Mapping a Course for Biofuels: Science-informed Policy Needed

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Biofuels offer an attractive alternative to fossil fuels, but they are no panacea. Proper deployment requires a consistent scientific framework to inform policies that maximise the positive potential of biofuels and minimise their negative impacts.

Numerous countries are moving towards the partial and gradual replacement of fossil fuels with biofuels, mainly ethanol. The increased move towards biofuels is spurred by global political, economical and environmental events, especially rising oil prices. Between 1974 to 1979 oil prices increased tenfold and threatened the economic stability of oil-dependent countries and of the world at large. This stimulated research into the use of biodiesel (produced from oilseeds and animal fat) and of ethanol (produced out of starch and sugars) as a potential alternative to gasoline. Those promoting voluntary and/or mandatory use of biofuels in diesel and gasoline engines in the transportation sector highlight the fact that it: a) contributes to the reduction of greenhouse gas (GHG) emissions [1] in an effort to mitigate climate change; b) diversifies the energy matrix, which is beneficial considering uncertainties of oil supply and increased prices; c) generates income for farmers and full deployment of agribusiness chains; and d) maintains and/or expands agricultural and industrial subsidies. Thus far, however, the only country to have succeeded in large-scale production and use of biofuels is Brazil.

Newly cut sugar cane.

This article addresses some issues related to biofuels policies, arguing the need for a global research agenda to properly quantify biofuel potentials and comparatively assess current and future biomass conversion technologies that might enhance the environmental, economic and social performance of biofuels.

The Use of Ethanol as a Fuel

Preexisting policies in Brazil were conducive to the production of biofuels. Sugar cane and sugar production and export have been important national economic activities for centuries. Sugar prices are volatile, however, and production of ethanol from sugar surplus became an attractive alternative in times of low sugar prices. In 1931 the Brazilian government wrote the world's first biofuels policy, a decree [2] to develop ethanol as a fuel and blend it with gasoline.

Today the sugar and ethanol production chain in Brazil is completely liberalized and, after a long period of research and investment in the science and technology of sugar cane and ethanol production, production costs are competitive with gasoline. The government established a mandatory blending of anhydrous ethanol into gasoline that varies from 20% to 25%. In 2003 flexi-fueled [3] cars

Country	2004	2005	2006
Brazil	3,989	4,227	4,491
U.S.	3,535	4,264	4,855
China	964	1,004	1,017
India	462	449	502
France	219	240	251
Russia	198	198	171
South Africa	110	103	102
U.K.	106	92	74
Saudi Arabia	79	32	52
Others	1,108	1,541	1,356
Total	**10,770**	**12,150**	**12,871**

Table 1. Annual World Ethanol Production by Country (Millions of Gallons)

Source: F.O. Litch, 2007.

Table 2. Projections for EU Production of Ethanol 2012

	2006				2012			
	Ethanol production		Feedstock production		Ethanol production		Feedstock production	
	(mn liters)	share	(mn tons)		(mn liters)	share	(mn tons)	
Total	**1,560**		**Total**	**For ethanol**	**10,085**		**Total**	**For ethanol**
Wheat	504	32.3%	109.3	1.4	4,034	40%	135.9	11.2
Barley	440	28.2%	53.6	1.1	440	4%	46.1	1.1
Corn	200	12.8%	44.6	0.5	1,291	13%	51.9	3.2
Rye	200	12.8%	7.8	0.5	200	2%	9.1	0.5
Beet	88	5.6%	141.7	0.8	3,864	38%	120.7	35.2
Wine	128	8.2%	—	—	256	3%	—	—

Sources: eBIO, European Commission, calculations by the authors.

started to be commercialized. By 2006, they represented 83.1% of new cars sold [4] creating a very strong internal market for ethanol.

The United States' growing interest in ethanol recently has enhanced the visibility of biofuel issues globally. Initial driving factors were concerns about public health and air quality, which stimulated a search for cleaner alternatives and policies requiring their use, especially in big cities. The US also launched a policy for the rapid substitution of MTBE (a gasoline additive that is toxic and highly pollutant). MTBE was then replaced by ETBE, derived from ethanol.

The promotion of ethanol from corn made the US the world's largest producer of ethanol in 2006 (Table 1), overtaking Brazil. The US has the capacity to produce almost 5 billion gallons annually, and its biodiesel production is one of the fastest growing in the world. However, ethanol production is also heavily subsidized and importations are taxed to protect domestic producers.

