance crop yields and pesticides to prevent pest-related damage.
- The environmental drawbacks of biofuels are often site- and crop-specific. Data required for such a site- and crop-level analysis is largely unavailable.
- On an aggregate level, apart from ozone depletion and potentially some minor greenhouse gas emissions savings, biofuels generally score worse than fossil fuels on environmental and health indicators. These include among others terrestrial, freshwater and marine eutrophication, and particulate matter formation (potential greenhouse gas savings are discussed in the next section).
- Using average water footprints per feedstock by (Ayres, 2012), the study estimates the EU water footprint as a result of biofuel production at around 82 km^3, of which 39 km^3 is used from European water resources To put that number into perspective, Germany's total annual freshwater resource is around 188 km3. Biofuels water footprint warrants further assessment as to the impact of biofuel production on the EU's water resources.
- Water depletion and especially land-use change as a result of biofuel production and consumption in the European Union are responsible for loss of biodiversity in the EU and beyond.

6.0 *Benefits*

6.1 Economic Benefits

6.1.1 Tax Payments Generated by the Biofuel Industry

Tax payments generated by the domestic biofuel industries in Member States represent a benefit to the government. Depending on the growth of the industry and taxes paid, such an amount could be significant. To date, little has been published on taxes paid by the EU biofuels industry, nor has the industry itself used it as an argument in favour of maintaining support for biofuel production or its expansion. Some industries, such as the European Automobile Manufacturers Association (2012), estimate and publish their annual tax payments contributions to the EU. As part of this report, an assessment of the EU biofuel industry's taxes was undertaken but due to time and resource constraints no estimate was developed.

Taxes paid by the biofuels industry, could also be provided at the municipality level, as well as the federal level. For example, in Hungary a range of municipal taxes could be paid by the biofuels industry. These could include building taxes, land tax, communal tax, or local business tax which is set by the local municipality on up to 2 per cent on income defined as net sales revenue on products sold or services provided (Hungarian Investment and Trade Agency, 2012). It is likely that EU biofuel companies are contributing tax payments at the municipal in other Member States.

One method to calculate taxes could be to make use of company-level data. When annual reports are published, they often include profit before tax and profit after tax statements. Using company production data, it would then be possible to calculate a tax paid per unit of biofuel produced. This exercise could be repeated for other companies within the jurisdiction (member state). In a final step, total production within the member state could be multiplied with the average tax per unit of biodiesel to estimate total taxes paid. This method is difficult to apply in practice because of the following reasons:

1. Not all biofuel producers produce publicly available annual or financial reports with data on profit before tax and profit after tax.
2. Of those that are available, the profit before and after tax often applies to the entire company, and not necessarily only to the segment responsible for producing biofuels
3. Of those that are available, actual annual production data are not always communicated in reports.

BOX 7: COMPANY TAX CONTRIBUTIONS FROM EU BIOFUEL PRODUCERS.

An assessment of 2010 and 2011 financial statements published by EU based ethanol and biodiesel producing companies who are members of the European Renewable Ethanol Association (ePure)[32] and the European Biodiesel Board[33] (EBB) found that data on tax payments made by EU biofuel companies is weak and there appears to be no aggregated estimates for tax contributions from either the ethanol or biodiesel industry. The review of company level public financial or annual statements focused on before and after tax profits, paid taxes and number of employees. The main findings can be summarized as the following:

- 21 ethanol companies' financial statements were reviewed with over half having basic financial and tax information available. 62 financial statements from biodiesel companies were assessed with basic financial information less available. In general, financial statements for the majority of companies assessed were not available on company websites. Company level financial reports could be found on other online public databases either free of charge (i.e., Duedil) or subject to a payment (i.e., Registro imprese and Axesor[34] for Italian and Spanish companies).
- French biofuel industries tended to have a high level of transparency with all French companies assessed having published their financial statements online. This is probably a reflection of the fact that in France, all limited (Sarl) and public (SA) companies need to file accounts, deposited at the Institut National de la Propriete Industrielle (INPI).[35] Financial reports provided quite detailed information on the financial situation of the company through the year. As an example, "Cristal Union" is an agro-industrial group specialized in sugar and alcohol production and its annual report is easily downloaded from their website providing detailed information on their annual financial performance. In 2011, the company's profit before tax was EUR 89 million, taxes paid amounted to EUR 20 million (Cristal Union,[36] 2012, p. 47) and the number of employees were 1223 (Cristal Union, 2012, pp. 24, 47).
- For some of the companies assessed ethanol and/ or biodiesel production represents only a fraction of their business activities, such as the French company "Roquette frères"[37] which owns food and non-food related industries around the world. It is difficult to identify tax data for biofuel related activities within a complicated financial statement which refers to a broad range of business activities.

Key findings

- Industry wide, or company by company estimates of taxes paid by the EU biofuel industry were not available. Companies that are active in a number of sectors will publish annual company and financial reports, and business activities relating to the production of biofuel are generally not differentiated between taxes paid relating to the business unit operating the biofuels segment of the company.
- Biofuel companies contribute to a number of local, regional and national taxes. The level of tax paid varies by site, and local taxation laws or waivers.

6.1.2 Benefits to Crop-Growing Farmers in Terms of Income Increases

Farmers' income is another important consideration for EU policy-makers, therefore it is important to understand the order of magnitude of farmers' sales of feedstocks to the EU biofuel industry.

The previous section on costs to consumers of agricultural commodities and food describes the data limitations. The same caveats apply to the case of estimating EU farmers' income from selling feedstock to the biofuel industry. As discussed above, biofuel policies have impacts on the prices of commodities far beyond the immediate biofuel feedstocks through to a range of second-tier effects. However, these effects in their entirety can only be modelled

32 http://www.epure.org/producing-members
33 http://www.ebb-eu.org/members.php
34 Websites: http://www.registroimprese.it/ and http://www.axesor.es/
35 Institut National de la Propriete Industrielle-INPI. Website: http://www.inpi.fr
36 Cristal Union (2012).Cristal Union, France. Retrieved from: http://www.cristal-union.fr/wp-content/flippingbook/rapport-annuel-2011/files/assets/downloads/publication.pdf
37 http://www.roquette.com/

with varying degrees of approximating the reality. A further caveat is that if agricultural commodity prices rise in the long run increasing farming profitability, this is likely to result in increased land values, which would erode this benefit to those farmers who lease land.

A quantification exercise below focuses just on the key biofuel feedstock, vegetable oils, wheat, maize, barley and sugar beet. Importantly, not all feedstocks used for biofuel production in the European Union originate from the EU; a lot of feedstock is imported. Due to data constraints, the ultimate origin of feedstock has again to be modelled, and the latest estimate of this type is available for 2008 (see Tables 22 and 23).

TABLE 22: ULTIMATE ORIGIN OF FEEDSTOCK FOR BIODIESEL CONSUMED IN THE EUROPEAN UNION IN 2008, EXPRESSED IN VOLUME OF BIODIESEL (KTOE)

	RAPESEED OIL	SOYBEAN OIL	PALM OIL	SUNFLOWER OIL	TALLOW	RECYCLED VEGETABLE OIL	TOTAL
European Union	3,233	82	14	124	212	235	3,900
Canada	122	18			4	6	149
Ukraine	252	10					261
United States	13	528			133		673
Argentina	4	238					242
Brazil		342					343
Indonesia			624				624
Malaysia			414				414
Other	111	52					164
Total	3,734	1,269	1,053	124	348	241	6,770

Source: Ecofys et al. (2011), p. 42.

TABLE 23: ULTIMATE ORIGIN OF FEEDSTOCK FOR BIOETHANOL CONSUMED IN THE EUROPEAN UNION IN 2008, EXPRESSED IN VOLUME OF BIOETHANOL (KTOE).

	WHEAT	MAIZE	BARLEY	RYE	TRITICALE	SUGAR BEET	WINE	SUGAR CANE	OTHER	TOTAL
European Union	373	207	20	51	7	427	148		149	1,381
United States	2									3
Norway	2									2
Ukraine	1	1								3
Argentina		12						5		17
Brazil		6						289		296
Pakistan								33		33
Bolivia								19		19
El Salvador								13		13
Peru								13		13
Egypt								14		14
Guatemala								11		11
Costa Rica								10		10
South Africa								2		2
Other	2							1		4
Total	381	228	20	51	7	428	148	411	149	1,822

Source: Ecofys et al. (2011), p. 43

Combining the data of Tables 22 and 23 on the ultimate origin of feedstock, data on feedstock prices from Eurostat and FAOstat, and estimates of feedstock consumption for biofuels production in the European Union from Table 19 and the AGLINK-COSIMO model (as published in European Commission, DG AGRI, 2011), it is possible to estimate the value of feedstock sales by the EU farmers to the EU biofuel industry in 2011, as summarized in Table 24.

TABLE 24: ESTIMATED ANNUAL VALUE OF EU FARMERS' SALES OF SELECTED CROP FEEDSTOCKS TO THE EU BIOFUEL INDUSTRY IN 2010–2011.

	BIODIESEL FEEDSTOCKS	ETHANOL FEEDSTOCKS			
	VEGETABLE OILS	WHEAT	SUGAR BEET	MAIZE	BARLEY
Physical volume of feedstock used for biofuel production in the EU, million tonnes (vegetable oils – based on FEDIOL 2012, other feedstocks – based on European Commission, DG AGRI, 2011)	~ 7.7	4.3 – 4.8	18.2 – 20.6	3.3 – 3.8	0.6 – 0.7
Share of EU-grown feedstock in total feedstock for biodiesel in the EU (latest estimate available for 2008, based on Ecofys et al. (2011)	56%	98%	100%	91%	100%
Average feedstock price per tonnes, EUR (weighted averages based on OECD/FAO, 2012, Eurostat and FAOstat data)	~ 800 – 1,000	~ 120 – 160	~ 30	~ 160 – 210	~ 130 – 180
Estimated value of the EU farmers' sales of crop feedstock to the biofuel industry, billion EUR	3.5 – 4.5	~ 0.6 – 0.8	~ 0.6 – 0.8	~ 0.6 – 0.7	~ 0.1
Estimated value of the imports of biofuel feedstocks in the EU, billion EUR	3 – 4	~ 0	~ 0	~ 0.1	~ 0

Source: IISD-GSI data compilation and calculations based on FEDIOL 2012, European Commission, DG AGRI 2011, OECD/FAO 2012, Eurostat, FAOstat and Ecofys et al. (2011).

In total, **the annual value of biofuel feedstocks' sales by the EU farmers to the EU biofuel industry can be estimated at EUR 3.5 – 4.5 billion for biodiesel and EUR 2.5 – 3.5 billion for ethanol over 2010-2011.**[38] These values can be seen as direct cash flows to the EU farmers linked to the EU biofuel policies. In the meantime, it is important to underscore that if the farmers were not growing biofuel feedstocks, they would be still growing and selling some other crops, even the same ones, but for other uses (e.g., corn for exports rather than ethanol production).

Further, it has been argued that farmers growing biofuel feedstocks benefit from the longer-term nature of supply contracts with the biofuel industry (FAO, 2008, p. 83), which in certain cases may have reduced the volatility of the prices at which feedstocks are sold to the industry, creating a more certain business environment for farmers. On top of this, the EU farmers also benefit from higher prices for all crops they sell for all uses as the agricultural commodities' prices are driven upwards by biofuel policies as described above.

In the meantime, the impacts of biofuel policies on farmers' incomes are not limited to the revenue gained from feedstock sales. In terms of boosting farmers' incomes, it has been argued that feedstock producers may be receiving a better price when selling to a local biofuel facility than if they were selling their feedstock to some other buyer at

[38] These figures are based on an annual average for 2010 and 2011.

a greater distance thanks to a significant reduction in transport costs (Swenson, 2006). However, for those farmers who lease their land rather than own it, the capitalization of biofuel subsidies in the value of land may have resulted in higher lease rates and thus additional costs (Swenson, 2006).

What would happen to EU farmers' income if biofuel market support were removed in the European Union? In light of the discussion above it is possible to see that, *with all things being held equal*, depending on what feedstock the farmers are growing, their income would contract at least within the same ranges as ranges of the price effects described in Table 18. At a new lower equilibrium price, EU farmers would be able to supply their produce to other markets, e.g., for animal feed, both within and outside the EU. Davies (2012) simulated a removal of the current EU biofuel market support using the AGLINK-COSIMO model. According to this research, there would be negligible changes in production, area harvested and yields of the major biofuel feedstocks relative to the baseline levels (i.e., subsidized levels). Under this scenario, the EU farmers would re-orient some of their sales to external markets: e.g., wheat and vegetable oil exports from the EU would increase by 33 per cent and 20 per cent respectively through 2020.

In the meantime, a comprehensive discussion of the benefits that EU farmers are reaping from policy-stimulated demand for biofuels is impossible without looking at the cost of producing biofuel feedstocks in Europe at a competitive cost in comparison with the options of importing it. EU farmers have experienced increased competition from feedstock providers from other countries, as can also be seen from Table 24. In particular, in 2008, 44 per cent of biodiesel in the European Union was produced using cheaper imported feedstock. These issues are discussed in more detail in Section 5.1.7 of the report.

Key findings

- In total, the annual value of biofuel feedstock sales by EU farmers to the EU biofuel industry can be estimated at EUR 3.5 - 4.5 billion for biodiesel and EUR 2.5 - 3.5 billion for ethanol for the calendar years 2010-2011.
- Farmers growing biofuel feedstocks often benefit from longer-term supply contracts (FAO, 2008).
- Only about half, if not less, of the value of biofuel sales in the EU market went to the EU farmers growing feedstock crops.
- EU farmers have experienced increased competition from foreign feedstock providers. For example, in 2008 44 per cent of biodiesel consumed in the European Union was produced using imported feedstock.
- If biofuel market support were removed in the European Union, farmers' revenues would likely decrease, mainly due to lower prices for agricultural commodities. But, according to the available modelling results, farmers would be able to re-orient some of their sales to external markets.

6.1.3 Employment and EU biofuel policies

Introduction

This section reviews the key issues associated with defining and measuring jobs generated by the development of the EU biofuels sector. Many EU governments consider the potential impacts of various options on employment in developing biofuel and energy-sector policy. As this section illustrates, if job creation is considered an important objective for supporting the development and deployment of biofuels, the level of detailed information available on employment effects is currently insufficient. A key finding is more research is required into assessing and monitoring biofuel-sector employment, in order to balance the expected benefits and outcomes from the industry against associated opportunity costs (IRENA, p.4, 2011).

Biofuel production: what types of jobs are being created?

Liquid biofuels for transport differ from wind and solar renewable energy as they involve energy inputs that are not freely available (in contrast with the wind and solar radiation), such as crops used as biofeedstocks or residues from various industries. Ethanol and biodiesel industry representatives claim an expansion of biofuel consumption, either first generation or second generation fuels, would create direct jobs within the industry and additional jobs in other sectors, such as agriculture (ePure, 2012; EBB, 2012). For the production of agricultural commodities used as biofuel feedstocks, jobs in agriculture–notably farmers and seasonal workers – are required.[39] For second-generation biofuels, to the extent that they are based on residues or waste products, their collection and pre-treatment generates jobs in this stage of the production process. Refining ethanol and biodiesel requires technically skilled labour, like chemists, plant operators and engineers, before the biofuel can be distributed for sale (ePure, 2012). Aside from agriculture, the EU biofuel industry foresees the development of skilled jobs to be created in areas such as scientific research, technology development and engineering (EBB, 2012; ePure, 2012).

