Research Paper No. 0707251

# Greener Pastures for Globalization: How European Farmers can Help Save the Planet as well as the Doha Round

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*July, 2007*

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## Papers in Energy, Resources, and Economic Sustainability

This report is part of a series of research studies into alternative energy pathways for the global economy. In addition to disseminating original research findings, these studies are intended to contribute to policy dialogue and public awareness about environment-economy linkages and sustainable growth. All opinions expressed here are those of the authors and should not be attributed to their affiliated institutions.


## Abstract

Farm support in higher income countries is a testament to the fundamental social and economic importance of agriculture, yet domestic efforts to support this sector can arouse multilateral discord in a world of global food markets. In this paper, we argue that the advent of biofuels offers a new opportunity for agriculture to contribute to society, and to do so in a way that reduces two important multilateral risks, climate change and trade rivalry. Biofuel gives farmers a new source of income while they provide environmental services (greenhouse gas mitigation) and help reduce external energy dependence. European farm support is also an impediment to global trade negotiations, and we believe a new food-fuel perspective can help overcome this by reconciling the needs of EU farmers and those in Europe and elsewhere who gain from more liberal international trade.

# Greener Pastures for Globalization:

# How European Farmers can Help Save the Planet as well as the Doha Round

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## 1. Introduction

Two of the most momentous policy issues of modern times are climate change and globalization. Europe has shown consistent and remarkably unified leadership in the first context, yet the same cannot be said of its role in the latest round of WTO negotiations. The EU's path breaking initiatives for carbon trading and affirmation of commitments beyond the Kyoto Protocol have given essential impetus to global greenhouse gas mitigation, and the European private sector has responded with alacrity to emerging green technologies and investment opportunities. In contrast to this, the EU (along with some other OECD economies) have consistently resisted the agricultural reforms necessary to facilitate competition in global food markets.

Because of seemingly intractable deadlocks over farm support policies, this round has been robbed of important momentum and retarded the progress in other European sectors (manufacturing and services) with much higher employment levels and GDP shares. Moreover, agricultural trade protection inflates the exchange rate with respect to most trading partners,

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undermining EU export competitiveness across the board. While Europe is not the only obstacle to concluding the round, we believe a new perspective can reconcile the needs of EU farmers and those who gain from more liberal international trade.

This paper poses a challenge to European farmers and policy makers to advance both the trade and environmental agendas by expanding production of biofuels. The farm support agenda has always been premised on the importance of agriculture to European society, until now defined primarily in terms of food and direct environmental services. The advent of biofuel offers two dramatic new contributions from agriculture, greater domestic energy self-sufficiency and global greenhouse gas mitigation. Biofuels represent the remarkable option of substitution between two leading commodities, food and energy, within a single sector. Both are essential to Europe, one is in excess supply and the other largely imported and increasingly scarce. Until now, Europe has leaned toward self-sufficiency in the first commodity, while becoming ever more import dependent on the other. A one-sided approach like this is rarely optimal, yet agricultural support strongly biased the European food-energy portfolio in this direction because food was the primary source of farm livelihoods. Now that farmers can use their resources to earn income as energy producers, the EU has a wider range of food-energy portfolio choices.

Using detailed data on EU land use and energy conversion estimates, our results indicate that Europe's existing crop potential could displace over 23% of its transportation fuel imports through domestic ethanol and biodiesel substitution. This is far in excess of current EU renewables targets, and the same strategy would necessitate significant food imports (without, it must be emphasized, a corresponding loss of EU farm livelihoods). Whether such trade substitution is beneficial of course depends upon other factors, including relative world prices and more complex institutional issues. At the other extreme, if production were confined only to land that now produces beyond EU self-sufficiency in biofuel crops, over 5% of oil imports would be displaced. Surely, the optimum mix of imported and domestic food and energy lies somewhere in between. An essential feature of the biofuel option is that these decisions can be made in a way that offsets revenue losses for domestic agricultural interests.

The environmental implications of EU biofuel substitution are equally promising, with net aggregate CO2-equivalent emission reductions of up to 9% and 2%, respectively, in the two scenarios discussed above. Finally, 34% aggregate farm balance sheets would be revenue-neutral at $65/bbl with existing farm support levels. An essential difference in this case, however, is that producer support for biofuel is not currently recognized as a trade distorting measure [check this], and a significant portion of EU agriculture could be removed from Doha negotiation. Ultimately, in the face of rising energy prices, there may be significant scope for unwinding support levels in these crop categories ($27.5 billion in 2004, about a quarter of producer income) and redirecting the fiscal savings to other priorities.

The next section of the paper provides a country and crop specific overview of European biofuel capacity. This is followed in section three with empirical estimates of opportunities for biofuel to displace imported oil in the transport sector, including the implications of this for reducing European greenhouse gas emissions. Section four evaluates the implications of these policy scenarios for Europe's role in the Doha Round, and a fifth section provides concluding remarks.

## 2. European Biofuel Capacity and the Potential to Increase Production

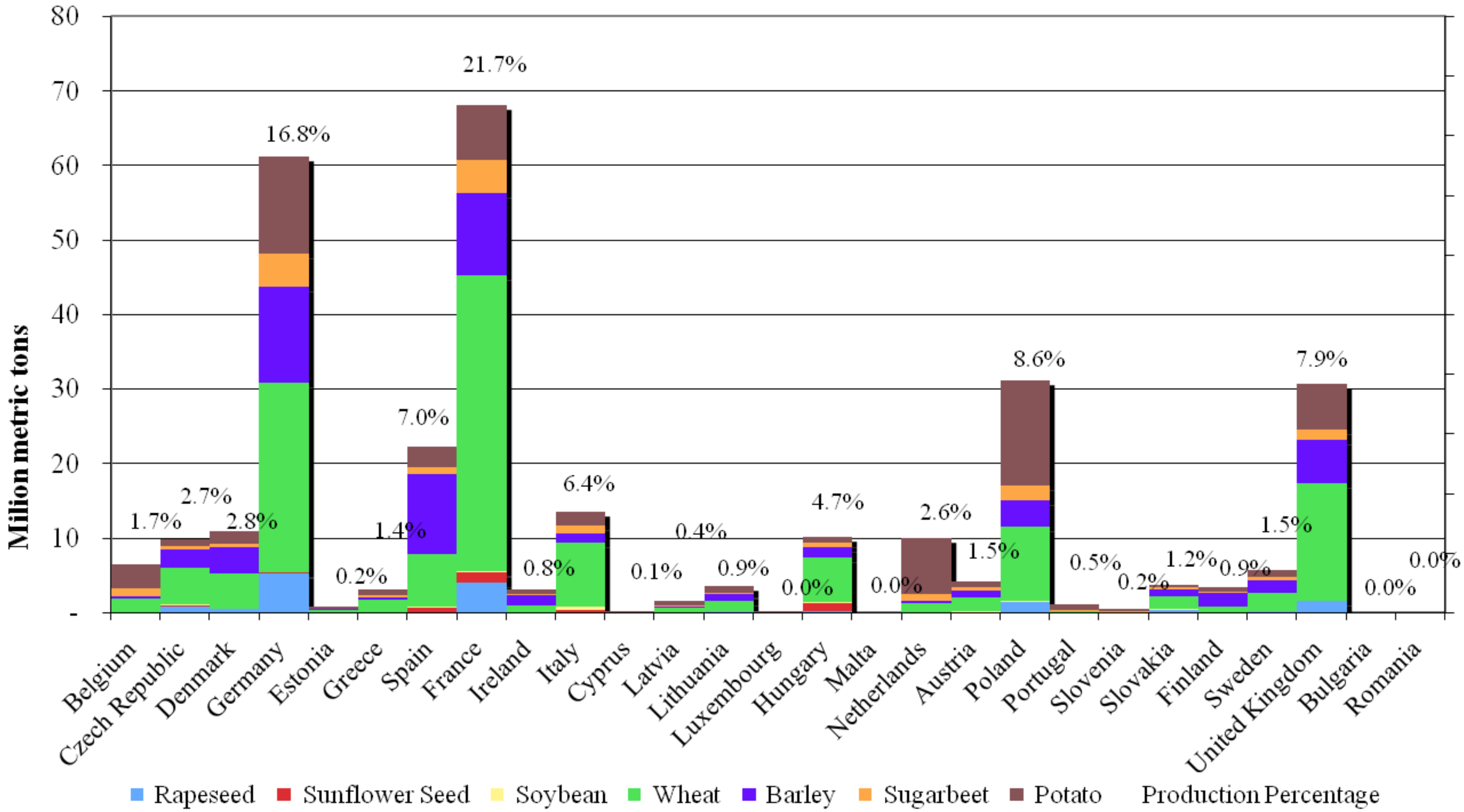
Although the EU biofuel sector is only just emerging, a substantial amount of European agriculture is already dedicated to crops that are eligible as biofuel feed stocks, including Corn, Sugarbeet, Wheat, Barley, Soybean, Sunflower, etc. Figure 1 shows these crop portfolios for the EU27 economies, indicating crop specific yields and the percent of all European output represented by each country. Crop allocation is quite diverse across countries, with traditional staples like Wheat, Barley, and Potatoes dominant. As one might expect from their land area, Germany and France are by far the largest producers of biofuel eligible crops, with 16.5 and 21.3 percent, respectively, of all European production.