Other countries are also investing in ethanol production from sources such as cassava, in the case of Southeast Asia (for sources in the case of EU countries, see Table 2).

Biodiesel Production and its Rationale

The production of commercial biodiesel grew increasingly important in the 1990s, mainly in Europe. Europe currently represents approximately 90% of the global production. Germany, France and Italy are the biggest biodiesel producers in the world. See Figure 1 below.

European farmers were the

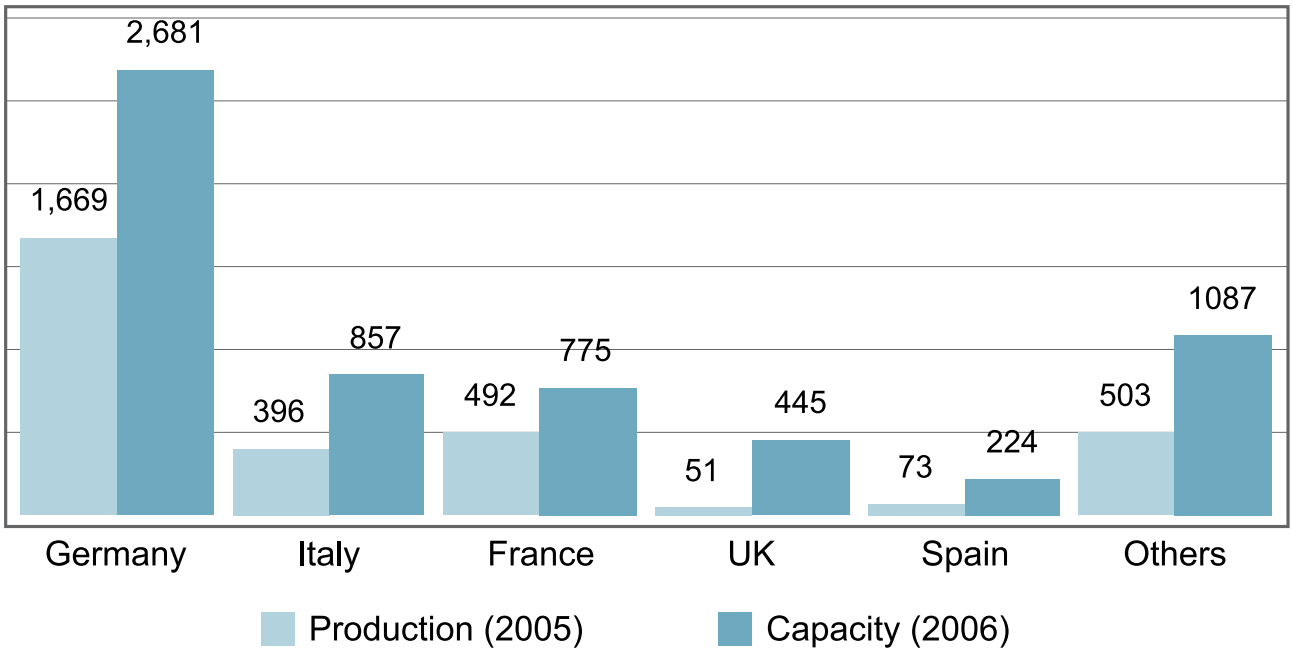

Figure 1. Main producers of biodiesel in the EU – Source: IEA, 2007.

first to support policy incentives towards biodiesel production. Their main concern was to address the persistent problem of vegetable oil surpluses. Much less competitive than American and South American farmers in this area, European farmers were worried about international trade agreements that partially opened European markets for foreign agribusiness commodities, mainly soybean oilseed, oil and oil meal produced in the US.

The Environmental Debate and Biofuels

The 1992 Earth Summit [5] in Brazil resulted in two important Conventions: the Convention on Biological Diversity (the CBD) and the United Nations Framework Convention on Climate Change (UNFCCC). One of the most concrete products of the UNFCCC processes, the Kyoto Protocol, [6] defined responsibilities for the most polluting countries, including quotas for greenhouse gas emission reductions. The Protocol came into force in 2005. Other significant results similarly pressuring policy makers to adopt environmental-oriented policies were the conclusions of the Third Assessment Report [7] of the United Nations Intergovernmental Panel on Climate Change (IPCC) that anthropogenic activities influence current and future climate changes and the Fourth Assessment Report that the evidence for anthropogenic climate change was unequivocal. Current policies to gradually increase renewable energy use in transportation sectors are part of a broader agenda of reducing dependence on fossil fuels and reducing greenhouse gases to mitigate climate change and its impacts through carbon sequestration.