Defining and measuring biofuel-related jobs

Biofuel-related jobs can be broadly classified into the following categories: **direct jobs** (those employed by the project itself), **indirect jobs** (people employed to supply inputs to the project or sector), and **induced jobs of type 1** (people employed to deliver goods and services to meet additional consumption occurring from directly and indirectly employed workers) (IRENA, p.4, 2011) and induced jobs of type 2 where increasing prices for transportation reduces consumption and hence production and employment in these sectors (Breitschopf et al., 2012). The biofuels production process starts with the growing of biofeedstocks and extends to the final sale of biofuels to the consumer, resulting in a production and consumption cycle straddling agricultural and energy markets and systems. Due to the wide range of sectors in which jobs are claimed to be created, especially in the upstream agricultural sector, this has become a highly contested space, with the overall number and quality of jobs created by the biofuels industry subject to disagreement (Ecofys, 2012; Swenson, 2006). One criticism relating to the claims that the biofuels sector creates new jobs is that many of the farm related jobs would likely have existed with or without biofuels. A key issue is one of additionality, in that the additional jobs created by the biofuels sector are likely those associated with biofuel processing facilities or transport (due to the increased use of tanker drivers given challenges in piping biofuels) (Swenson, 2006). These additional jobs may be offset by losses in petroleum processing facilities, for example.

Box 8 outlines the key methods in estimating and assessing biofuel-related jobs.

39 Jobs associated with the production and harvesting of feedstocks will depend on the feedstock used.

BOX 8: METHODOLOGIES TO MEASURE BIOFUEL-RELATED JOBS.

Data gathering

- **Project-level case studies**: calculates the number of direct and indirect jobs generated by a specific biofuel refinery, project and related supply chains. Generally used to provide site specific information, potentially aggregated upwards, and used to verify or triangulate other calculation methods.
- **Supply-chain mapping**: analyzes the supply chain for a biofuel refinery and estimates material and labour costs and profit margins at each link in the chain. The necessary labour to match the supply-chain structure can be calculated to determine employment factors. This will involve interviews with firms to establish supply-chain data.

Data generation

- **Employment factors**: estimates the average number of jobs per unit of capacity installed or fuel generated in litres, multiplied across the production base or volume of litres produced in the European Union in a given year (Data sources could include: reports & studies, survey in industry and farming, case studies, national statistics on consumption and production capacities).
- **Input-output models**: can be developed to forecast macroeconomic outcomes based on linkages through an entire economy. They are able to provide an estimate of direct, indirect, and induced employment benefits in all sectors, as well as negative effects in jobs from the fossil-fuels sector being displaced. They can be a) gross input out-put models (assessing jobs in a particular sector and upstream industries directly and indirectly involved in the construction and installation of the technology) b) net input output model, static model in which industries interactions are based on coefficients which are fixed, and c) full economic model, a dynamic model with several feedback looks and multipliers (Breitschopf et al., 2012).

Project-level case studies and supply-chain mapping are frequently used to gather data on jobs, which in turn can be used to develop **employment factors and input-output models**, which attempt to assess jobs at a national or sectorial level.

There are various methods for assessing jobs of different types. This section focuses on employment factors (see Box 8 above), as they are often cited by the EU biofuels sector. A simple approach to measure jobs (such as direct jobs) at biofuel refining sites was carried to by surveying a small sample of biofuel production plants to identify the number of reported employees working at the refining site and the plant's installed annual capacity production. Dividing the plant's installed capacity by the number of onsite jobs generated a production (in litres) multiplier for onsite jobs of 0.00000036 per litre of ethanol and 0.00000026 jobs per litre of biodiesel produced in the European Union. It should be noted, this very basic approximation, given the facilities sampled is small relative to the size of industry, annual production can varies in relation to the reported name plate installed production capacity, and additional technical modifications could have been conducted to the sampled plants, to increase or decrease their annual installed production capacity. The sample of facilities assessed is contained in the table below.

TABLE 25: SAMPLE OF EU ETHANOL AND BIODIESEL FACILITIES, PRODUCTION CAPACITY AND ONSITE JOBS

ETHANOL					
Company	**Country**	**(1) Onsite Jobs**	**(2) Annual production capacity (litres)**	**Multiplier**	**Source**
ENSUS	UK	100	400,000,000	0.00000025	(ENSUS,2012)
UK Vivergo plant	UK	80	420,000,000	0.00000019	(Vivergo,2011)
Pannonia	Hungary	80	240,000,000	0.00000033	(Pannonia Ethanol, 2012)
British Sugar	UK	42	79,000,000	0.00000053	(British Sugar, 2011)
Abengoa (Castilla y Léon)	Spain	110	159,000,000	0.00000069	(Abengoa, 2011b)
Abengoa (Netherlands)	Netherlands	84	477,000,000	0.00000018	(Abengoa, 2011a)
Average ethanol multiplier				**0.00000036**	
BIODIESEL					
Company	Country	(1) Jobs	(2) Annual production capacity (litres)	Multipliers	Source
Futurol (in Pomacle)	France	12	180,000,000	0.00000007	(Futurol, 2011)
Neste Oil (Rotterdam)	Netherlands	150	907,000,000	0.00000017	(Neste Oil, 2011)
Argent Energy	UK	39	51,000,000	0.00000076	(Argent Energy, 2011)
Infinita Renovables (Castellon)	Spain	75	679,000,000	0.00000011	(Infinita Renovables, 2011)
Infinita Renovables (Ferrol)	Spain	60	339,000,000	0.00000018	(Infinita Renovables, 2011)
Average biodiesel multiplier				**0.00000026**	

Using the average biodiesel and ethanol multipliers contained above an estimate for the number of jobs at biofuel plants (based on EU ethanol and biodiesel production figures) for 2011 was generated. As illustrated in the table below the number of onsite jobs in 2011, was estimated at 3,630.

TABLE 26: NUMBER OF JOBS AT BIOFUELS REFINING FACILITIES IN THE EU, BASED ON 2011 PRODUCTION FIGURES AND AVERAGE BIODIESEL AND ETHANOL MULTIPLIERS

	BIODIESEL**	ETHANOL***	TOTAL NUMBER
EU biofuels production (Million litres)	9,743	4,392	14,135
Average job multiplier*	0.00000026	0.00000036	
Jobs at EU biofuel refining sites	2,502	1,128	3,630

**Multipliers are the production capacity of an individual biofuel refining plant divided by the number of jobs at the site.*

***Production figures for biodiesel from EBB (2012).*

****Production figures for ethanol from ePure,(2012).*

Using employment factors assesses gross employment, which considers the sum of positive employment effects occurring from investments in the biofuels sector and does not take into account negative employment effects that may result in other sectors of the economy.

Modelling employment benefits generated by the EU biofuels sector

The second approach looks at employment, using **input-output models** with both positive and negative effects accounted for. There are, however, significant challenges in accurately calculating the net jobs to an economy over time from a specific biofuel project, policy, or at the sectorial level (Gülen, 2010, p. 10). A number of modelling studies have attempted to estimate the number and type of jobs created in the biofuels sector based on a variety of renewable-energy policy and biofuel market penetration scenarios. While studies modelling how policies may play out in the future provide some insights into potential outcomes, these studies must be viewed in the context of a number of specific challenges, ranging from defining what constitutes a job generated by the biofuels sector, the long-run uncertainties of biofuel production levels, and complicated linkages between different labour markets and a general lack of empirical data

In the case of biofuels, and other renewable energy sources, there are a range of effects from specific policies, with some jobs being "eliminated without direct replacement" and "some employment will be substituted" (World Watch, 2008, p. 4).

Is it a numbers game: jobs in the ethanol and biodiesel industry

While Box 8, "Methodologies to measure biofuel-related jobs," outlines a number of options for assessing jobs, employment factors offer a simplified approach to assessing the number of jobs created by the biofuels industry. Based on an **employment factor** proposed by the European Renewable Ethanol Association (ePure), for every 1 million litres of domestically produced renewable ethanol approximately 16 jobs are created (ePure, 2012). In 2009, ePure reported ethanol industry jobs were 73,500 (ePure, 2012). Based on the ePure multiplier, EU ethanol production in 2011 (4.4 billion litres) generated 70,272 (production figures from ePure, 2012; GSI; authors' calculations).

Based on an **employment factor** for the EU biodiesel industry cited in EurObserv'ER, every 1 million litres of biodiesel produced in the European Union creates 5.3 jobs[40] (EurObserv'ER, 2011, p. 157). Applying this **employment factor** to 2011 biodiesel production figures (9.7 billion litres) the number of jobs generated by the industry was 51,639 (production figures from EBB, 2012; GSI; authors' calculations). A coalition of organizations (EBB, ePure, COCERAL, CIBE, Copa-Cogeca, FEDIOL & EOA, 2012) reports that the EU biofuels industry creates direct jobs to 100,000 European citizens.

These employment factors are based on biofuel production remaining in the EU, however our analysis has shown that increasing amounts of imported biofuels and feedstocks (such as rapeseed, soybeans, wheat and corn are occurring) are observed (refer section: ***5.1.7. Impact on the EU's external trade and current account****). Increased imports of biofuels and feedstocks will lead to a reduction in jobs within the EU and an increase in jobs in foreign countries where biofuels is produced and exported to the EU.*

Using the figure for on-site jobs created at biofuel refining facilities (3,630) multiplied by a gross salary of €20,000 per annum (as a lower bound) and an average EU salary of EUR 28,663 gross per annum (Eurostat, 2012) as a upper bound, equates to the sector spending EUR 73 million and EUR 104 million in 2011 on salaries. Based on the number of direct, indirect and induced jobs (121,911) generated by the industry using EurObserv'ER and ePure multipliers, a EUR 20,000 per annum gross salary, as a lower bound an average EU salary of EUR 28,663 gross per annum (Eurostat, 2012) as an upper bound, its estimated the EU biofuels sector and related industries (such as transport and

[40] The EurObserv'ER based its estimate of the socio-economic impacts of EU biodiesel and vegetable oil production on an assumption of 0.007 jobs per TOE.

agriculture) spent between EUR 2.4 billion and EUR 3.5 billion on salaries in 2011. Thus, depending on the definition of jobs applied, the biofuels sector and related industries could have spent anywhere between EUR 73 million and EUR 3.5 billion on salaries in 2011 related to the biofuels sector.

Employment factors would normally be derived through some form of data analysis, although it is unclear how ePure's or EurObserv'ER's were generated. In 2011, EurObserv'ER estimated biofuel related jobs at 109,150 (EurObserv'ER, 2012a, p. 156). However, more clarity is required on whether such figures represent direct, indirect or induced jobs.

The 121,911 people employed is less than one third of the number of people working in Strasbourg metropolitan area[41], France, but more than the number of all people employed in Freiburg[42], Germany. Together with the dependents of those employees, the population of "Biofuelbourg" would be 260 – 270 thousand people.[43]

Rural development and the geographic location of jobs

The European Union supports the use of biofuels in order to pursue "opportunities offered by biofuels in terms of economic activity and job creation within the context of the cohesion policy and rural development policy" (EU, 2006). The geographic spread of jobs is seen as important, with many rural areas of Europe experiencing higher-than-average unemployment, or average incomes being lower in rural areas compared with cities. Hence ethanol and biodiesel industry jobs in rural areas are seen to correspond to one of the original policy objectives for subsidizing biofuels: rural development.

In referring to Figure 5, "Biodiesel and Ethanol Plants in Study Countries," biodiesel and ethanol plants in the five key case study counties, the majority of installed production capacity is located in "Competitiveness and Employment Regions," which are considered economically developed compared with the less developed "Convergence Regions."[44] With direct and indirect employees of the biofuels industry likely clustered around biofuel refining sites, the majority of jobs created by the EU biofuels industry are likely in "Non-Convergence Regions." Though, with the exception of one hand, north-eastern Germany is a Convergence Region and has a high concentration of production facilities. Jobs, whether it be in agriculture, or the biofuels sector, may be more important if the area is economically underdeveloped. Focusing on individual biofuel plants or the EU-wide industry as a whole reveals different levels of job creation. The Dunaföldvár biofuel plant run by Pannonia Ethanol is located in a rural, under-developed part of Hungary. Unemployment in Hungary is on average 10.3 per cent and below the EU average of 10.9 per cent (Eurostat, 2012, p. 1). The plant employees 80 staff and generates indirect and induced employment in the farming and other local sectors (Hetfa, 2012). The table below illustrates the distribution of biofuel-related jobs across the Competitiveness and Employment Regions and Convergence Regions using production-linked employment factors.

41 The economy Strasbourg metropolitan area employed slightly over 460 thousand people in 2012 (Istrate, E.; Nadeau, C., 2012)

42 The economically active labour force of Freiburg, Germany, amounted to slightly over 100 thousand in 2010 (Gesamtstadt Freiburg: sozialversicherungspflichtig Beschäftigte nach Wirtschaftskreisen am Arbeitsort).

43 Strasbourg metropolitan area was home to 1020 thousand people in 2012 (Istrate, E.; Nadeau, C., 2012), and Freiburg's population was slightly over 210 thousand in 2011 (Gesamptstadt Freiburg. Einwohner nach Jahr, Alter, Geschlecht und Deutsche Staatsangehörigkeit Zeitreihe seit 1977)

44 Convergence Regions are areas within the EU where the per capita GDP is less than 75% of the average of the EU-25 countries.

TABLE 27: BREAKDOWN OF BIOFUEL RELATED JOBS IN EU DEVELOPMENT REGIONS IN 2011[45]

EMPLOYMENT FIGURES BASED ON 2011 PRODUCTION FIGURES				
	ETHANOL		BIODIESEL	
Location	Number	%	Number	%
Competitiveness and Employment region	48,414	69	33,049	69
Convergence region	21,858	31	18,590	35
Total	**70,272**	**100**	**51,639**	**100**

Source: Biofuel production numbers converted into number of jobs based on employment multiplier factors (Ethanol: ePure [2012]; Biodiesel: EurObserv'ER [2011]).