The results in Figure 2 embed biofuel feedstock in the larger setting of European agriculture, indicating land area committed to each crop and the percent of total Utilizable Agricultural Area (UAA) currently committed to biofuel eligible crops. Land use results resemble those of output in Figure 1, but can differ because of varying yield per hectare in different countries. Also interesting is the percent of UAA in potential feedstock crops. This varies significantly across the EU 27, from highs of over 50 percent to well below 10 percent. As the value of biofuel rises with energy prices generally, there will likely be a re-examination of existing cropping patterns. Our results indicate that substantial potential exists across Europe to expand biofuel production, and this potential can be more fully realized if alternative uses (food) are evaluated with reference to more competitive international agricultural markets.

Food security must be a primary consideration for biofuel crop conversion, so it is reasonable to ask how self-sufficient EU economies are in these crops. Figure 3 shows that about half the EU27 are self-sufficient in aggregate biofuel crop production (individual crops are presented in companion Table 1). Both France and Hungary, for example, are producing more than double their food requirements in biofuel eligible crops. Clearly, there is significant potential within Europe to explore alternative uses.

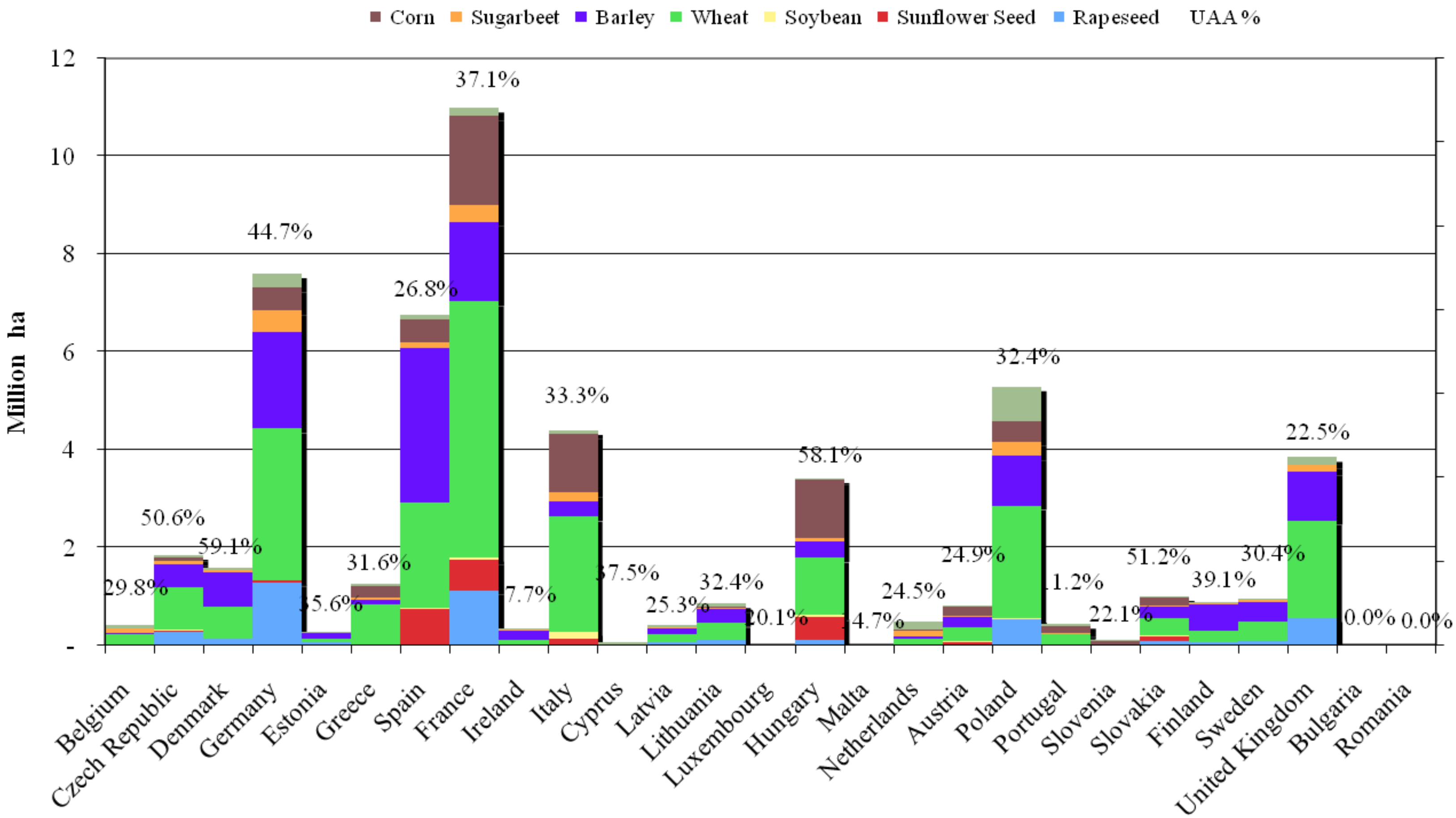
Production levels and land utilization for the seven biofuel feedstock crops considered in this analysis were used to generate Figures 1 & 2. All data is 2004 levels, the most recent year for which data was available.  Production percentages in Figure 1 reflect the aggregate production of these seven crops by country.  The therefore represent the endowment of biofuel feedstock crops by country.  Percentages in Figure 2 are the production of these seven crops as a percentage of total UAA within each EU-27 country.  Self-sufficiency levels presented in Figure 3 are production-weighted average self-sufficiency levels by country.  Self-sufficiency levels reported in Table 1 are from the Eurostat database.  In instances where 2004 self-sufficiency levels were unavailable, 2003 levels were used.