A wide range of technologies are being introduced to increase use of renewable sources of electricity, including wind power, photovoltaic panels, small hydropower plants, biogas and biomass conversion plants. The only products currently available to significantly replace liquid fossil fuels in transportation on a global scale are biodiesel and ethanol fuels, however, despite advances of electric cars and hydrogen powered ones. As a result, several policies have been proposed recently to support biofuels research and production. In May 2003, the European Commission launched its Biofuels Directive 2003/30/EC [8], establishing a legal basis for blending biofuels and fossil fuels. EU member countries were urged to replace 2% of fossil fuels with biofuels by 2005 and 5.75% by 2010. From 2003 to 2005 EU members enhanced biofuels' market share from 0.6% to 1.4% [9]. However, they have not yet achieved the first target. The EU Directive 2003/96/EC [10] has also established tax incentives to encourage renewable energy use. [11]

The Need for a Scientific Agenda and Framework to Fully Deploy Biofuels' Potentials

The most relevant biofuel policies were designed during this decade, significantly stimulating biofuel production worldwide, and raising worries about the sustainability of biofuel production and its environmental, economic and social impacts.

One important concern is the environmental performance of biofuels. Considering that one of the main goals is to reduce greenhouse gas emissions, proper understanding of the relative emissions from biofuels and fossil fuels is needed. Each type of biofuel has to be studied independently, as their greenhouse gas emissions and energy balance differ (See Figure 2).

Other causes for concern are land use changes and associated processes affected by the expansion of bioenergy crops, particularly non-planned expansion in developing countries. The competition between food production and land and water use, as well as between other production factors, is also subject to concern.

Several initiatives and projects are being established to define sustainability criteria to assess the benefits and impacts of biofuels. Some of these work through market instruments, such as the implementation of certification processes and schemes. In addition, several projects are addressing new technologies for biomass conversion towards the second generation of biofuels and the synthetic renewable ones.

While the above concerns are well-justified, some criticism of biofuels and their impacts are motivated by protectionism and interest in agricultural subsidies and agribusiness production chains in several developing countries. Proposed certification schemes may become non-tariff barriers rather than environmentally and socially sound schemes. Scientific and technological assessments about the performance of the different kinds of biofuels are needed to reduce the play of such interests and to establish the strengths and potential of biofuels along with their dangers and limitations.

The OECD's [12] latest report on biofuels [13] illustrates how fears can be perpetuated without proper scientific basis. Suggestively titled "Biofuels: is the cure worse than the disease?", the report stated:

"Even without taking into account carbon emissions through land-use change, among current technologies only sugarcane-to-ethanol in Brazil, ethanol produced as a by-product of cellulose production (as in Sweden and Switzerland), and manufacture of biodiesel from animal fats and used cooking oil, can substan-