Notes:

**In estimating the number of jobs in countries with both Convergence regions and Competitiveness and Employment regions (such as Germany, Italy and the United Kingdom) the surface area of the Convergence region was divided by the country's total surface area (Source: http://www.internetworldstats.com/europa.htm)" to establish the percentage surface area of the country with Convergence designated areas. The geographic location of biofuel refineries for the country was then plotted between Convergence regions and Competitiveness and Employment regions, a percentage of the countries installed production capacity was estimated to each region. The two percentages (for the amount land designated as either of Convergence or Competiveness and Employment areas and the average distribution of installed production capacity split between the two regions) were then averaged out and used as the factor multiplied with biofuel production for that year in order to estimate whether jobs were situated in Convergence regions or Competitiveness and Employment regions.*

**The jobs separated by region do not represent specific country figures or data and are only illustrative based on production figures and employment multipliers.*

Key findings

- If rural development and job creation is an important objective or expected outcome, there is insufficient detail or granular information on a number of key issues. These include the following: a) the number of direct, indirect and induced jobs; b) the type of jobs, whether they are rural agricultural jobs or more skilled technical roles; and c) their geographic location across the EU (i.e., located in Convergence Regions or not).
- More work is needed to understand the overall net job impact on the EU economy from biofuels. Caution needs to be exercised when assessing jobs generated by any renewable energy industry, not just biofuels, as data on green jobs are generally weak, sensitive to modelling or job counting definitions or assumptions.
- For 2011, using the figure for on-site jobs created at biofuel refining facilities the sector may have spent between EUR 73 million and EUR 104 million on salaries, based on the number of direct, indirect and induced jobs (121,911) generated by the industry using EurObserv'ER and ePure the EU biofuels sector and related industries (such as transport and agriculture) may have spent between EUR 2.4 billion and EUR 3.5 billion on salaries. Thus, depending on the definition of jobs applied, the biofuels sector and related industries could have spent anywhere between EUR 73 million and EUR 3.5 billion on salaries.
- Based on a review of available modelling studies, an overall net benefit to the economy from additional jobs created by supporting the biofuels industry is possible, though results from these studies indicate these benefits may not be significant and depend on assumptions and future market trends.
- Jobs created by the industry may not be located in the poorest rural areas of the EU (i.e., such as in Convergence Regions).

[45] Job figures represented in the table are illustrative and calculated using employment factors for ethanol and biodiesel (16 jobs per 100 million litres for ethanol, 5.3 jobs per million litres for biodiesel) against 2011 EU ethanol and biodiesel production by country.

6.1.4 Reduced consumption of fossil fuels

The various projections available of biofuel consumption illustrate the uncertainty that exists around the industry size and the levels of production and imports that can be expected by 2020. Figure 23 shows a comparison between current consumption, the EC Impact Assessment to 2020, and the targets from the member state National Renewable Energy Action Plans (NREAPs).[46] The Renewable Energy Directive (2009/28/EC) (European Commission, 2009a) requires all countries to submit NREAPs detailing how they propose to meet the legally binding 2020 renewable energy targets. The graph shows that if the targets in the NREAPs are met the consumption of biofuels will increase by two to three times by 2020. This would result in an increase from approximately 14 to 42 billion litres for biodiesel, and 6 to 23 billion litres for ethanol.

An increase in consumption of this scale seems at odds with the current concerns over the sustainability of biofuels. Anecdotal evidence shows that a number of countries have already revised down targets or announced moratoriums on the production of food-crop-based biofuels (Biofuels Digest, 2013) (Reuters, 2013). In light of the changing political climate for biofuels, the NREAPs should be revised to reduce the national targets and to better reflect current realities.

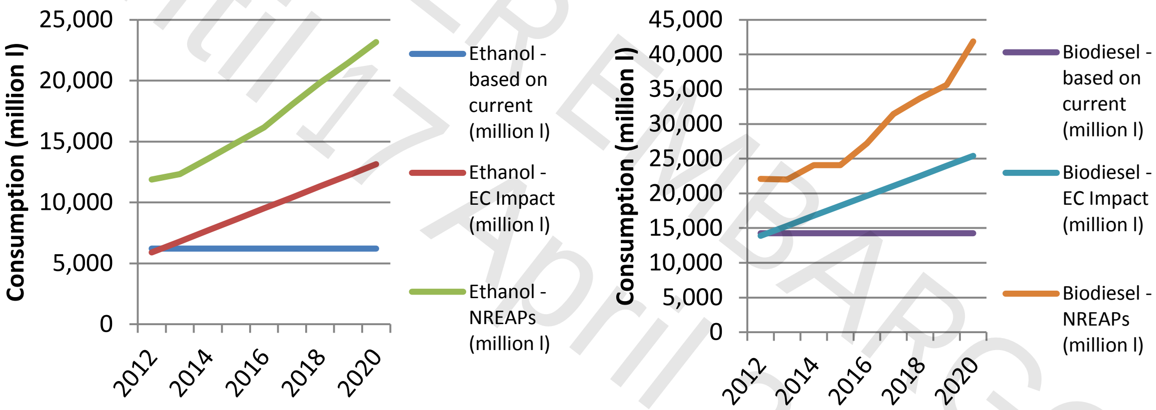


FIGURE 23: PROJECTIONS OF BIOFUELS CONSUMPTION BASED ON CURRENT CONSUMPTION, THE EC IMPACT ASSESSMENT AND COUNTY NREAPS.

The quantity of fossil-fuel consumption that will be offset by the consumption of biofuels, in petrol-and diesel-equivalent volumes, is shown in Figure 24. The projections show that if current consumption is maintained, approximately 3.7 billion litres of petrol and 11 billion litres of diesel will be replaced by biofuels. If biofuel consumption increased in line with the EC Impact Assessment, 7.8 billion litres of petrol and 17.6 billion litres of diesel would be displaced per year by 2020. If biofuel consumption followed NREAP's projections, 13.7 billion litres of petrol and 32.3 billion litres of diesel would be displaced per year by 2020.

[46] National Renewable Action Plans (NREAPs) found here: http://ec.europa.eu/energy/renewables/action_plan_en.htm.

BOX 9: PETROLEUM AND COMMODITY MARKET PRICE INTER-LINKAGES.

Increasingly prices for a basket of food commodities used in the production of biofuels (such as corn) are tracking prices for gasoline and diesel (which are a factor of oil prices given this is used to refine road transport fuels) (Kretschmer et al., p. 27). Linking crop markets to fuel markets may have a small portfolio effect on fuel markets, helping to dampen price volatility a little, but this can also make part of the fuel market vulnerable to factors such as drought that affect agricultural commodity prices. The volatility is not, like in some portfolios, counter-cyclical, but partially linked. That means that fuel-price peaks may occur simultaneously with crop-price peaks, aggravating each other -- as happened in 2007-08. Moreover, for the portfolio effect to work, demand for biofuels should be responsive to prices. That is, when petroleum prices are moderate but crop prices are high, consumers should be able to back off on their consumption of biofuels. But they are unable to due to consumption mandates. So the volatility-moderating effect works only in one set of circumstances: when petroleum prices are high and crop prices are low (FAO, 2011, p. 12).

Indigenously produced biofuels displacing imported petroleum products could provide an avenue for improving the EU's level of energy self-sufficiency.[47] However, this would only be true if the raw materials were produced in the EU and this seems unlikely. The EU's energy dependence rate has remained roughly stable since 2008 and was 54 per cent in the EU-27 in 2011 (Eurostat, pg.1, 2012). The ability of domestically produced biofuels to improve the dependence rate is subject to a number of uncertainties. The potential costs of scaling up domestic biofuel production is one significant barrier to greater deployment, another is the impact on food security. Alternatively, imported biofuels could also offer a more cost-effective way of reducing emissions by displacing petrol and diesel consumption, but result in greater net energy imports from foreign countries outside the EU. Energy dependence rates also vary at the national level for Member States, with the UK's dependence rate at 36 per cent, and Denmark as a net exporter of energy being negative, at -9 per cent (Eurostat,pg.2, 2012). Consequently the ability of indigenously produced biofuels to meaningful impact energy dependence rates will depend on Member States ability to source biofuels from their domestic industry or trade with other Member States. The degree of energy dependency can also be reduced through measures impacting energy demand, for example fuel efficiency measures. These may provide a much cheaper way of achieving the same outcome.

Increased biofuel use also has energy–security impacts through portfolio effects, where the costs and risks associated with each energy source are considered (Awerbuch, 2006). Increasing biofuels may have a positive impact on energy security through increased diversity and the reduction of risks related to exposure to fossil-fuel markets.

[47] The energy dependency rate is a measure of the proportion of energy that an economy must import. Defined as net energy imports divided by gross consumption plus exports. http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Glossary:Energy_dependency_rate

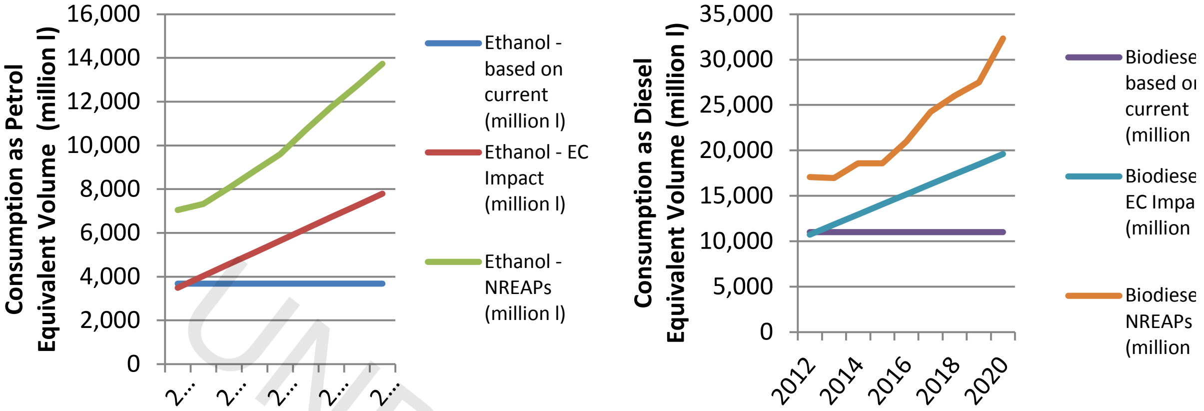


FIGURE 24: PROJECTIONS OF BIOFUEL CONSUMPTION TO 2020 PRESENTED AS PETROL AND DIESEL EQUIVALENT VOLUMES

Effects of biofuel consumption on the EU's energy bill

The EU's growing biofuel consumption has considerable effects on the EU's energy bill. In 2012, 131 billion litres of petrol and 197 billion litres of diesel (including biofuel blends) were consumed in the EU (European Energy and Transport Trends to 2030, DG Trend, 2009) at an average price of 0.72 and 0.77 EUR/litres (European Commission, 2012a, Energy Policy) respectively, which lead to a total spending for non-biofuel road fuels of EUR 247 billion: 94.8 billion for petrol and EUR 152.1 billion for diesel[48] (source: authors' calculations based on European Commission price data and European Energy and Transport Trends to 2030, DG Trend consumption data). When it comes to official sources, this figure is slightly higher: the EC Directorate-General for Energy estimates that each year the European Union spends EUR 329 billion on petroleum products (EC Directorate-General for Energy, 2011).

TABLE 28: EFFECTS OF BIOFUEL CONSUMPTION ON THE EU'S ENERGY BILL

YEAR 2012	PETROL	DIESEL	TOTAL
EU Consumption of road fuels including biofuels (million litres)	131,000	197,000	328,000
EU consumption of road fuels excluding biofuels (million litres)	127,000	186,000	313,000
Road fuels displaced by biofuels use (million litres)	3,680	11,000	14,700
Average price per petrol and diesel (€/litre)	0.72	0.77	
Total expenditure on road fuels (including biofuels) (billion €)	97.5	160.6	258.1
Reduction in expenditure on road fuels due to biofuel offset (billion €)	2.67	8.52	11.18
Total cost of road fuels products (excluding biofuels) (billion €)	94.8	152,1	246,9
Reduction in expenditure on non-biofuel road fuels (%)	2	4	

Sources:

Average prices (net of duties and taxes): (European Commission, 2012a, Energy Policy)

Consumption and litre petrol/diesel displaced: (European Energy and Transport Trends to 2030, DG Trend, 2009) (conversion factors applied from Eurostat)

Consumption of ethanol and biodiesel: EurObserv'ER, 2012a.

[48] Figures include blended biofuels and the calculation doesn't account for different excise tax regimes applied to the petrol, diesel, ethanol or biodiesel

In general, the use of biofuels can effectively reduce the expenditure of EU motorists on petrol and diesel, in 2012, the amount of ethanol displaced equalled 3.7 billion litres and the amount of biodiesel equalled 11 billion litres, which led to EUR 2.7 billion and EUR 8.5 billion reductions in expenditure on petroleum products.

Key Findings

- The projections show that if current consumption is maintained, approximately 3.7 billion litres of petrol and 11 billion litres of diesel will be replaced by biofuels. If biofuel consumption increases in line with the EC Impact Assessment, 7.8 billion litres of petrol and 19.6 billion litres of diesel will be displaced by 2020. If consumption dramatically increases in line with NREAPs, 13.7 billion litres of petrol and 32.3 billion litres of diesel per year will be displaced by 2020.
- The level of conventional biofuel consumption in the EU from 2013 through to 2020 will be a function of policy decisions, given the policy-driven nature of the EU biofuels market.
- The use of domestically produced biofuels may improve EU energy dependence ratios by decreasing the importation of energy in the form of foreign oil or related petroleum products, while imported biofuels or feedstocks will count as imported energy.[49]

6.2 Non-Economic Benefits

6.2.1 Technology and innovation spillovers

The full economic benefit to society of investing in research and development (R&D) cannot be fully captured by the firm making that investment. This is because the knowledge generated by the research will, to some degree and over time, flow to other firms in the economy. Knowledge 'spillovers' are a positive externality, boosting productivity of the industry and the economy as a whole. The sum of the private rate of return of R&D investments and the external benefits is known as the social rate of return (Parsons & Phillips, 2007). Because firms are not able to harness the full social rate of return, they tend to invest less in R&D than is socially optimal. Governments attempt to correct this market failure by providing R&D subsidies. At the time of writing, there were no studies quantifying the social rate of return for biofuels-related R&D.[50]

The existence of a spillover effect does not justify a subsidy in itself. Several other factors must be taken into account:

- the responsiveness of private R&D investment to the subsidy;
- whether the size of the spillover is sufficient to offset the subsidy, including the economic inefficiencies generated by raising the public funds to finance the subsidy (the marginal cost of public funds);
- the extent to which incentives in one industry will draw investment and capacity away from R&D investment in another industry;
- the cost of administering and complying with the provision of the subsidy.

[49] The energy dependency rate is a measure of the proportion of energy that an economy must import. Defined as net energy imports divided by gross consumption plus exports http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Glossary:Energy_dependency_rate

[50] (Corderi & Lin, 2011) estimated the social rate of return in the energy manufacturing sector (coal, petroleum products and nuclear fuel) in 13 OECD countries. They found a social rate of return of between 3 per cent and 26 per cent in the EU countries examined. However, this is a lower-bound estimate because the study only examined intra-industry and domestic productivity gains. Knowledge will also flow between industries and countries, generating larger productivity gains. Many studies attempting to measure the social rate of return in the industrial sector vary widely depending on countries, time periods, industries and methods of calculation. In a summary of the literature, (Hall, Mairesse , & Mohnen, 2010) found that estimates of domestic inter-industry social rates of return varied from 0 per cent to 100 per cent or even higher in some studies. (Parsons & Phillips, 2007) found that estimates of these rates of return for OECD countries varied between 11 per cent in France in one study to 270 per cent in Australia in another.