## Figure 1: Production of Potential Biofuel Feedstock Crops[1] 2004



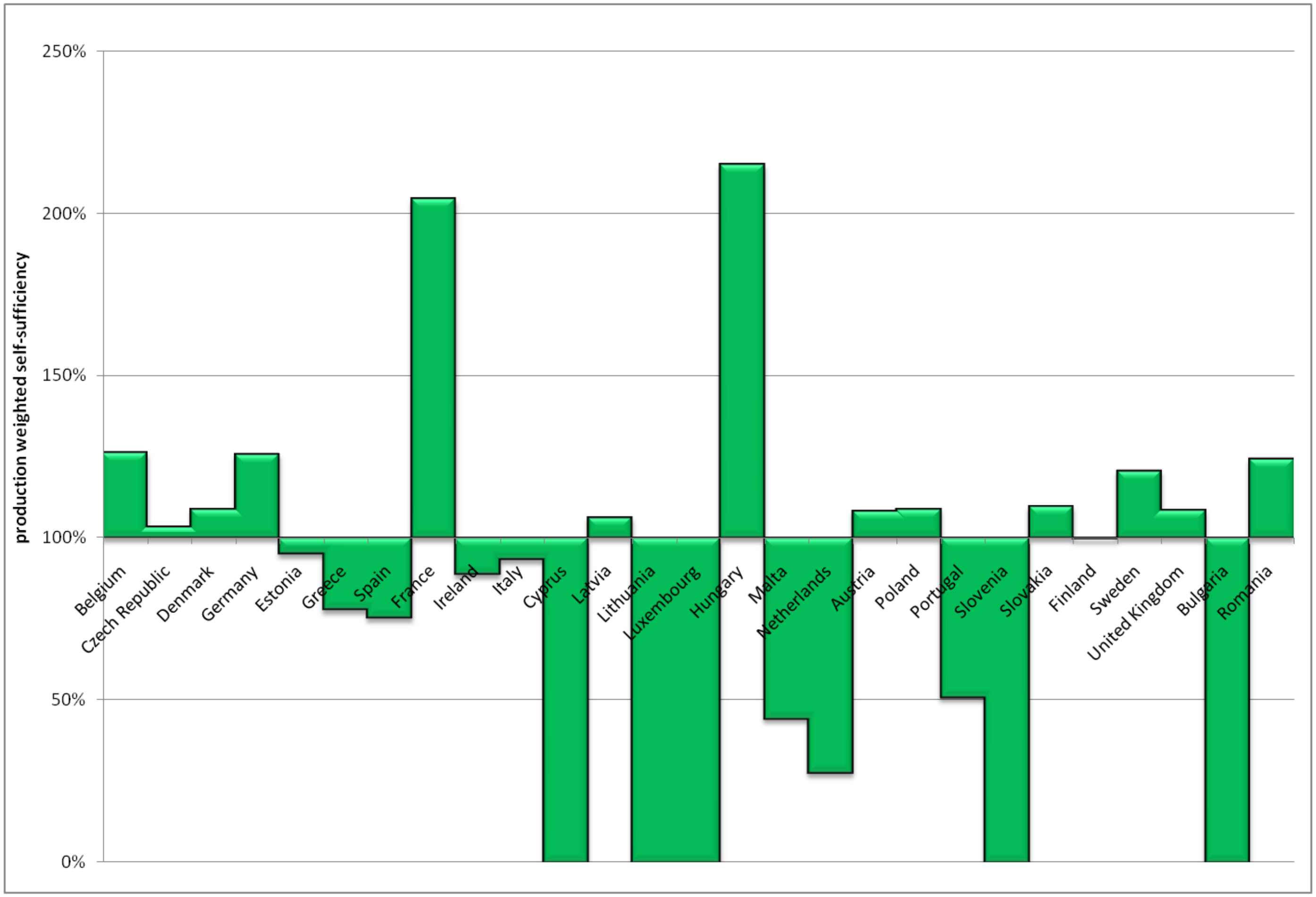

Note: Percentages are country percentages of total EU potential biofuel feedstock production.
Sources:
(1) EU DG Agriculture & Rural Development (2005). Agriculture in the European Union - Statistical and Economic Information 2005. (2) Eurostat.

# Figure 2: Potential Biofuel Feedstock Land Utilization[1] 2004




Note: Percentages are biofuel feedstock landuse percentages of the country's total utilizable agricultural area (UAA).
Sources:
(1) EU DG Agriculture & Rural Development (2005). Agriculture in the European Union - Statistical and Economic Information 2005. (2) Eurostat.

**Figure 3: Production-weighted Average Self-sufficiency Levels for Biofuel Crops, 2004**




Note: Production weights assigned based on country-level production percentages. 2003 self-sufficiency levels were used in instances where 2004 levels were not available. Sources: (1) EU DG Agriculture & Rural Development (2005). Agriculture in the European Union - Statistical and Economic Information 2005. (2) Eurostat.

**Table 1: Self-sufficiency Levels in Biofuel Crops**

| EU-27 | Wheat | Barley | Corn | Potatoes | Sugarbeet | Rapeseed | Sunflower | Soybeans |
|---|---|---|---|---|---|---|---|---|
| Belgium | 55 | 61 | 25 | 172 | 135 | 3 | 0 | 0 |
| Czech Republic | 79 | 161 | 103 | 87 | 0 | 0 | 0 | 0 |
| Denmark | 107 | 110 | 0 | 98 | 100 | 162 | 0 | 0 |
| Germany | 152 | 128 | 80 | 110 | 100 | 93 | 36 | 0 |
| Estonia | 88 | 105 | 0 | 86 | 0 | 96 | 0 | 0 |
| Greece | 81 | 41 | 79 | 71 | 100 | 0 | 12 | 0 |
| Spain | 76 | 87 | 54 | 68 | 0 | 13 | 62 | 0 |
| France | 215 | 266 | 223 | 108 | 100 | 172 | 136 | 22 |
| Ireland | 76 | 106 | 45 | 66 | 100 | 100 | 0 | 0 |
| Italy | 100 | 50 | 102 | 63 | 0 | 13 | 47 | 26 |
| Cyprus | | | | | | | | |
| Latvia | 129 | 94 | 0 | 94 | 101 | 0 | 0 | 0 |
| Lithuania | 156 | 119 | 6 | 98 | 100 | 2000 | 0 | 0 |
| Luxembourg | 105 | 92 | 27 | 56 | 0 | 16526 | 0 | 0 |
| Hungary | 250 | 156 | 210 | 91 | 103 | 505 | 218 | 99 |
| Malta | 0 | 0 | 0 | 44 | 0 | 0 | 0 | 0 |
| Netherlands | 31 | 27 | 12 | 0 | 0 | 0 | 0 | 0 |
| Austria | 150 | 98 | 86 | 91 | 100 | 52 | 81 | 103 |
| Poland | 120 | 103 | 103 | 102 | 100 | 131 | 14 | 0 |
| Portugal | 39 | 7 | 38 | 72 | 0 | 0 | 0 | 0 |
| Slovenia | | | | | | | | |
| Slovakia | 68 | 127 | 145 | 87 | 100 | 140 | 269 | 49 |
| Finland | 101 | 105 | 0 | 88 | 100 | 55 | 0 | 0 |
| Sweden | 125 | 149 | 0 | 81 | 100 | 69 | 0 | 0 |
| United Kingdom | 113 | 126 | 0 | 82 | 100 | 112 | 0 | 0 |
| EU25 | 105 | 108 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bulgaria | 91 | 81 | 90 | 85 | 100 | 183 | 180 | 100 |
| Romania | 143 | 167 | 114 | 99 | 95 | 710 | 125 | 116 |