(Parsons & Phillips, 2007) performed an analysis of Canada's Federal Tax Credit for Scientific Research and Experimental Development using a partial equilibrium analysis. They found that the R&D spillover effect more than offsets the tax distortions and compliance costs associated with the R&D tax incentives. Overall, the estimated net welfare gain per dollar of tax subsidy program was 0.109 (i.e., based on a tax subsidy of $2.9 billion in 2004, the net welfare gain was over $300 million). Similarly detailed analyses would be necessary in the EU to determine whether any spillover benefits justify the costs of the R&D subsidies in place.

The above discussion relates to subsidies specific to R&D. Government's use of downstream subsidies (such as consumption tax exemptions or blending mandates) also creates an incentive to innovate by increasing the commercial viability of the end product (Rausser, Torani, & Stevens, 2010). The biofuels attracting the majority of downstream subsidies are using mature technologies that have been in existence for several decades, creating little R&D spillover benefits. . However, if government measures were more differentiated on the basis of the desired objective, e.g., on greenhouse gas performance, this would provide a much stronger incentive for innovation.

In 2007, corporate R&D investment in transport biofuels was estimated to be EUR 269 million, based on an assessment of 23 companies by (Wiesenthal, Leduc, Schwarz, & Haegeman, 2009). This would more than four times public investment of EUR 65 million in the same year. The R&D intensity is the ratio of the industry's expenditure on R&D compared with sales, and for biofuels it is higher in the EU than for other renewable-energy technologies.

TABLE 29: COMPARISON OF R&D INTENSITY OF SELECTED ENERGY AND INDUSTRIAL SECTORS IN THE EU, 2007

SECTOR	ESTIMATED R&D INTENSITY (%)
Transport biofuels	3.6 - 4.5
Solar energy	2.2 - 2.5
Wind power	2.6 – 3
Electricity	0.6
Oil and gas	0.3
Automobiles and parts	4.6

Source: (Wiesenthal, Leduc, Schwarz, & Haegeman, 2009)

Key findings

- To date no studies have quantified the social rate of return for biofuels-related R&D. Existing studies on social rates of return in a variety of sectors demonstrate a wide range of estimates. It is important to note that in spite of social returns, spillover effects do not necessarily justify the subsidy itself. A biofuel analysis should include, among others, an assessment of the responsiveness of private R&D investment to the subsidy and the opportunity cost of the subsidy.
- Differentiated biofuel policy on the basis of the desired objective such as greenhouse gas performance could stimulate greater innovation.
- The R&D intensity represents the industry's expenditure on R&D compared with sales. It is found that R&D intensity for biofuels in the EU is higher than the one for other renewable energy technologies. In 2007, it was estimated at in between 3.6 and 4.5 per cent.

6.2.2 EU biofuel policies and Greenhouse gas emissions

Emissions from biofuels can be broadly split into two different groups: (1) direct emissions from the cultivation, processing and transport of biofuels, including direct land-use change, and (2) indirect land use changes leading to emissions from growing biofuel feedstock crops (European Commission, 2012). This section assesses the emissions generated by biofuel use under a number of scenarios of energy consumed in road transport, and of policies relating to the level of biofuel consumed in the EU through to 2020. It first deals with direct emissions exclusive of direct land use change, and subsequently with land use change related emissions.

Scenarios and Sensitivity Analyses

A single estimate for direct and indirect land-use change emissions would unjustifiably reduce the complexity of measuring emissions from biofuel policies and projections for transport energy demand. Therefore, the following assessment incorporates 5 policy scenarios, 3 transport energy demand projections and a sensitivity analysis based on Monte Carlo simulations for the calculation of emissions associated with ILUC (described more in detail in the ILUC section of the Technical Annex).

In October 2012, the European Commission proposed to limit the use of conventional biofuels from food crops by capping the contribution that first-generation biofuels could make to meeting the 10 per cent target of the Renewable Energy Directive to 5 per cent (European Commission, 2012). The Commission established that this would be equal to current production levels of first-generation biofuels. This proposal, subject to the normal legislative procedure is now with the Council and European Parliament for consideration. Because the 5 per cent cap is the official proposal and is claimed to represent current ethanol and biodiesel production levels, the "5 per cent scenario" is the central scenario.

There are five scenarios related to a cap on biofuels:

1. 5 per cent food based biofuels
2. 3 per cent food based biofuels
3. 7 per cent food based biofuels
4. 7 per cent food based biofuels with ethanol growth only
5. 10 per cent food based biofuels

In the three standard scenarios, linear growth or decrease is assumed.[51] The "7 per cent ethanol growth only" scenario steps away from this and assumes a status quo in biodiesel production, while the additional 2 per cent is met by an increase in ethanol consumption. It must be noted that a linear assumption with 2 per cent ethanol growth has certain limitations. In particular ILUC factors may change if ethanol production and consumption increases strongly. However, to date it has not been demonstrated that ILUC factors would change significantly when affected by the consumption values under discussion. Finally, as linear growth is an imperfect assumption, a second 10 per cent scenario is based on 2020 feedstock distribution projections by the European Commission (in itself taken from IFPRI-MIRAGE-BioF simulations). This 10 per cent biofuels scenario, based on EC projections will be useful to evaluate how far off linear assumption might be.

[51] This simply means the study assumes an equal feedstock distribution in 2020 as the latest reported distribution (2008).

These scenarios are all based on the assumption that a 5 per cent cap, which is made up of roughly 17 per cent ethanol and 83 per cent biodiesel, is equal to around 14 million tonnes of oil equivalent (MTOE) of biofuels, which is roughly equal to current production levels, as there are negligible levels of second-generation biofuels consumed in the European Union. This figure for the energetic value of current biofuel production provided by the European Commission explaining the 5 per cent scenario in its Impact Assessment accompanying the proposal and indeed represents current production levels. However, since the different scenarios are based on percentages, caution is warranted. The percentage of biofuels (based on an energy content) that might be used in the transport sector and not to exceed the caps depends on how one estimates or projects the overall energy used in road transport. The following table outlines the three road transport energy scenarios assessed in this study.

TABLE 30: THREE SCENARIOS FOR PROJECTED ROAD TRANSPORT ENERGY DEMAND, 2020

PROJECTED ROAD TRANSPORT ENERGY DEMAND (MTOE) - 2020	EXPLANATION	SOURCE
280 MTOE Scenario	Current biofuels consumption level (14 MTOE) represents 5 per cent. Level is about equal to the 2020 Fleet and Fuels reference scenario of JEC (281 MTOE).	(Lonza, Hass, Maas, Reid, & Rose, 2011)
312 MTOE Scenario	Value estimated in the Impact Assessment accompanying the 5 per cent cap proposal of the EC.	(European Commission, 2012)
350 MTOE Scenario	High-end scenario of 2020 projection derived by JEC from European Energy and Transport Trends to 2010.	(Lonza, Hass, Maas, Reid, & Rose, 2011).

For example, a 5 per cent cap based on a projected road transport energy use of 312 MTOE (the estimate of the European Commission in its impact assessment) would result in 15.6 MTOE of food-crop-based biofuels used in 2020. This value is significantly higher than the 14 MTOE of energy delivered by biofuels today. It would represent only 4.5 per cent biofuels under a 312 MTOE road-energy-demand scenario. The amount consumed that was subject to a percentage cap would therefore be largely dependent on the transport energy demand in 2020. The study looks at three different scenarios for energy demand.

One element that has not been treated in this greenhouse gas analysis but that has potential important impacts on total greenhouse gas savings is the one of Indirect Fuel Use Change (IFUC). Rajagopal, Hochman and Zilberman (2011) hold that biofuel mandates may lead to higher fuel prices in the domestic market as a result of higher biofuel prices. This may lead to a reduction in consumption. However, at the same time, such a reduction in domestic consumption can decrease international fuel prices and subsequently be responsible for an increase in fuel consumption in other parts of the world. These indirect fuel use change effects can alter alleged emission savings from biofuels.

Total Emissions from EU Biofuel Policies

Total emissions as a result of EU biofuel policies under different scenarios are based on the sum of direct emissions and emissions as a result of indirect land use change, exclusive of credit for reduced food consumption and other indirect effects such as IFUC. A deeper analysis of the issues, methodological challenges and associated results can be found in the accompanying Technical Annex in Section 7, "Direct Emissions and Emissions from Land Use Change." This study has included sensitivity based on low and high ILUC factors as found under the Monte Carlo analysis performed by Laborde (2011). The use of low and high ILUC factors improves the robustness of the analysis.

Caps on first generation biofuels have the strongest effect on total estimated emissions of all three variables. Assuming a central ILUC factor and a 312 MTOE road energy demand in 2020, we find a large difference between biofuel caps, with a general emission intensity of about 11 million tonnes of CO_2 per 1 per cent biofuels. ILUC emissions are significant. For biodiesel ILUC emissions reach 55.17 gCO_2/MJ. For ethanol this is 12.36 gCO_2/MJ. A 3 per cent cap would generate a little over 30 million tonnes CO_2 eq, while a 5 per cent and 7 per cent cap would respectively generate about 55 million tonnes and 75 million tonnes CO_2 eq. When 7 per cent is met by ethanol growth only, total emissions are estimated at a little over 60 million tonnes. Finally, a 10 per cent scenario generates very high emissions, at around 110 million tonnes CO_2 eq. In this case, it can be seen that emission savings as a result of biofuels are severely limited (see below).

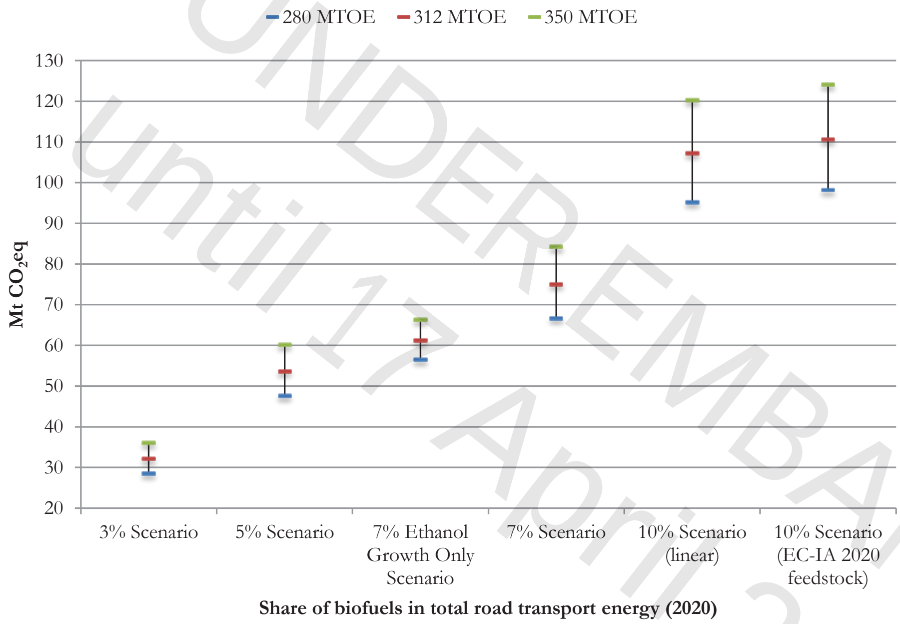


FIGURE 25: TOTAL TRANSPORT-RELATED GREENHOUSE GAS EMISSIONS UNDER A CENTRAL ILUC FACTOR SCENARIO

Source: Author calculations

In line with the findings on ILUC estimates, a sensitivity analysis on ILUC factors also shows remarkable differences. Under a 5 per cent cap and a 312 MTOE road-energy-demand scenario, total emissions can vary from a low of about 40 million tonnes CO_2 eq to a high of around 66 million tonnes CO_2 eq, with a central scenario of 54 million tonnes CO_2 eq. These results indicate that in spite of uncertainty related to ILUC and related modelling, total emissions from biofuels are likely to remain very high.

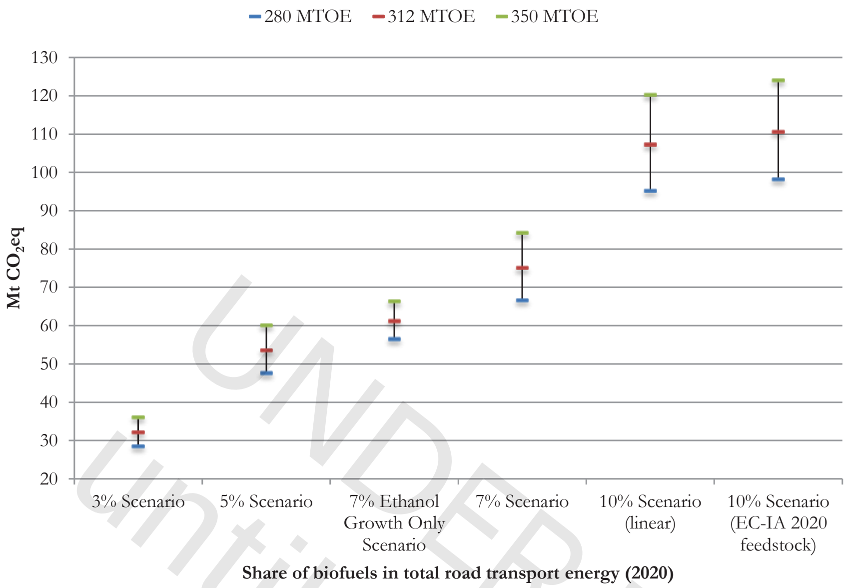


FIGURE 26: TOTAL TRANSPORT-RELATED GREENHOUSE GAS EMISSIONS UNDER A 5 PER CENT CAP SCENARIO (VARIABLE ILUC FACTORS)

Source: Author calculations

Emission Savings from EU Biofuel Policies

To estimate emission savings, we first calculated how much emissions would be generated in a no-biofuels scenario where fossil-fuels are the only transport fuel. For this, we used the fossil-fuel comparator that was used by the European Commission in its Impact Assessment (90.3g CO_2 eq/MJ) and the equivalent share of energy (MJ) from biofuels consumption levels (3 per cent, 5 per cent, 7 per cent and 10 per cent) under different road transport energy demand scenarios, inclusive of ILUC estimates. The 90.3 g/MJ fossil-fuel comparator may, however, be a conservative one. The Renewable Energy Directive, for example, specifies that 83.8 g CO_2 eq/MJ can be used to calculate emission savings (European Parliament and Council, 2009). If this latter number would be used, emission savings from biofuels would be even lower in the calculations below.

TABLE 31: EQUIVALENT FOSSIL-FUEL EMISSIONS FROM BIOFUEL SHARE UNDER THE DIFFERENT SCENARIOS (MILLION TONNES OF CO_2 EQ)

		TOTAL ROAD TRANSPORT ENERGY DEMAND (2020)		
		280 MTOE	312 MTOE	350 MTOE
Share of biofuels in total road energy (2020)	3 per cent scenario	31.8	35.4	39.7
	5 per cent scenario	52.9	59.0	66.2
	7 per cent scenario	74.1	82.6	92.6
	10 per cent scenario	105.9	118.0	132.3

Source: Author calculations

Table 32 then shows the emissions savings from biofuels. In a 280 MTOE scenario, assuming ILUC emissions are very low (5th percentile), a maximum of 17 million tonnes CO_2 eq is then saved by using biofuels compared to fossil fuels. On the other hand, when assuming high ILUC (95th percentile), net emissions even increase by 6 to 8 million tonnes CO_2 eq. When assuming a central ILUC factor, one can observe that in any road energy demand scenario, emissions saved would be at most 6 million tonnes CO_2.

TABLE 32: CHANGES IN THE EMISSION FROM BIOFUELS UNDER 5 PER CENT BIOFUEL CAP SCENARIO AND DIFFERENT ASSUMPTIONS ABOUT ILUC FACTORS AND TOTAL ROAD TRANSPORT DEMAND (MILLION TONNES IN 2020)

		TOTAL ROAD TRANSPORT ENERGY DEMAND (2020)		
		280 MTOE	312 MTOE	350 MTOE
Share of biofuels in total road energy (2020)	5th	-16.9	-18.4	-20.6
	25th	-9.5	-10.1	-11.3
	Central	-5.3	-5.3	-6.0
	75th	-0.9	-0.3	-0.4
	95th	+5.9	+7.3	+8.2

Source: Author calculations:

To put these numbers in perspective, we show what share of total transport fuel emissions could be saved by using biofuels under a 5 per cent scenario. For a reference emission number, one could use the Annual European Union greenhouse gas inventory report 2012, submitted to the United Nations Framework Convention on Climate Change (UNFCCC) Secretariat on 27 May 2012. Using this report, it was possible to calculate the emissions from road energy transportation for the EU15 at 871 million tonnes. (European Environment Agency, 2012). However, this figure is only to provide a context, since it only covers tailpipe emissions of the EU15. The biofuel numbers, however, cover direct emissions beyond tailpipe emissions, including elements such as direct emissions from processing and transportation. Therefore, we simply estimated total emissions per road transport energy demand scenario using the fossil-fuel comparator of 90.3 g/MJ.

TABLE 33: SAVINGS FROM BIOFUELS RELATIVE TO TOTAL EU-27 ROAD TRANSPORT EMISSIONS (PER CENT)

TOTAL ROAD TRANSPORT ENERGY DEMAND (2020)		
	312 MTOE	
Percentile of ILUC factor in Monte Carlo analysis	5th	1.6
	25th	0.9
	Central	0.5
	75th	0.0
	95th	-0.6

Source: Author calculations

As expected, variations were low between different road transport energy demand scenarios as a result of the percentage based cap (i.e., relative to total demand, percentage savings remain similar). At best, when assuming a low ILUC factor, biofuels would save 1.6 per cent of total road transport emissions. In a standard scenario using central ILUC factors, it is clear that first-generation biofuels would save a maximum of 0.5 per cent of total tailpipe road transport emissions. These already limited emission savings cancel out when the precautionary principle according to (Di Lucia, Ahlgren, & Ericsson, 2012) is applied (assuming higher ILUC factors). In the highest percentile of ILUC factors, first-generation biofuels can even be responsible for a 0.6 per cent increase in transport emissions and this is before taking account of reduced food consumption and any rebound in oil consumption.

Benefit and costs associated with emission savings

a. Social cost of carbon

The social cost of carbon (SCC) refers to the monetized cost (damage) of the impacts of climate change. It is estimated as the net present value of the impact of an additional tonnes of carbon emitted today or in a given year (Downing, et al., 2005). This monetized cost includes, among others, losses in agricultural production and reduced or foregone economic activity as a result of damage related to extreme weather events and climate-change impacts on human health (Interagency Working Group on Social Cost of Carbon, United States Government, 2010). It is thus an estimate on the value of reducing future damage of carbon emissions today or in a given year. Technical Annex, Section 8: The Social Cost of Carbon contains a more detailed discussion.

In the SCC science, any policy that saves emissions is granted a 'social benefit' to society from those emission decreases. This, however, does not mean that there is a net social benefit from those policies. The only thing the social cost of carbon does is monetizing the benefit from emission savings. For example in the case of biofuels, a social benefit from the emissions savings under a central scenario does not include costs associated with, for example, environmental and biodiversity degradation as a result of feedstock and biofuel production. It is crucial to keep in mind that the social cost of carbon thus only relates to emissions. The useful part is to be able to compare the monetized social benefit to the amount of subsidies to biofuels.

As is the case for emissions savings from biofuels, the social benefits generated by emissions savings is dependent on total road transport energy demand in 2020 and the choice of ILUC factors. When taking the least precautionary approach and assuming a low ILUC factor (5th percentile) and lower climate impacts on the economy, we find that the value of avoiding 18 million tonnes of CO_2 eq in 2020 reaches about EUR 100 million. On the contrary, when assuming a high ILUC factor (95th percentile) and a low climate impact on the economy, EU biofuel consumption generates additional costs to society as a result of emission increases as a result of biofuels, rather than benefits. The value of economic costs of adding 7.3 million tonnes of CO_2 eq reaches EUR 38 million. When we apply the most precautionary approach and assume a high ILUC factor and a large impact of climate change on the economy, we logically find the highest economic cost of adding 7.3 million tonnes emissions at around EUR 450 million.

TABLE 34: SOCIAL BENEFITS OF EU BIOFUEL EMISSION REDUCTION IN 2020 (MILLION EUR, 5 PER CENT CAP, 312 MTOE)

	DISCOUNT RATES			
ILUC FACTOR PERCENTILE	**5 PER CENT AVG**	**3 PER CENT AVG**	**2.5 PER CENT AVG**	**3 PER CENT 95TH**
5th percentile	96.6	373.5	592.2	1,146.2
25th percentile	52.9	204.6	69.2	627.8
Central	28.0	108.4	171.8	332.5
75th percentile	1.8	7.0	11.0	21.4
95th percentile	-38.4	-148.4	-235.3	-455.4

Source: Author calculations

Note: lower discount rates imply a higher impact of climate change on the economy or, differently put, a higher cost of carbon, which means that emissions savings from any policy are valued higher. The 95th percentile of the 3 per cent discount rate represents the highest impact of climate change on the economy.

When we assume a central ILUC factor, a median road transport energy demand and a 3 per cent discount rate for the social cost of carbon, we find that value of emissions avoided as a result of EU biofuel consumption only reaches EUR 108 million. This is a very low monetized benefit from emission savings when one compares this amount with the EUR 10.6 billion of subsidies flowing to first generation biofuels. This stark contrast remains even when one assumes a scenario with very low ILUC factors (5th percentile) and the highest impact of climate change on the economy (95th percentile of 3 per cent discount rate). The lesson behind this is one of opportunity costs: biofuel subsidies are not cost-effective in generating (relatively little) greenhouse gas emission reductions. There is a large range in economic benefits or costs of avoiding or adding emissions in 2020 as a result of biofuels. As it cannot be excluded that the use biofuels will add emissions as a result of ILUC, it is possible that biofuel policies will cause a net cost on top of the subsidies to society.

b. CO_2 abatement cost of EU biofuels

The CO_2 abatement cost of renewable energies is a useful indicator to estimate how costly a carbon reduction policy is, in comparison with other forms of renewable energy. For the EU, it is possible to divide the Total Support Estimate of biofuels as a whole by the emissions saved as a result of EU biofuel policies. To estimate the difference between ethanol and biodiesel the method for calculating total greenhouse gas emissions was partially adjusted in that direct emissions were not taken from the EC Impact Assessment accompanying the October 17 proposal directly, but rather they were calculated using the factors provided in the Well-to-wheels Analysis of Future Automotive Fuels and Powertrains in the European Context, which is the study upon which the EC had based its direct emission calculations.

Using the Well-to-wheels analysis make it possible to calculate direct emissions for biofuels from different types of feedstock. In this analysis we assumed the most optimal use of feedstock, even though this does not always represent the reality. For example, we assumed palm oil with methane capture, even though it is unlikely that methane capture is already widely applied in the main palm-oil producing countries. The total emissions savings estimated using these methods are in line with estimates given above, with some small variation as a result of differences in the model.

The findings are useful to understand the difference between ethanol and biodiesel. When no ILUC is included, we find a social abatement cost of around EUR 285 - 325 per tonne CO_2 for biodiesel and EUR 350 - 400 per tonne CO_2 for ethanol. However, policy-makers and scientific researchers widely agree ILUC is real and significant. When including the lowest ILUC factor (5th percentile of the Monte Carlo analysis) in the equation, social abatement costs for biodiesel and ethanol increase to around EUR 780 - 900 for biodiesel and EUR 385 - 440 for ethanol. When a moderately low ILUC factor is used (25th percentile), they increase to EUR 5,200 – 6,000 for biodiesel and EUR 415 - 475 for ethanol. This shows the fundamental significance of land use change related emissions in biodiesel production. Even when not applying the Precautionary Principle and assuming lower ILUC factors than the central scenario, the CO_2 abatement cost of biodiesel becomes very high. This implies that there are significantly cheaper methods to reduce greenhouse-gas emissions. These results are in line with those shown in Appendix 8 of the *EU Transport GHG: Routes to 2050 II* study (Schroten et al., 2012), which considered a wide range of sources.

Even more striking are the results when applying the minimum precautionary principle (i.e., a central ILUC factor, which is used by the European Commission in its Impact Assessment). In this case, the estimations observe that while the abatement cost for ethanol increases slightly, to around EUR 432 - 493 per tonne CO_2 avoided, there is no longer an abatement cost for biodiesel. Indeed, under such a scenario, emission savings from EU biofuels come exclusively from ethanol. Even more so, biodiesel is responsible for net emission increases of over 2 million tonnes of CO_2 eq. From the moment higher ILUC factors are used it is not possible to calculate an abatement cost for biofuels as they are responsible for net emission increases as a result of biodiesel. When ethanol is considered individually, abatement costs go up to EUR 490 - 560/tonne CO_2 eq using the highest ILUC factors.

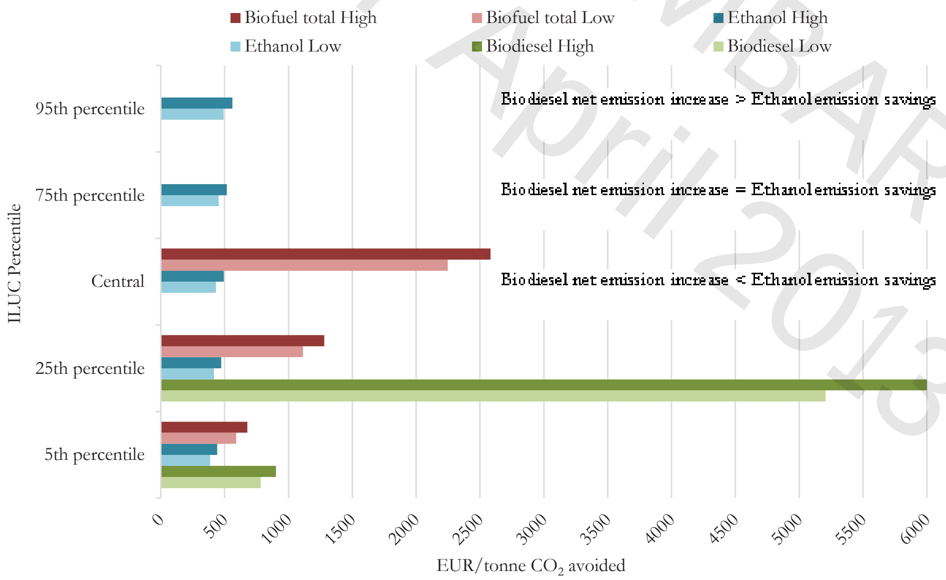


FIGURE 27: BIOFUEL ABATEMENT COSTS FOR DIFFERENT ILUC FACTORS.

Source: Author calculations.

Some types of biodiesel such as those from used cooking oil (UCO) as a feedstock are in fact competitive and have a low abatement cost. However, the portion of EU biofuels using WCO is nearly insignificant compared with those using virgin vegetable oils like rapeseed, soy, palm oil and sunflower.

Even while ethanol is performing much better in terms of greenhouse gas emission reduction potential, the abatement cost is still high compared with other renewable energies. A recent study by Marcantonini and Ellerman (2013) estimated average abatement costs from 2006 until 2010 in Germany for wind and solar energy at respectively EUR 44 and EUR 537 per tonne of CO_2 avoided. The reason for differences in abatement costs are often the fact that certain technologies (e.g., solar PV) are still higher up on the learning curve than others are not (e.g., wind).

Key Findings

- Using a central ILUC factor and without taking account of IFUC, EU biofuels would save a maximum of 5 million tonnes of CO_2 eq (or 0.5 per cent of total EU 27 road transport emissions under demand scenarios) in 2020. When applying a more stringent precautionary principle (higher ILUC factors), greenhouse gas savings are nullified or biofuels can even cause net emission increases. When a central ILUC factor is assumed, biodiesel consumption leads to net emission increases.
- Before assuming low ILUC factors, the CO_2 abatement cost of biodiesel is between EUR 785 - 900 (5th percentile ILUC factor) and EUR 5,200 – 6,000 (25th percentile) per tonne CO_2 avoided. In a minimal Precautionary Principle scenario, where central ILUC factors are assumed, EU subsidies are currently supporting net emissions increases in the case of biodiesel.
- The abatement cost of ethanol lies between EUR 385 - 440 (low ILUC factor) and EUR 490 - 560 (high ILUC factor). Given the difference in emission savings and abatements costs, greenhouse gas emission-reduction policies should distinguish between ethanol and biodiesel. When monetizing potential greenhouse gas savings, we find that at a high discount rate and assuming grave effects from climate change on the economy, the social benefits of avoided emissions achieved by the EU biofuel sector by 2020 reaches EUR 332 million. This is in stark contrast with the almost EUR 9.3 – 10.7 billion in subsidies flowing to biofuels each year. If the Precautionary Principle is stringently applied, the EU biofuel sector could have a social cost of over EUR 450 million to EU citizens, rather than an overall social benefit.
- According to EC projections of road transport energy demand in 2020, it seems that EU biofuels are now at 4.5 per cent of energy content, or even less.

6.2.3 Energy security

The International Energy Agency (IEA) defines energy security as the uninterrupted availability of energy products at an affordable price (IEA, n.d.). The European Commission adds a sustainability dimension by describing security of energy supply as:

> [T]he uninterrupted physical availability of energy products on the market, at a price which is affordable for all consumers (private and industrial), while respecting environmental concerns and looking toward sustainable development. (European Commission, 2000)

Energy security can be improved by increasing the security of supply of traditional energy sources (through long-term contracts or investments), increasing diversity of energy sources (both geographically and the types of fuels), reducing demand (by improving energy efficiency) and increasing flexibility within the energy sector.