Source: "Agriculture in the European Union - Statistical and economic information 2005", Agriculture and Rural Development DG.

### 3. Opportunities to Mitigate Energy Import Dependence and Greenhouse Gas Emissions

Given the substantial existing production eligible for biofuel conversion, not to mention even greater land resource capacity currently in alternative use, it is reasonable to ask how much Europe could reduce its current dependence on energy imports. Conversion of existing agriculture to biofuel raises issues of food security, but these have a compelling analogy in energy security. Food may be a more elemental human need, but energy is essential to modern society. Biofuel offers EU farmers an opportunity to defend basic living standards in both ways.

Using the crop and land use information of the previous section, combined with median estimates of biofuel yields and energy potential, our results indicate that the EU can reduce its current and long term energy import dependence substantially. While these results vary significantly across countries, the local sustainability aspect of biofuel means that the region can share a commons of greater self-sufficiency through internal trading systems operating without exchange rate risk.

**Table 2: Scenarios for Biofuel Production and Oil Import Substitution**

| | Energy-Equivalent Production (mtoe) [1] | | | | | Transport Energy | |
|---|---|---|---|---|---|---|---|
| **Scenario** | **Biodiesel** | **Ethanol** | **Biodiesel** | **Ethanol** | **Total** | **Total** | **Imports** |
| 1 | 7.08 | 87.14 | 6.16 | 58.39 | 64.54 | 347 | 278 |
| 2 | 1.42 | 20.25 | 1.23 | 13.57 | 14.80 | | |

**Displacement Potential (percent)**

| | Biodiesel Only | | Ethanol Only | | Total | |
|---|---|---|---|---|---|---|
| **Scenario** | **Oil Use** | **Imports** | **Oil Use** | **Imports** | **Oil Use** | **Imports** |
| 1 | 1.78% | 2.22% | 16.84% | 21.01% | 18.62% | 23.22% |
| 2 | 0.36% | 0.44% | 3.91% | 4.88% | 4.27% | 5.33% |

Table 2, accompanied by country detail in Figures 4 and 5, represents two relatively extreme scenarios. In the first, we assume that all Europe's eligible crop production is converted to biofuel and used in the transportation sector. In this case, food needs in the same crops would have to be met by increased capacity (i.e. conversion from other crops) or imports. Scenario 2 evaluates the potential of converting only the eligible output in excess of today's self-sufficiency levels (the highlighted cells in Table 1 above).

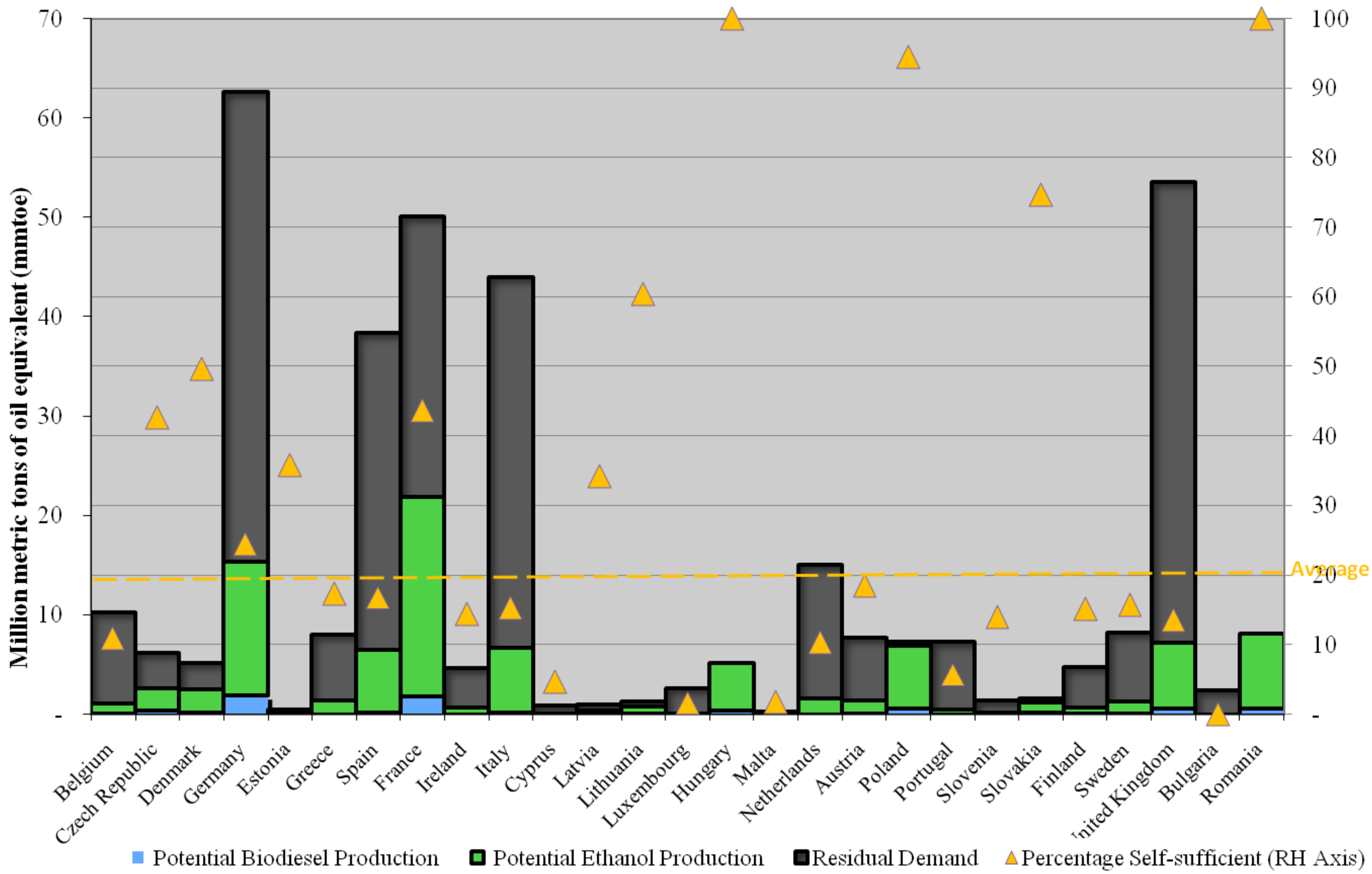
European agricultural potential to reduce oil imports is substantial. In Scenario 1, we estimate that over 23% of overall EU27 transport fuel imports could be displaced. This figure is far higher than EU targets for biofuel development, indicating that it might be appropriate to reconsider the food-fuel tradeoff. Some countries have much higher levels of displacement potential, including Hungry, Romania, and Poland, who could in theory become self-sufficient (or very nearly so) in transport fuels. Such a policy would probably not be optimal in the presence of an EU trading system, just as food self-sufficiency can be inefficient at the national or even regional level

When biofuel conversion is limited only to the proportion of eligible crop output that exceeds national self-sufficiency, it is still possible to displace over 5% of EU transport fuel imports. This number also exceeds current biofuel development targets, and suggests strongly that the latter may be too conservative. In France, for example, crops are over double food requirements in these categories, and biofuel conversion of the excess could displace over 10% of imported transport fuel.

By its nature, biofuel conversion is dominated by ethanol production, yet by global standards the EU has a relatively large share of diesel in transport fuel demand (see Table 3). This mismatch of fuel composition is relatively unimportant in the present case, since self-sufficiency levels remain below 25%. In any case, energy markets can reconcile these differences, so Europe can get the fuel it wants while its farmers reap the rewards of producing valuable energy crops.

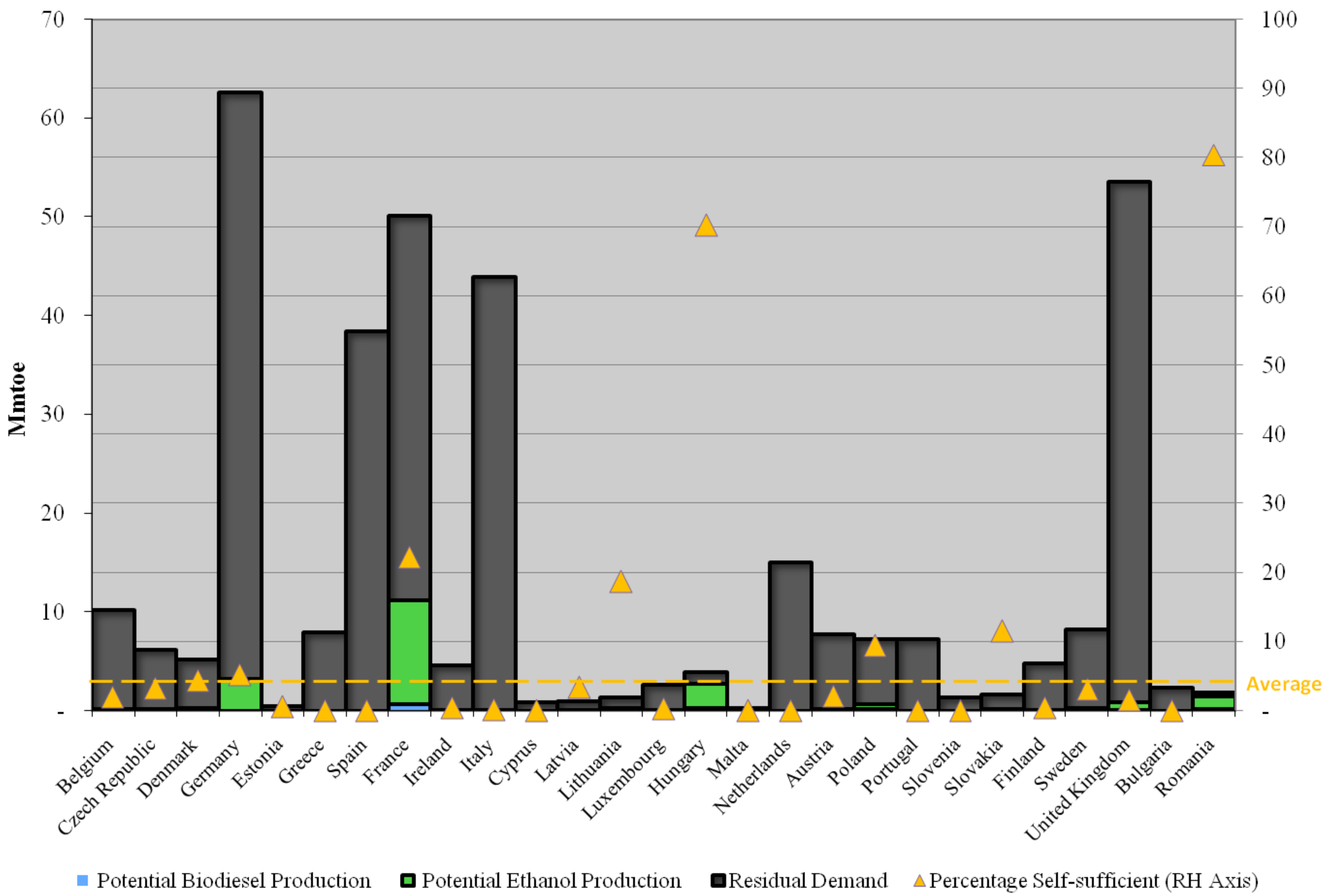
We calculate potential biofuel production levels holding current crop production levels constant. We then compute biofuel production amounts by applying the appropriate conversion factor by crop and adjusting these production amounts to account for lower energy contents of biofuels compared to their fossil fuel equivalents (ethanol has 33% lower energy content than gasoline and biodiesel has 13% lower energy content than diesel). This yields the fossil fuel energy equivalent biofuel production amounts. Crop conversion factors are included in the Annex.

**Figure 4: Scenario 1 - Petroleum Displacement Potential for Complete Conversion of Biofuel Crops**




Note: Figures based on converting total current biofuel feedstock crops to biofuel.
Sources: OECD (2005).