The European Commission's strategy for energy security is linked to its strategy for diversification, emission reduction and energy efficiency. Biofuels have the potential to improve energy security by diversifying fuel supply including from primary sources that are locally available and more widely distributed than crude oil (European Commission, 2006).

In the simplest analysis, biofuels could be said to improve energy security to the extent that they displace fossil-fuels and reduce reliance on imported crude oil. This is overly simplistic. Just as a range of factors contribute to the security of supply of crude oil at any given time, biofuels have security-of-supply issues that must be taken into account.

Three types of analyses have been employed to assess the economic cost of energy security and policy measures that aim to reduce insecurity: pure geopolitical analysis, indicators to compare the relative security of different energy types and economic models (Labandeira & Manzano, 2012). Both indicators and modelling have been used to assess the impact of biofuel policy on EU energy security.

Hamelinck et al. (2011) developed an indicator for the security of energy supply for biofuels based on the diversity of feedstock used in their production, taking into account import dependencies via the number of countries of origin and country specific import amounts. This was compared with a similar indicator for fossil fuels. The authors found that ethanol and biodiesel were a more secure source of energy supply for the EU transport sector than fossil-fuels. In 2008, biofuel supply comprised 12 different feedstock, derived from 60 countries. In the same year, 99 per cent of fossil-fuel consumption was derived from crude oil, which was sourced from 24 countries.

While biofuels had a small share of energy consumption in the transport sector in 2008 (3.4 per cent), their higher energy security indicator elevated the energy security indicator for the transport sector overall (Table 35). Increasing the share of biofuels to 10 per cent, as envisaged by the EC for 2020, increased the overall energy security indicator further.

As recognized by Hamelinck et al. (2011), the above indicator has limitations. Important factors were not taken into account, such as the cost of biofuels compared with alternatives or susceptibility of feedstock supply to weather conditions. Nor does the indicator take into account that the highest diversity in feedstock sources is for ethanol, while the majority of consumption in the EU is biodiesel.

TABLE 35: ENERGY SECURITY INDICATORS FOR FOSSIL-FUEL, BIOFUEL AND THE TOTAL TRANSPORT SECTOR IN THE EUROPEAN UNION

ELEMENT	YEAR	INDICATOR[1]	SHARE IN TRANSPORT SECTOR (%)
Fossil-fuel Indicator	2008	0.07	96.6
Biofuel Indicator$_{2008}$	2008	0.60	3.4
Transport Sector Indicator$_{2008}$	2008	0.14	100.0
Fossil-fuel Indicator$_{2008}$	2008	0.07	90.0
Biofuel Indicator$_{2008}$	2008	0.60	10.0
Transport Sector Indicator$_{2020}$	2020	0.20	100.0

Notes: where the indicator ranges from 0 to 1, with 1 representing greatest security of supply

Source: (Hamelinck, et al., 2011)

Brannigan et al. (2012), in a study funded by the European Commission, concluded that biofuels were unlikely to contribute to the long-term energy security of the European Union. For 2010, biofuels scored 75 out of 100 for energy security (the higher the score the more beneficial for Europe's energy security). But by 2050 the score dropped to 42. While better than natural gas, petrol, diesel and liquefied petroleum gas (LPG), it was lower than electricity, hydrogen and energy demand reduction initiatives. The drop reflected several assumptions that were taken into account in the analysis. These included a contraction of supply of biofuels and feedstock to the Americas region (reducing diversity of supply), an increase in extreme weather conditions that will affect feedstock production, and reductions in the availability of land for growing biomass.

The International Energy Agency (IEA) has recently developed a Model of Short-Term Energy Security (MOSES). The model includes indicators for biofuel energy security based on external risks (level of import dependence, with resilience determined by the number of entry ports) and internal risks (volatility of agricultural output) (Jewell, 2011). The model was used to group countries into low, moderate or high categories for energy security risk for each category of fuel.

Hedenus, Azar and Joh (2010) used a partial equilibrium model to test the cost-effectiveness of energy security policies in the European Union. They found that replacing petroleum with ethanol was not a cost-effective way to mitigate the cost of oil disruption. However, replacement with imported ethanol became cost effective if greenhouse gas benefits were included. Domestically produced wheat ethanol was not cost-effective even if both the expected cost of oil disruption and greenhouse gas benefits were included.

Key findings

- Hamelinck et al (2011) found ethanol and biodiesel are more secure sources of energy supply for the EU transport sector than fossil-fuels. In 2008, biofuel supply comprised of twelve different types of feedstock, derived from 60 countries. Ethanol feedstock had the highest diversity, but most EU biofuel consumption is of biodiesel. The same year, 99 per cent of fossil-fuel consumption was derived from crude oil, sourced from 24 countries. However, the authors did not consider susceptibility of feedstock supply to weather conditions.
- Brannigan et al. (2012) concluded that biofuels were unlikely to be a major contributor to the long-term energy security of the EU. While biofuels scored 75 on a scale of 100 for energy security in 2010, this value is expected to drop to 42 out of 100 by 2050. While better than natural gas, petrol, diesel and LPG, biofuels score lower than electricity, hydrogen and energy demand reduction initiatives.

7.0 A Comparison of the EU Proposal to Reduce Emissions from Passenger Vehicles and the Use of Biofuels: An Assessment of Costs and Benefits

7.1 Introduction

Policy-makers have a range of technical options to reduce CO_2 emissions from transport, especially from light-duty vehicles (such as optimizing tire pressures and vehicle downsizing), which account for 12 per cent of total annual EU emissions (European Commission, 2012, Road Transport). In the area of transport, policy-makers tend to shy away from demand-side management or trying to change motorists' behaviour and instead favour intervening indirectly, such as maintaining the use of liquid biofuels for transport, Improving the fuel efficiency of new vehicles, as pursued in the Commission's proposal, "Reducing CO_2 emissions from passenger cars", provides another option, through tightening CO_2 emissions standards for passenger vehicles. Current targets for average fleet efficiency standards are 130g of CO_2 emitted per km for passenger vehicles with a 2015 target-date for implementation. A strengthening of the target to 95 grams of CO_2 emitted per km for passenger vehicles (expressed as 95 gCO_2/km), to be implemented by 2020, also provides an effective option to reduce fossil-fuel consumption and emissions from transport (European Commission, 2012e, Impact Assessment for Proposal from EC to Parliament). This section compares, in a qualitative fashion, some of the cost and benefits of promoting biofuel consumption in the European Union as one method for reducing emissions, versus incrementally strengthening binding vehicle emissions standards through to 2020.

7.2 Methodological Challenges in Comparing Policies

There are challenges in comparing the relative benefits or effectiveness of specific policies, especially biofuel support policies and emission standards, given the biofuels industry and car industry have benefited from substantial historical subsidies and sunk investments that affect their capacity, and the costs they may have to incur as an industry when responding to new policies. In estimating the costs of the automotive industry in meeting the 95 gCO_2/km emissions standard, the EU assessed a number of utility parameters (such as vehicle foot print and mass) adopting a vehicle mass cost based framework[52] (European Commission, 2011c, p. 4).[53] Rather than estimating the specific costs of programs or investments required by the car industry to meet the 95g CO_2/km emissions standard, the Commission adopted a utility parameter that links cost, vehicle weight and emissions reductions (ICCT, 2013b).

Liquid biofuels for transport and the proposed 95 gCO_2/km emission standard for passenger vehicles are compared in the following areas:

- CO_2 savings
- Reduced fossil-fuel consumption
- Jobs creation
- Economic output

[52] The cost of automotive manufacturers reducing vehicle weight was used as a parameter given the link between vehicle weight and emissions: light vehicles emit fewer emissions; however, there are costs in manufacturing lighter vehicles.

[53] The utility parameter is a way of regulating new vehicle emissions while recognizing diversity in the vehicle fleet and so trying to spread the reduction burden in a reasonable way.

7.3 Benefits of efficiency standards and the use of biofuels

7.3.1 Carbon Dioxide Savings

Based on the European Commission's Cars Regulation, the average fleet emissions to be achieved by all new cars is 130 grams of CO_2 per kilometre (expressed as 130 gCO_2/km) by 2015. Comparing emissions from vehicles meeting this standard vs. passenger vehicles meeting the more stringent 95g CO_2/km proposed for 2020 highlights the potential emissions savings offered by incrementally tightening this emissions standard[54].

An average vehicle in the European Union is driven 14,000 kilometres per year and has an average life of about 13 years for petrol powered cars (European Commission, 2012e, p. 19, Impact Assessment). Carbon dioxide emissions of 27.7 tonnes[55] would result based on a vehicles average lifetime and motoring distance.[56] A vehicle with 95 gCO_2/km emissions standard over the same period would emit 20.2 tonnes of CO_2, around 27 per cent less than a passenger vehicle meeting the 130 gCO_2/km.

Using new registrations of vehicles for 2011, which were 15.1 million (European Automobile Manufacturers Association, 2012), moving from a 130 gCO_2/km to a 95 gCO_2/km emissions standard could for that year's vehicle reduce their lifetime CO_2 output by 113 million[57] tonnes from 418 million to 305 million tonnes. These calculations do not take into account the complexity of the EU car markets, many market segments, such as fuel source (whether a car is petrol or diesel powered), or vehicle size (whether it's a small, medium, or large) (TNO, AEA, CE Delft, Ökopol, TML, Ricardo, IHS Global Insight, p.10, 2011). However, the example is illustrative of the vehicle emission savings potential from emissions standards, especially when multiplied across the entire EU passenger fleet and applied to new passenger vehicles.

It is difficult to estimate grams of CO_2eq per kilometre for vehicles using biofuels given the different emission values created in their production, in particular when Indirect Land Use Change is included in the assessment. For example, one can understand that biodiesel produced from rapeseed or palm oil will have a higher gCO_2eq/km than say, ethanol made from sugarcane. Measuring the abatement cost per tonne of CO_2 avoided for biofuels provides an indication of the cost of climate policy. As illustrated earlier, introducing new emissions standards could lead to 113 million tonnes lifetime reduction of CO_2 abated if one year's new vehicles in the EU theoretically moved from a 130g CO_2/km to 95g CO_2/km standard. The following table compares the abatement costs of provided by biofuels consumed in the European Union versus introducing the 95g CO_2/km standard.

[54] Based on the EC's Impact Assessment the costs are negative of reducing emissions to somewhere around 75g/km.
[55] This estimate has been adjusted upwards by 17% as real world emissions are higher than test emissions.
[56] Equation = 130 gCO_2/Km x 1.17 (test cycle) x 14/1000 x 13 years = 27.68 tonnes of CO_2.
[57] This figure is illustrative and assumes all new vehicles introduced in year 1 of the policy were subject to the emissions standard and assumes all registered vehicles conformed to the 130g/km standard. It also assumes average vehicle use to be 14,000 km per year.

TABLE 36: COMPARISON OF ABATEMENT COSTS FOR BIOFUELS AND EMISSION STANDARDS FOR PASSENGER VEHICLES

	A	B	C	D
1	**Biofuels**	**Costs[1] (EUR thousand)**	**Emission savings[4] (million tonnes CO_2 eq)**	**Abatement Cost[6] (EUR/tonne CO_2 eq)**
2	Biofuel (aggregated ethanol and biodiesel)	9,271 - 10,652	4.12	2,248 - 2,583
3	Ethanol only	2,954 – 3,372	6.84	432 - 493
4	Biodiesel only	6,317 - 7,280	-2.71	N.A.*
5	**Vehicle emission standard (95 gCO_2/per km)**	**Costs (EUR)**	**Emissions savings[5] (tonne CO_2 eq)**	**Abatement Cost (EUR/tonne CO_2 eq)**
6	[2] Investment in technology costs (per vehicle)	1,000	7.5	133
7	Investment in technology costs + fuel savings (per vehicle)	-3,255	7.5	-434
8	[3] Investment in technology costs (per vehicle)	1,750	7.5	233
9	Investment in technology costs + fuel savings (per vehicle)	-2,505	7.5	-334

Notes:

[1] Column B, Rows 2-4 total costs for ethanol and biodiesel are based on the Total Support Estimate for subsidies calculated by the GSI (2011).

[2] Column B, Row 6, Technology costs are based on ICCT (2013): Reducing CO_2 and fuel consumption from new cars: Assessing the near-term technology potential in the EU. (Costs assumed as the cost to car manufactures and consumers in developing and deploying vehicles).

[3] Column B, Row 9, based on European Commission (2011c), Support for the revision of Regulation (EC) No 443/2009 on CO_2 emissions from cars. (Costs assumed as the cost to car manufactures and consumers in developing and deploying vehicles).

[4] Column C, emissions savings for ethanol and biodiesel are, like the EC Impact assessment, calculated using a central ILUC factor (taken from Laborde 2011) and a fossil-fuel comparator of 90.3 gCO2/MJ).

[5] Column C, CO_2 emissions saved is the savings between a petrol vehicle meeting the 95 gCO_2/per km and 130 gCO_2/per km, assuming a vehicle life of 13 years and 14,000 kilometres driving per year.

[6] Column D, abatement costs are calculated by dividing costs by emissions saved; the abatement cost for biodiesel cannot be calculated because biodiesel is responsible for a net emission increase of 2.71 million tonnes CO_2 eq.

** For ethanol and biodiesel, consumption data from 2011 (EurObserv'ER, 2012a) is used.*

** Fuel savings based on a petrol vehicle and discounted at 3.5 per cent over 13 years.*

An assessment of abatements costs shows that when purely comparing the cost effectiveness of climate policy options, implementing vehicle emissions standards is an economical way of reducing CO_2 emissions compared to subsidizing biofuel production and consumption. Average emissions abatement for biofuels was estimated at EUR 2,248 - 2,583 per tonne of CO_2. While emissions abatement costs for moving from 130 gCO_2/km to 95 gCO_2/km passenger vehicle standard was EUR 133 - 233 per tonne of abated emissions. This was based on the more expensive cost estimate for developing lighter vehicles, and without factoring in fuel savings. When factoring in fuel savings negative abatement costs were observed.

While outside the scope of this study, it is worth noting the European Commission is developing a strategy to reduce greenhouse gas emissions from Heavy Duty Vehicles (HDVs) (European Commission, 2013). While biodiesel could be used to power HDVs, initial assessments show that depending on the market segment considered, large CO_2 reductions are possible at negative costs. As illustrated by the abatement curve below, cumulative carbon savings of 30 per cent could be achieved at negative cost (Ce Delft, 2012, p. 37).

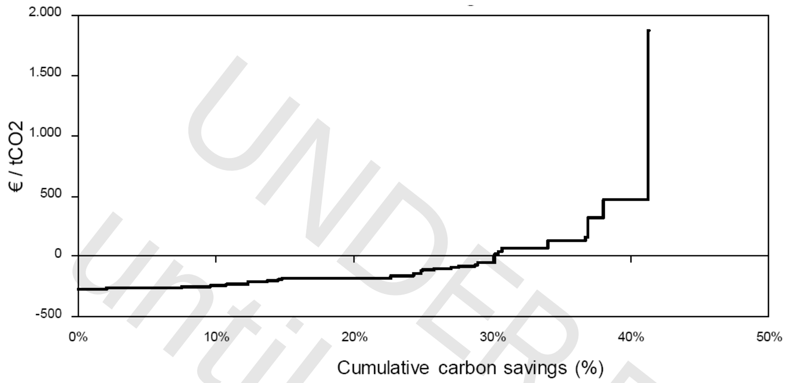


FIGURE 28: COST CURVE, AVERAGE TRUCK.
Source: Ce Delft (2012).