**Figure 5: Scenario 2 - Petroleum Displacement Potential for Conversion of Surplus Biofuel Crops**



## Table 3: Displacement Potential Summary for EU-27

| | (mtoe-yr) | (mbbl-day) |
|---|---|---|
| Total Transportation Energy Use | 353.79 | 7.14 |
| Petroleum Percentage[2] | 98% | 98% |
| Petroleum Use for Transportation | 346.72 | 7.00 |
| Import Dependency | 80% | 80% |
| Oil Imports[3] | 277.94 | 5.61 |
| | | |
| Current Biodiesel Production | 1.93 | 0.04 |
| Current Ethanol Production | 0.42 | 0.01 |
| Current Total Biofuel Production | 2.36 | 0.05 |
| % of Total Transportation Energy | 0.67% | 0.67% |
| Oil Equivalent Value (Millions, @$65/bbl) | $ | 1,129 |
| Revenue Neutral Oil Price (estimated) | $ | 1,129 |
| **Scenario 1: Complete Conversion of Biofuel Crops to Biofuels[4]** | | |
| Potential Biodiesel Production | 7.08 | 0.14 |
| Potential Ethanol Production | 87.14 | 1.76 |
| *Total Biofuel Production Potential* | *94.22* | *1.90* |
| Oil Equivalent Value (Millions, @$65/bbl) | $ | 45,137 |
| Petroleum Displacement Potential on an Energy Equivalent Basis:[5] | | |
| % of Transportation Energy Use | 19% | 19% |
| % of Imports | 23% | 23% |
| | | |
| **Scenario 2: Conversion of Excess Production to Biofuels[6]** | | |
| Potential Biodiesel Production | 1.42 | 0.03 |
| Potential Ethanol Production | 20.25 | 0.41 |
| *Total Biofuel Production Potential* | *21.67* | *0.44* |
| Oil Equivalent Value (Millions, @$65/bbl) | $ | 10,381 |
| Petroleum Displacement Potential on an Energy Equivalent Basis: | | |
| % of Transportation Energy Use | 4% | 4% |
| % of Imports | 5% | 5% |
| | | |
| **Scenario 3: Risk-Minimizing Production[7]** | | |
| Potential Biodiesel Production | 4.48 | 0.09 |
| Potential Ethanol Production | 57.98 | 1.17 |
| *Total Biofuel Production Potential* | *62.47* | *1.26* |
| Oil Equivalent Value (Millions, @$65/bbl) | $ | 29,925 |
| Petroleum Displacement Potential on an Energy Equivalent Basis: | | |
| % of Transportation Energy Use | 12% | 12% |
| % of Imports | 15% | 15% |

## 4. Opportunities for Greenhouse Gas Mitigation

A primary impetus for modern biofuel development has been to reduce CO2 emissions by shifting carbon fuel demand from fossil to renewable sources. In this sense, the conversion of eligible feedstock crops has a strong environmental justification, and indeed the EU has asserted leadership globally in promoting renewables to mitigate greenhouse gas emissions. Our results on EU biofuel capacity indicate there may be significant scope to further these environmental objectives, and in this section we offer estimates of exactly what benefits might accrue.

**Figure 6: Net CO2 Mitigation Scenarios**

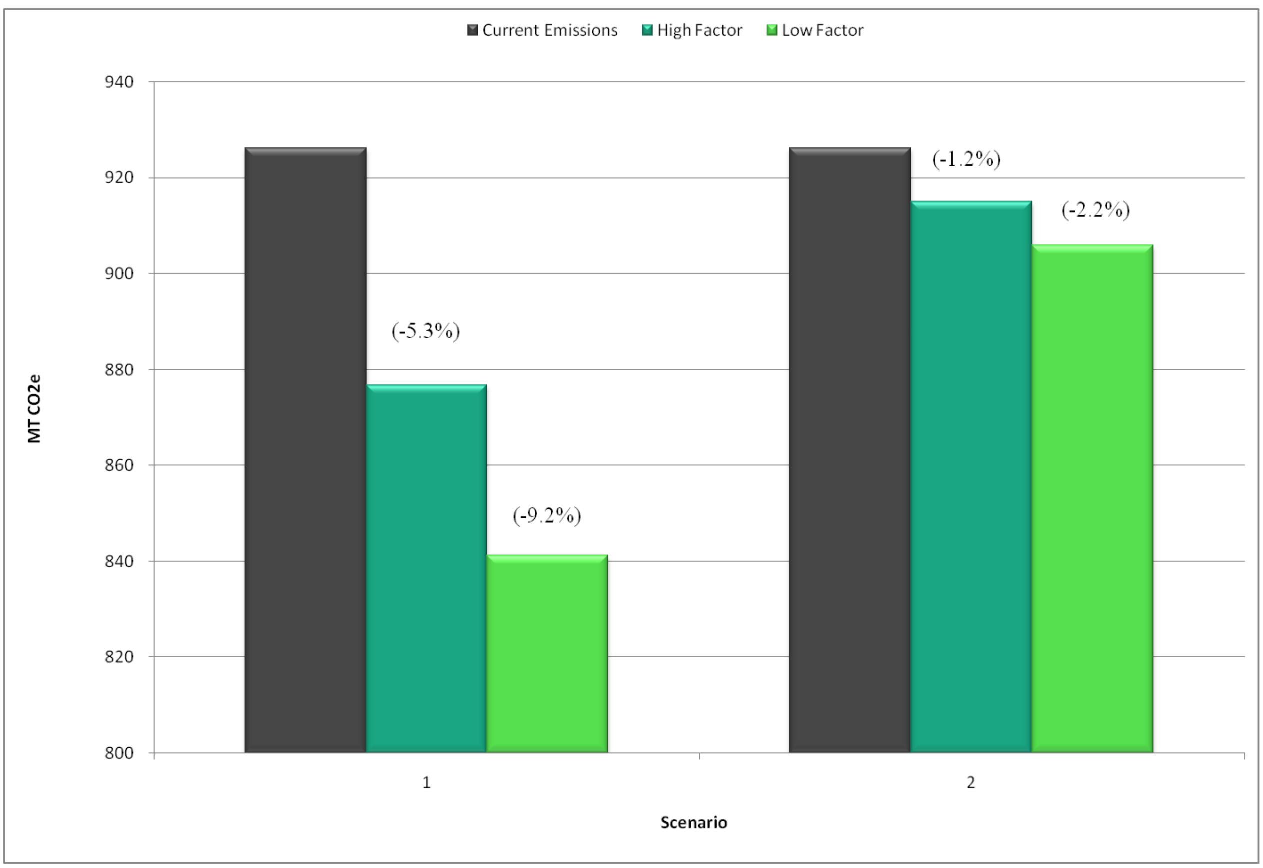



Figure 6– shows how much net CO2-equivalent mitigation could occur in the two previous scenarios, taking account of two alternative emissions factors. In light of uncertainty regarding

biofuel life cycle emissions, a range of emissions factors was used to evaluate the possible environmental impact. For each feedstock, a high and low CO2-equivalent emissions factor was selected. Where emission factor estimates for a specific feedstock were not available, the factor for the most similar feedstock was used (e.g. wheat's emissions factor was used for barley). In general, emissions from biodiesel feedstock cultivation are lower than ethanol feed stocks mainly due to lower fertilizer application rates. Moreover, both biodiesel and ethanol have lower life cycle emissions than diesel and gasoline. The emissions factors used are included as an annex to this paper. Increasing biofuel production has important potential to reduce road transport emissions. Scenario 1 offers the largest potential reduction, ranging from roughly 5.3-9.2%. Scenario 2, the more conservative case, offers the lowest potential reduction (1.2-2.2%). The results are summarized in Table 4 below.

**Table 4: Summary of Potential CO2e Emission Reductions from Increased Biofuel Production**

| | | Scenario Emissions | | Percent Change | |
|---|---|---|---|---|---|
| | Current Emissions from Road Transport | High Case | Low Case | High | Low |
| Scenario | (MT $CO_2$e) | (MT $CO_2$e) | (MT $CO_2$e) | (%) | (%) |
| 1 | 926.20 | 876.77 | 841.25 | -5.34% | -9.17% |
| 2 | 926.20 | 915.07 | 905.97 | -1.20% | -2.18% |
| 3 | 926.20 | 893.67 | 869.19 | -3.51% | -6.16% |

## 5. European Biofuel and the Doha Round

Agriculture is widely seen as the primary stumbling block in the current Doha Round of WTO mediated trade negotiations. Within this category, farm support in higher income countries is seen as trade distorting, putting taxpayer subsidized downward pressure on global food prices and, by extension, the livelihoods of farmers in lower income countries. While the degree of such price-income transmission is an independent empirical question, there is no doubt that existing patterns of farm support, particularly in Europe, are a highly contentious negotiating point. In this section, we examine the possibility of supporting farmers in a different way, one that recognizes their contribution to energy self-sufficiency rather than food self-sufficiency.

The general situation in terms of market value and support for the crops in question is summarized in Figures 7 and 9 below. If a substantial share of existing EU agricultural production would be eligible for biofuel production, and this in turn can reduce the likelihood that current surpluses (see again Table 1) might repress international prices by their diversion to international food markets. At current market prices for crops, biofuel, and oil, Table 5 summarizes the authors' estimates of crop values in the two alternative uses, including estimates of support and tax levels.

**Table 5: Food, Fuel, Support, and Taxation Levels for Biofuel Eligible European Crops (millions of 2005 USD and percentage)**

| Crop | Value at basic price | Subsidies on products | Taxes on products | Net Support | Percent of Net | Value at producer price | Biofuel Value | Food Premium |
|---|---|---|---|---|---|---|---|---|
| Wheat | 61,610 | 18,370 | 126 | 18,244 | 66 | 43,409 | 25,629 | 17,781 |
| Barley | 13,110 | 4,137 | 4 | 4,133 | 15 | 8,983 | 8,470 | 513 |
| Sugarbeet | 7,654 | 11 | 228 | (216) | - | 7,870 | 957 | 6,913 |
| Grain Maize | 14,685 | 2,799 | 50 | 2,749 | 10 | 11,936 | 13,136 | (1,200) |
| Potato | 11,057 | 112 | 2 | 110 | 0 | 10,948 | 5,597 | 5,350 |
| Rape and Turnip Seed | 5,560 | 1,537 | 0 | 1,537 | 6 | 4,023 | 4,336 | (313) |
| Sunflower Seed | 2,445 | 615 | 1 | 614 | 2 | 1,831 | 1,193 | 638 |
| Soybean | 444 | 153 | 11 | 142 | 1 | 302 | 144 | 158 |
| | 116,566 | 27,735 | 422 | 27,529 | 100 | 89,302 | 59,462 | 29,840 |

The two most arresting aspects of these results are somewhat contradictory. There is a significant aggregate value disadvantage for biofuel eligible crops, but also apparent are highly diverse returns to crops between the two markets. The former helps explain the slow uptake of biofuel conversion, but the latter identifies important opportunities for Europe to pursue energy price risk management while reducing the scope of Doha actionable food support. Both Maize and Rape/Turnip seed crops have a negative food premium, indicating that biofuel values exceed support inclusive food value. In these cases energy markets not only offer alternative demand for farm products, but may also bear part of the cost of producer support. Alternatively, these savings could be used to step up support for crops with low food premia, making them revenue-neutral to farmers in fuel production. If Barely, Sunflower, and Soybeans were brought in this way, fully 34% of net CAP support would be removed from food marketed commodities.

The magnitude of this kind of product diversion is of course very ambitious, and in all societies there are non-market reasons for domestic food production. The potential to influence Doha also depends how negotiators treat biofuels in comparison to food. Furthermore, many assumptions have gone into the present estimates, since support levels themselves are imprecise and we have for convenience assumed food and fuel processing costs are comparable. Despite the need for more rigorous empirical work on this issue, we believe these preliminary results show the important role the food-fuel conversion issue and play an important role in European agricultural, energy, and trade policy.

**Figure 7: Existing Value by Crop**
**(producer prices, 2004, USD Millions)**

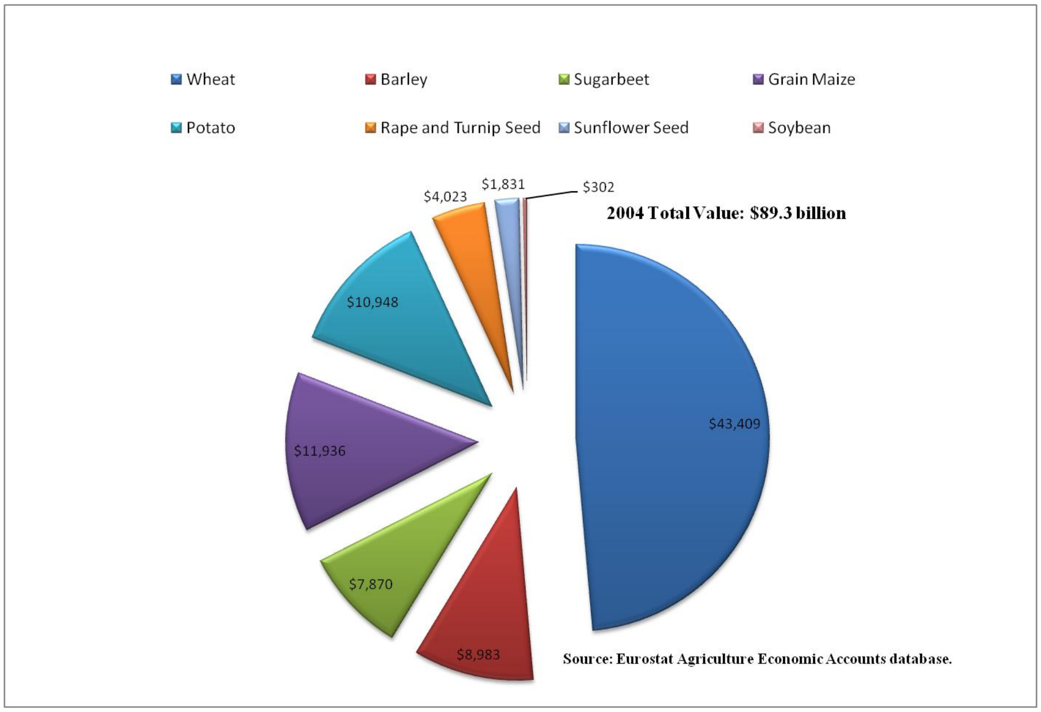
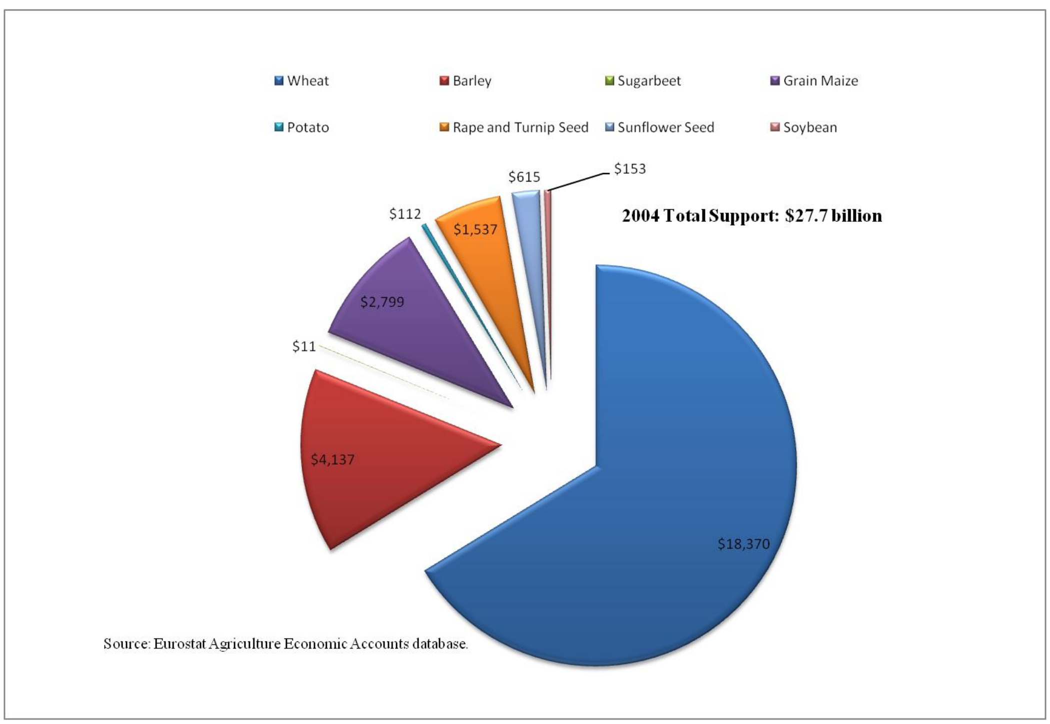