7.3.2 Reduced fossil-fuel consumption

The 130 gCO_2/km fuel efficiency standard equates to a consumption rate of 5.6 litres per 100 km (European Commission, 2012a), which over the average life of a petrol passenger vehicle of 13 years travelling 14,000 km per year equals 10,192 litres of fuel consumed. Fuel costs based on an EU-wide average petrol price (euro super) as at March 2013, without taxes of EUR 0.71 per litre (European Commission, 2012, Energy Policy, Oil Bulletins) and with taxes EUR 1.61 per litre (European Commission, 2012, Energy Policy, Oil Bulletins) would equate to motoring costs of EUR 562 and EUR 1,262 for a single year. The introduction of a 95 gCO_2/km emissions standard would result in fuel consumption rates of 4.1 litres per 100 km (European Commission, 2012a) for a petrol vehicle. This equates to 7,462 litres of fuel consumed over the average life of the vehicle which is around 27 per cent less than the 130 gCO_2/km fuel efficiency standard. 2,730 litres of fossil-fuels saved could equate to 38 barrels of foreign oil that didn't need to be imported into the EU[58] (GSI authors' calculation). Motoring costs (assuming EU average petrol prices with full taxes) are also reduced from EUR 16,460 to EUR 12,051 for the lifetime of the vehicle, a savings of EUR 4,255.[59] The European Commission estimates introducing tighter passenger vehicle standards will lead to avoided fuel use rising progressively from EUR 27 billion per year in savings over the 2020 to 2025 period to EUR 36 billion per year in savings over the 2025 to 2030 period (EC, p. 3, 2012b).There may be some mixed effects from fuel savings achieved by efficient vehicles, with rebound effects where motorists drive more due to additional savings (EC, Impact Assessment), to savings being available to be spent on local goods and services – benefiting the EU economy (Transport and Environment, 2012).

[58] 1 barrel of oil when refined generates gasoline, diesel and a range of by-products. For the purposes of estimating the amount of oil displaced from using petrol this study equates to a barrel of oil delivering 72 litres of petrol.
[59] Fuel savings of 13 years were discounted at a rate of 3.5 per cent.

The prices of ethanol, biodiesel, petrol and diesel, vary depending on the point at which they are sold. In the EU, petrol and diesel are taxed, while making ethanol and biodiesel are exempted from excise taxes by member states. There are consequently differences in whole market prices, and retail prices paid by the consumer. Assessing wholesale market prices for biofuels, such as those emerging from EU trading hubs in Rotterdam, in The Netherlands, and petroleum product prices without taxes, provides one avenue for comparing relative motoring costs (though it should be noted these figures don't represent final prices to the consumer, as this will vary between Member States based on a complex set of taxes and or excise exemptions structures applied in each). The following table illustrates the respective price of a litre of petrol, diesel or ethanol or biodiesel, in the EU in 2011.

TABLE 37: COMPARING AVERAGE EU BIOFUELS (WHOLESALE PRICES) TO FOSSIL-FUEL PRICES (UNTAXED)

AVERAGE EU PRICES PER LITRE, EUROS (2011)			
[1] Ethanol (EUR cents)	€ 0.63	[5] Biodiesel (EUR cents)	€ 0.90
[2] Ethanol adjusted for energy content (EUR cents)	€ 0.85	[6] Biodiesel adjusted for energy content (EUR cents)	€ 0.99
[3] Gasoline (EUR cents)	€ 0.72	[7] Diesel (EUR cents)	€ 0.77
[4] Difference per litre - energy adjusted (EUR cents)	€ 0.13	[8] Difference per litre - energy adjusted (EUR cents)	€ 0.22

Sources:

[1] *EU ethanol wholesale average price: OECD/FAO (2011).*

[2] *Ethanol price adjusted for energy content, energy density of bioethanol is 64.8 per cent that of petrol.*

[3] *Average 2011 EU-27 gasoline price, untaxed (European Commission, 2012a).*

[4] *Difference (euros) per litre (energy adjusted) between ethanol and petrol.*

[5] *Average 2011 wholesale biodiesel price, source: BigOil.net; Platts European Market Scan (Platts, 2013b).*

[6] *Biodiesel price adjusted for energy content, energy density of biodiesel is 90.5 per cent that of diesel.*

[7] *Average 2011 EU-27 diesel price, untaxed (European Commission, 2012a).*

[8] *Difference in price per litre (energy adjusted) between diesel and biodiesel.*

Per litre ethanol has an energy density of 64.8 per cent that of petrol, while biodiesel a 90.5 per cent energy density of a litre of diesel. Energy adjusted, in 2011 the average wholesale ethanol price was EUR 0.13 per litre more expensive than petrol (untaxed), and the wholesale biodiesel price was estimated at EUR 0.22 per litre more expensive than diesel (untaxed). The difference in price for these fuels is not static and will change over time as the market prices moves. Higher petrol and diesel prices will mean the additional costs of biofuel mandates imposed on consumers is reduced as the gap between the pump price for fossil fuels and biofuels closes, as fossil-fuel prices rise relative to the more expensive biofuels. Assuming that feedstock prices don't track oil price, but there is mounting evidence they appear to. The inverse is also true, if fossil-fuel prices drop and biofuel prices rise, the cost of biofuels to the motorist increases (or to the Member State if they impose excise tax exemptions).

7.3.3 Job creation

Based on 2010 data, the European automotive industry estimates it directly employs 2 million people (in auto mobile manufacturing, equipment accessories) and 1.2 million indirectly (in the supply sector) with a total of 3.2 million jobs directly or indirectly relating to automotive manufacturing (European Automobile Manufacturers Association, 2012). The production of increasing volumes of vehicles with tighter efficiency standards is anticipated to lead to decreases in demand of relatively non-labour intensive sectors (such as refineries, extraction) and a shift toward the more labour intensive manufacturing of motor vehicles as well as other goods.

A literature review of 30 studies conducted by Delft (2012) noted there is positive evidence pointing to the benefits for job creation from switching to fuel efficient vehicles, due to two factors. Firstly, by moving to fuel efficient cars the total costs of car owner-ship (purchase costs and mileage costs) can be brought down, freeing up consumer incomes for spending in other parts of the economy, thereby creating additional net jobs. Secondly, fuel efficient vehicles maybe more labour intensive in the manufacturing phase, thereby creating additional automotive jobs (Delft, pg. 4, 2012). The European Commission estimates the increasing use of more efficient vehicles with result in annual expenditure on labour increase by around EUR 9 billion (European Commission, 2012b). In principle the fuel savings are then spent elsewhere which creates jobs in the economy.

A recent study by Cambridge Econometrics and Ricardo-AEA (2013) assessed the number of jobs generated by the current policy initiative of achieving the EU's proposed 2020 CO_2 target of 95 g/km and 147 g/km for cars and vans respectively. Assessing both direct impacts from increased spending on vehicle technology and indirect impacts that result from lower fuel bills across the economy, they estimated 365,000 net additional jobs would be generated by current policies (Cambridge Econometrics & Ricardo-AEA, pg. 5, 2013). Only a small part of the additional jobs come from auto sector, as outlined in the figure below (blue bars representing the current policy initiative) a large proportion of additional jobs are generated in the manufacturing, accommodation and food service industries.

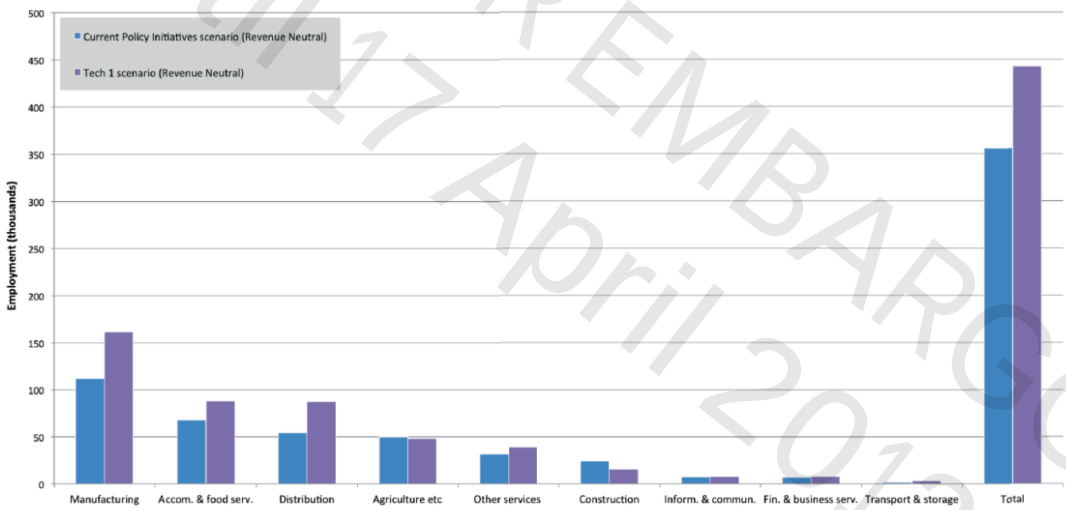


FIGURE 29: EMPLOYMENT IMPACT OF LOW-CARBON VEHICLE SCENARIOS.

Source: E3ME, Cambridge Associates

Based on the ePure and EurObserv'ER multipliers EU ethanol production in 2011 (4.4 billion litres) generated 70,272 jobs (production figures from ePure, 2012; GSI; authors' calculations) and biodiesel production (9.7 billion litres) generated 51,639 jobs (production figures from EBB, 2012; GSI; authors' calculations).[60] This equates to a combined figure of 125,704 jobs in 2010. In 2011, EurObserv'ER estimated biofuel related jobs at 109,150 (EurObserv'ER, 2012a, p. 156). There are challenges in comparing the number and quality of jobs, generated by either introducing the 95 gCO_2/km emissions standard, or the biofuels sector as a whole, given the poor quality of data on green jobs generally. Due to the significant variations differences between the automotive and biofuels industry, directly comparing the

[60] Based on an employment factor for the EU biodiesel industry cited in EurObserv'ER, every 1 million litres of biodiesel produced in the EU creates 5.3 jobs (EurObserv'ER, p.157, 2011).

employment effect of investing in one area compared to another is problematic, and does not take full account of the underlying assumptions of how these employments affects were estimated. Based on a review of available literature the following tables provided a qualitative assessment illustrating the positive or negative effect of various sectors within the EU resulting from the development of the biofuels sectors and the increasing production of more effective vehicles.

TABLE 38: EMPLOYMENT EFFECTS ON SECTORS WITHIN THE EU ECONOMY FROM THE DEVELOPMENT OF THE BIOFUELS SECTOR

EU BIOFUELS SECTOR		
SOURCES	**SECTOR**	**EFFECTS**
(European Commission, 2007b, p. 21) (EmployRes, pg. 140, 2009)	Overall net effects on the economy	Positive
(Neuwahl, Löschel,Mongelli, and Delgado, 2008) (Edwards, R., Szekeres, S., Neuwhal, F., Mahieu, V., 2008).	Biofuels sector	Positive
(EuObserv'ER, 2011, p. 81) (Biodina, pg .3, 2011).	Agricultural Supply Chains	Positive
(Edwards, R., Szekeres, S., Neuwhal, F., Mahieu, V., 2008).	Energy sector	Negative
(Neuwahl, Löschel,Mongelli, and Delgado, 2008)	Food sector	Positive
(Neuwahl, Löschel,Mongelli, and Delgado, 2008)	Industry	Positive or negative
(Neuwahl, Löschel,Mongelli, and Delgado, 2008) (Edwards, R., Szekeres, S., Neuwhal, F., Mahieu, V., 2008).	Services	Negative
(Neuwahl, Löschel,Mongelli, and Delgado, 2008)	Transport	Negative
(Neuwahl, Löschel,Mongelli, and Delgado, 2008)	Fuels	Negative

TABLE 39: EMPLOYMENT EFFECTS ON SECTORS WITHIN THE EU ECONOMY FROM THE INCREASING USE OF FUEL EFFICIENT VEHICLES IN THE EU

INCREASING PRODUCTION OF VEHICLES WITH TIGHTER EMISSIONS STANDARDS		
SOURCES	**SECTOR**	**EFFECTS**
(Delft, 2012) (European Commission, 2012e, Impact Assessment) (European Commission, 2012b, p. 4, ES of the IA)	Overall net effects	Positive
(European Commission, 2012e, Impact Assessment) (European Commission, 2012b, p. 4, ES of the IA)	Auto motive Industry (Component Suppliers)	Likely positive, possibly negative for some suppliers
	Agricultural Supply Chain	No data
(European Commission, 2012e, Impact Assessment) (European Commission, 2012b, p. 4, ES of the IA)	Energy	Positive
	Food	No data
(European Commission, 2012e, Impact Assessment) (European Commission, 2012b, p. 4, ES of the IA)	Industry	Positive or Negative
	Services	No data
	Transport	No data
(European Commission, 2012b, p. 4, ES of the IA)	Fuels or fuel suppliers	Negative

7.3.4 Economic output

The EU car industry had a market turnover in 2009 of EUR 625 billion (European Automobile Manufacturers Association, 2012) and provides EUR 350 billion in fiscal revenues, which represents approximately 8 per cent of the European Union's total general government revenues (European Commission, 2012e, p. 10, Impact Assessment). The economic benefits of the emission standard could are estimated by the European Commission to be additional GDP to the EU economy of EUR 12 billion a year (European Commission, 2012c, Further CO_2 Emissions Reductions).

The total wholesale biofuel market in Europe is estimated at approximately EUR 15.2 billion in 2011. Market size (the total volume of transactions) is estimated by measuring total production or consumption of biofuels and some measure of the market price. Urbanchuk (2012) Some estimates are available for economic output (Urbanchuk, pg. 18, 2012) with Gross Output for ethanol estimated at USD 17.3 billion in 2010, and USD 38 billion in Gross Output for biodiesel.

Many studies and impact assessments will look to economic impact multipliers usually developed from input-output (I/O) models of the economy and are an approach adopted by many researchers and governments as a tool to calculate impact of industry activity and economic policy. Input-out (I/O) models are dependent on their underlying assumptions; hence it is difficult to assess the accuracy of estimates, or compare estimates for different sectors or policies. The automotive and biofuels industries, in terms of economic output, are different by order of magnitude. Hence, this analysis is unable to draw any conclusions as to the costs and benefits generated by either.