**Figure 8: Crop Subsidies for Potential Biofuel Feedstock Crops**
**(2004, current USD Millions)**



## 6. Conclusions

Farm support in higher income countries is a testament to the fundamental social and economic importance of agriculture, yet domestic efforts to support this sector can arouse multilateral discord in a world of global food markets. In this paper, we argue that the advent of biofuels offers a new opportunity for agriculture to contribute to society, and to do so in a way that reduces two important multilateral risks, climate change and trade rivalry. Biofuel gives farmers a new source of income while they provide environmental services (greenhouse gas mitigation) and help reduce external energy dependence. European farm support is also an impediment to global trade negotiations, and we believe a new food-fuel perspective can help overcome this by reconciling the needs of EU farmers and those in Europe and elsewhere who gain from more liberal international trade.

Using data from the 27 EU economies, we find that Europe has biofuel capacity that could contribute substantially reduce dependence on imported transport fuels, nationally and regionally, while expanding use of renewable fuels that mitigate global warming potential. Europe's existing biofuel crops represent the equivalent of over 23% of current transport fuel imports, while crops in excess of food self-sufficiency –could still displace over 5% of EU27 imports. As a renewable substitute for imported fossil fuels, these benefits would compound over time against rising world oil prices.

Critics of agricultural support generally, and agricultural trade protection in particular, often argue that domestic farming is being overly rewarded for its economic and environmental contributions. We argue that farming's environmental promise is even greater now, and that its economic value is destined to rise substantially with the cost of oil, risks of global warming, and the rising energy yields from biofuel. Just as importantly in the present context, we believe that rising private valuations renewable energy products can shift the burden of securing farm livelihoods from governments to markets, freeing public resources for other uses and removing significant distortions from global food markets.

Extensions of the present work would include a more detailed examination of the potential for energy trading to distribute biofuel benefits, both within Europe and with respect to the rest of the world. The EU's biofuel capacity is currently dominated by ethanol, yet it consumes a relatively high proportion of diesel by global standards. Trading systems can reconcile this as well as other national disparities in biofuel capacity. It is also reasonable to expect trading to animate a far reaching re-examination of existing cropping patterns, another important subject only alluded to in this paper. As biofuel potential is examined more actively, and particularly as carbon fuel prices continue their historical ascent, it is reasonable to expect adjustments in agricultural land use, both for conventional crops and more innovative alternatives (switchgrass, miscanthus, etc.).

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Notes on Tables:

Table 1:
Source: OECD (2005)
Table 2:
Notes:
Scenario 1 converts all exisiting potential feedstocks into biofuels.
Scenario 2 converts excess production (self-sufficiency >100%) into biofuels.
Scenario 3 converts risk-minimizing amount of agricultural imports (as calculated from the risk model in the paper) into biofuels.

1. Adjusts for lower biofuel energy conents compared to fossil fuels.

Sources:
Transportation energy use and import data from:
EU DG Energy & Transport (2006).
Feedstock production values from:
EU DG Agriculture and Rural Development (2005)

Biofuel conversion factors from:
Argonne National Laboratory (2006) (Corn)
Edwards et al (2006b) (Sugarbeet)
Elsayed et al (2003) (Sugarbeet, rapeseed)
Punter et al (Wheat)
Sheehan et al (1998) (Soybean)
IEA (2000). (Barley)
Pimentel, D. and T. Patzek (2005). (Sunflower seed)
Smeets et al, E.M.W., M. Junginger and Faaij A.P.C. (2006) (Potato)

<u>Table 3:</u>

1. All calulations based on 2004 data.
2. See EU DG Research (2006). Biofuels in the European Union: A Vision for 2030 and Beyond. ec.europa.eu/research/energy/pdf/draft_vision_report_en.pdf
3. Total imports are calculated as import dependency
times transportation energy use as total raw imports
for the EU-25 exceeded total energy use.

4. Biofuel production potential calculated by converting
all current biofuel feedstock production into biofuel.
For ethanol, feedstock crops are wheat, barley,
sugarbeet, corn and potatoes.
For biodiesel, feedstock crops are rapeseed, sunflower
seed and soybean.
5. On an energy equilvalent basis, a barrel of ethanol
has 67% the energy content of gasoline and biodiesel
has 87% the energy content of diesel.
See: International Energy Agency (2004), Biofuels for Transport.
6. Biofuel production potential calculated by converting
excess crop production (self-sufficiency level >100%) to biofuels.
7. Converts optimal agricultural import level of production,
as derived from the risk model presented in the paper, into biofuels.
Sources:
Transportation energy use and import data from:
EU DG Energy & Transport (2006).
Feedstock production values from:
EU DG Agriculture and Rural Development (2005).
Biofuel conversion factors from:
Argonne National Laboratory (2006) (Corn)
Edwards et al (2006b) (Sugarbeet)
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Table 4:
1. Scenario emissions calculated using life cycle emission factors for specific feedstocks. Emission factors for each feedstock were not available and in such instances, the emission factor for the closest crop type was used.
For example, the wheat emission factor was used for barley, rapeseed was used for sunflower seed and corn was used for potatoes.
2. Emission scenarios calculated using two estimates of emissions factors for each feedstock. The larger of the two was used to calculate
emissions under the high case scenario and the lower for the low case scenario.

Sources: Production amounts from Table 7. Biofuel emission factors from Elsayed et al (2003), DTI Sustainable Energy Programme (Sugarbeet, rapeseed), Hill et al (2006) (Corn, soybeans), Woods and Bauen (2003) (Rapeseed, wheat, sugarbeet), Farrell et al (2006) (Corn).