Key Findings

- Average emissions abatement for biofuels was estimated at EUR 2,248 - 2,583 per tonne of CO_2.
- The implementation of a 95 gCO_2/km emissions standard by 2020 provides a cost effective means of abating CO_2 compared to subsidizing the production and consumption of biofuels (noting this comparison doesn't to take into account the costs and benefits generated). Taking into account manufacturing costs of EUR 1,000 per vehicle to move from the 130 gCO_2/km to the 95 gCO_2/km standard the cost of abatement is EUR 133, nearly 20 times cheaper than the average CO_2 abatement cost for biofuels assuming central ILUC factors. Taking into account manufacturing costs of EUR 1,750 per vehicle to move from the 130 gCO_2/km to the 95 gCO_2/km standard, the cost of abatement is EUR 233. This calculation doesn't take into account fuel savings, which would lead to abatement costs being negative, or essentially money would start to be saved if these actions were pursued.
- Moving to mandatory 95 gCO_2/km emissions standard for the average automobile by 2020 will reduce motoring costs (assuming EU average petrol prices with full taxes) from EUR 16,460 to EUR 12,051 for the lifetime of the vehicle, a savings of EUR 4,255[61] per vehicle.
- A reduction in the use of petroleum products will lead to a reduction in oil consumption, thereby helping reduce the EU's reliance on foreign produced oil.

[61] Fuel savings of 13 years were discounted at a rate of 3.5 per cent.

8.0 Conclusions

The study analyses the costs and benefits that the EU biofuels policies to the key stakeholder groups in the EU: motorists, farmers, consumers of agricultural commodities and food, the biofuel industry and businesses operating in both fossil-fuel and renewable energy sectors, car manufactures, and policy-makers themselves. From the policy-making perspective, the study pays particular attention to the extent to which the EU biofuel support policies have been meeting three key "public good" objectives, (a) reducing greenhouse gas emissions, (b) promoting the security of energy supply, (c) providing opportunities for employment and regional development, in particular in rural and undeveloped areas, by assessing a collection of costs and benefits generated by supporting the sector. Due to insignificant production of advanced biofuels in the European Union at present, the analysis focused principally on conventional ("food-based') biofuels. All estimates are provided at the EU-level, with country-specific discussions covering the markets of five key Member States, France, Germany, Italy, Spain, and the United Kingdom.

On October 17, 2012, the European Commission released a legislative proposal to limit food-based biofuels counting toward the EUs 10 per cent target for renewable energy in transport at 5 per cent. This study finds that the Commission's proposal, if accepted, *will limit the additional costs associated to moving to a 10 per cent market penetration of food based biofuels*. The avoided costs are significant, and can amount to billions of euros per year. The savings include foregone government spending in the form of subsidies, the cap on additional costs to motorists using biofuels, and reducing hikes and volatilities in agricultural commodity prices.

This discussion of avoided costs and savings resulting from the Commission's proposal of 17 October 2012, provides a useful context for examination of the negative impacts of EU policy-driven conventional biofuel industry's expansion started in 2003 and intensified by the RED and FQD in 2009. In the meantime, the benefits generated by the consumption and production of conventional biofuels are subject to disagreement, and on-going assessment. The study concluded that costs and subsidies linked to current EU biofuel production and consumption are high, and do not cost-effectively reach stated policy objectives. A summary of the key findings is provided below.

The EU biofuels industry is not a homogenous sector. There are differences across key characteristics, including the underlying economics of ethanol and biodiesel production, operational costs, and the historical growth of markets in key Member States.

The size of the EU market grew between 2009 and 2011. The EU wholesale biofuel market grew to approximately 15.2 EUR billion in 2011. Along the value chain the EU biodiesel industry purchased around EUR 3.5 – 4.5 billion worth of crop feedstock from the EU farmers, while the ethanol industry purchased 2.5 – 3.5 billion. Importantly, the EU biodiesel industry also imported about EUR 3 – 4 billion worth of feedstock such as palm oil, soybean oils, oilseeds, etc. The EU also imported approximately EUR 0.5 billion worth of ethanol feedstock. Thus, due to the purchasing of foreign biofuels and feedstocks, only about a half, if not less, of the value of biofuel sales in the EU market went to the EU farmers growing feedstock crops.

In 2011 the value of the annual government support to the biofuels sector through subsidies and market support through blending mandates is estimated at between EUR 9.3 billion and 10.7 billion by the Global Subsidies Initiative (and USD 11 billion [EUR 8.4 billion[62]] in 2011 as estimated by the IEA, in the World Energy Outlook 2012) while the size of capital base is estimated at EUR 6 billion. On a per litre basis, ethanol receives more support per litre, in 2011 receiving between 48 and 54 euro cents per litre, with biodiesel receiving 41 to 51 euro cents a litre. The level of support provided through key policy support mechanisms, such as tax exemptions and mandates is sensitive to

[62] Based on average exchange rate for 2011: 1 USD = 0.7661 EUR (http://www.oanda.com).

consumption levels. For example, as biofuel consumption grows the level of foregone revenue increases. The study also identified EUR 1 billion in Single Payment Scheme (SPS) payments under the CAP to farmers for biofeedstock production in the European Union, based on land use data from 2008. Serious questions are raised over the availability of data, as the European Commission does not estimate the level of SPS payments to energy crop farmers, nor provides accurate, up-to-date, time series, data, on the acreage used for growing different types of biofuel feedstock. Many commentators call on developing countries to rigorously monitor the effects of biofuel production on land use patterns, especially relating to high value bio diverse areas, while the EU itself fails to accurately monitor or publish similar data sets.

Despite the significant support from the Member States, biofuels remain more expensive vis-à-vis, petrol and diesel when recognizing the lower energetic values per litre generated by biofuels. Consumption mandates, are influential support mechanisms, used in 11 Member States transferring the cost of promoting biofuels to the consumer purchasing blending fuels at the pump. While the future costs of biofuels or fossil fuels can only be modelled as an approximation of reality, additional motoring costs for ethanol were estimated to be in a range of EUR 1 to 1.2 billion in 2013, decreasing to around EUR 362 to 808 million in 2020, assuming ethanol is able to achieve reductions in production costs. Biodiesel was estimated to be in the range of EUR 5.3 to 5.9 billion in 2013, increasing to around EUR 4.8 to 8.9 billion in 2020.

In terms of capital investment, biodiesel was less capital intensive (with a median of 0.3 EUR/litre) than ethanol (with a median value of 0.7 EUR/l). Spurred on by significant policy support, ethanol production capacity started to grow in the five key countries between 2004 and 2006, and plateaued in 2009. Investments in ethanol production facilities peaked in 2007, then generally declined from 2009 onwards. Biodiesel production capacity grew up until 2010; then declined in a number of countries. Investments in biodiesel peaked between 2007 and 2009 before subsequently beginning to decline. The global financial crisis may have also played a role in halting investments in the sector.

Plant utilization rates are low in the European Union, with ethanol plant utilization reported to have fallen from 89 per cent in 2006 to 61 per cent in 2011, similar falls have been observed in biodiesel utilization from 55 per cent in 2006 to 47 per cent in 2009. Estimates place raw material costs at approximately 90 per cent for biodiesel and between 70 to 80 per cent for ethanol. During the cost recovery period for biofuels facility a drop in demand or prices could render production economically infeasible, creating a risk of stranded assets. The high raw material costs and low CAPEX and non-fuel OPEX costs render the biofuel production industry extremely sensitive to changes in feedstock price. However, closer inspection shows the actual period of cost recovery depends on the financial structure and financing period of the project. In some cases projects are refinanced several times reflecting the value of the underlying business rather than the original capital value of the assets.

A review of the recent efforts to model the impact of the biofuel policies on prices for agricultural commodities, testified to a clear positive link between the growth of biodiesel consumption in the European Union and rising global prices for vegetable oils, although within an extremely wide range of estimates (with a factor of 36!) for the extra costs. EU biofuels were estimated to add additional costs between EUR 100 million and EUR 4 billion a year for food and animal feed end uses of vegetable oils. The increase food crop prices also meant the biofuel industry itself had to pay an additional EUR 60 million to 2.2 billion a year over 2010 – 2011. When reviewing these estimates it should be noted that the degree of uncertainty is significant concerning food and feed markets, and related data.

In assessing biofuels environmental benefits, apart from ozone depletion and potentially some minor greenhouse gas savings, indicated biofuels generally score worse on environmental and health indicators than fossil fuels. There is a body of research indicating biofuels have negative impacts on human toxicity, water depletion and can increase terrestrial eutrophication. Biofuels in the European Union are responsible for significant consumption of water inside and outside the EU. Within the European Union, 39 km3 of European water resources is used for biofeedstock and biofuel production. To put this number in perspective, total annual freshwater resources in Germany (Europe's largest country and the one with the highest freshwater resources) is around 188 km3 (Eurostat, 2012). Indicating, biofuels water footprint requires greater monitoring and assessment. Water depletion as well as negative environmental impacts from increased biofuel production has resulted in biodiversity loss.

This analysis also reveals that jobs created by the industry are generally not located in the poorest rural areas of the European Union (i.e., such as in Convergence Regions). Given that the EU in 2011 spent between EUR 9.3 and 10.7 billion (GSI calculations) on subsidies, and a key driver is rural development and job creation is part of that, this area warrants official monitoring as part of EU statistics.

The biofuels sectors R&D intensity, the ratio of the industry's expenditure on R&D compared with sales, is higher in the European Union than for other renewable energy technologies. Some research indicated incentives for R&D in the field of second generation biofuels was more likely to lead to productivity gains than in other areas of renewable energy technology such as batteries, fuel cells, hydrogen, solar, and wind energy. The EU biofuels sector contributes taxation to municipal and state level of governments, though the extent to which this can be calculated is challenging, given the resources needed to accurately measure this. No aggregated or disaggregated, annual fiscal tax payments to the European Union, neither from the ethanol, biodiesel, or combined industries, is available, while industries such as the European Automotive Industry Association published an estimate for 2009 of EUR 350 billion in fiscal revenues paid to the EU.

As the proposal of the European Commission includes a percentage cap, and not an absolute cap, the notion that the European Commission is freezing biofuels at current consumption levels is unjustified given energy in road transport increases. Some estimates put biofuels consumption currently at 4.5 per cent of energy content, or even less. Based on a central ILUC factor (which could be considered as the minimum precautionary level), EU biofuels would save a maximum of 5 million tonnes of CO_2 eq (or 0.7 per cent of total EU 15 road transport emissions today) in 2020. The extent, to which this helps abate greenhouse gas emissions in transport, warrants discussion given the high cost of biofuel subsidies.

This is particularly the case for biodiesel, which has higher ILUC factors than ethanol. Under a central ILUC factor, biodiesel is responsible for net emission increases, and thus reduces the overall emission reductions from "biofuels" (i.e., those from ethanol). Overall greenhouse gas savings are nullified or even negative when a more stringent precautionary approach is taken, again as a result of net emission increases due to biodiesel. When monetizing potential greenhouse gas savings, we find that at a high discount rate and assuming significant effects from climate change on the economy, the social benefits of EU biofuel emission reduction in 2020 under a central ILUC factor is around EUR 332 million. If the Precautionary Principle is strictly applied, this social benefit turns into a social cost of over EUR 450 million. The greenhouse gas abatement cost of biodiesel is very high—around EUR 5,200–6,000 per tonne of CO_2 avoided, assuming a low ILUC factor from the 25th percentile. However, when assuming a central ILUC factor like the European Commission advises, biodiesel is responsible for net emission increases of over 2 million tonnes of CO_2 eq. The abatement cost of ethanol is less dependent on ILUC and lies between EUR 385 and EUR 560 per tonne CO_2 avoided. Greenhouse gas emissions reduction policies need to at least distinguish between ethanol and biodiesel, and preferably between different feedstocks.

8.1 Policy recommendations

The recommendations that can be drawn from this study suggest that it is advisable for EU policy-makers, along with those at the national government levels, to adopt the following:

- **Subsidies to the EU biofuels sector are significant and insufficiently targeted to support specific objectives**. If incentive measures are to be used then they should be differentiated in terms of their policy objectives. For example, if they greenhouse gas savings, then they should be for biofuels which can actually deliver against the stated policy objective as opposed to a blanket support mechanism available across technologies and parts of the production and consumption cycle.
- **Think in the longer-term and phase out support to conventional biofuels**. In the short term, governments should abstain from introducing new forms of government support to conventional biofuels and replace the rigid biofuel consumption mandates and targets with more flexible arrangements in order not to block interactions between the global markets of biofuels, food, animal-feed and related products during the periods when food supplies are endangered and there is a threat of food price hikes. In the middle term, governments should establish and implement a plan for removing national policies that support consumption or production of biofuels that a) compete with food uses for the same feedstock crops and/or b) have negative impacts on the environment. The proposed 5 per cent cap is a step in the right direction though remaining consumption of most food-based biofuels, in particular biodiesel, still represents significant costs that do not contribute in achieving key policy objectives. The EU ought to take steps toward removing of crop-based biofuel mandates.
- **In terms of greenhouse gas emission accounting, it is necessary for the European Union to include indirect land use change concerns in biofuel and other bioeconomy based policies, in order to ensure that public money does not support biofuels that increase CO_2 emissions**. "Biofuel" policies should be divided at least over the ethanol/biodiesel nexus, and ideally over feedstock.
- **A European Commission Agency is tasked to monitor and publish accurate data assessing the volume and origin of biofuel imports as well the end-use of key biofuel feedstock commodities such as vegetable oils**. Such approach will support evaluation of unintended impacts in third party jurisdictions, including land use change effects, and the extent to which benefits accrue to domestic or foreign industries. The Harmonised System trade codes and the existing statistical services do not always distinguish between feedstocks and other commodities being consumed, imported or exported for biofuel or other purposes, or a clear distinction of pure and blended products with fossil-fuels. The benefits of EU renewable energy targets may be accruing to foreign farming or biofuels sectors exporting feedstocks or biofuels to the EU.
- **The European Commission should consider publishing official statistics through Eurostat on the number and types of jobs generated by the EU biofuels sector**. Introducing official, mandatory statistically monitoring of biofuel related jobs should improve the availability of consistent data.
- **Agricultural subsidies (in the form of SPS payments) to energy crop producers are significant and should be considered as part of any EU consultation process or Impact Assessment to determine the effect of potential policy options.**
- **Accurate monitoring of changes in cropping patterns within the European Union should be improved to ensure the amount of land being used to grow feedstocks is published in a consistent time series**. Changes in land use patterns—with increasing levels of biofuel feedstocks being produced instead of food crops—is an important European Union and international issue. Each Member State should develop an annual calculation to determine the area of arable land used to grow biofeedstocks was accurate and based on the total amount of domestically produced biofuel.

- **The European Commission should provide greater clarity on the anticipated level of energy projected for road transport by publishing a revised official estimate**. The EU needs to provide greater clarity on the expected energy required for transport in order to estimate greenhouse gas emissions from biofuels.
- **National Renewable Energy Action Plans (NREAPs) for estimated biofuel consumption should be revised to reflect the cap and to take into account negative impacts of certain biofuels**. Member States should update NREAPs in order for biofuel related information to better reflect national policies anticipated and production and consumption levels through to 2020.

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