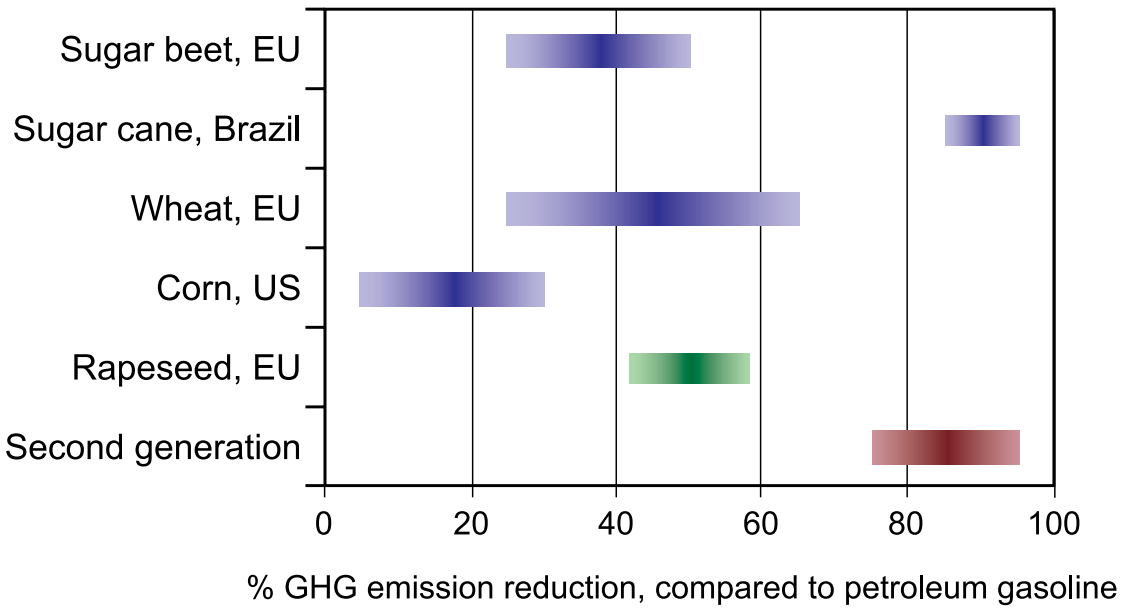

Figure 2. Greenhouse gas emission reductions gained by switching to the various biofuels, with gasoline as the baseline. Source: IEA/OECD 2006

tially reduce [greenhouse gases] compared with gasoline and mineral diesel. The other conventional biofuel technologies typically deliver [greenhouse gas] reductions of less than 40% compared with their fossil-fuel alternatives."

This report also recognized that while trade barriers would persist to the international market, it will be difficult for the world to take advantage of the environmental qualities of the use of some biofuels, mainly the ethanol form sugar cane and so forth, as international markets are not yet fully created for biofuels.

A huge challenge facing policy makers, businesses, scientists and societies as a whole is how to responsibly establish sustainable production systems and biofuel supplies in sufficient volume that meet current and future demands.

Biofuels are not a panacea. They do not solve all problems related to the over-consumption of fossil fuels, such as the emissions of greenhouse gases and climate change. But if properly deployed, biofuels can be environmentally beneficial and contribute to the diversification of the energy matrix globally, thus reducing the vulnerability that comes with dependence on a single energy source. A concerted and coherent scientific agenda involving scientists from different countries and disciplines is most welcome and needed to meet the challenge of designing technologies, systems and policies that maximize the positive potential of biofuels and reduce their negative impacts.

Without expansion, continuity, commitment and proper concentration of efforts, the multiple, isolated initiatives being carried out in the world will not help us sufficiently understand the critical questions of sustainable production of biofuels.

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Biofuel Notes

1. Greenhouse gases (GHG) occur naturally in the atmosphere and maintain the heat in the earth's surface. Anthropogenic activities, mainly the burning of fossil fuels, have increased greenhouse gas concentration in the atmosphere, which has resulted in progressive global warming.
2. The Decree 20.356 of 1 September had the aim to develop the use of ethanol as a fuel. Available at http://www6.senado.gov.br/sicon/MudaVisualizacaoDocumentos.action.
3. Flex-fuel vehicles are fueled with gasoline, hydrated ethanol or a mixture of both in any proportion.
4. National Association for the Automobile Industry (ANFAVEA/Brazil). Brazil- automobiles- production, internal retail and export. In Annual Report for the Brazilian Automobile Industry, Ed. 2007.
5. The documents from the Earth Summit (also known as the United Nations Conference on Environment and Development – UNCED) held in Rio de Janeiro, Brazil in 1992 are available at http://www.un.org/esa/sustdev/documents/docs_unced.htm
6. To learn more about the Kyoto Protocol and its rules, visit the United Nations Framework Convention on Climate Change (UNFCCC) website at http://unfccc.int/kyoto_protocol/items/2830.php
7. A summary for policy makers is available at the IPCC website http://www.ipcc.ch/pub/un/syreng/spm.pdf
8. Directive 2003/30/EC of the European Parliament and of the Council of 8 May 2003. On the promotion of the use of biofuels or other renewable fuels for transport. Official Journal of the European Union. Found at http://ec.europa.eu/energy/res/legislation/doc/biofuels/en_final.pdf
9. Communication from the Commission of the EC, An EU Strategy for Biofuels, 8 February 2006, found at http://ec.europa.eu/agriculture/biomass/biofuel/com2006_34_en.pdf
10. Directive 2003/96/EC of 27 October 2003 restructuring the Community framework for the taxation of energy products and electricity, Official Journal L 283 of 31.10.2003, found at http://eur-lex.europa.eu/LexUriServ/site/en/oj/2003/l_283/l_28320031031en00510070.pdf. To avoid undue distortion of competition and over-compensation, these tax concessions are considered state aids and may not be implemented without prior authorization by the European Commission.
11. United Nations Conference on Trade and Development, The Emerging Biofuels Market: Regulatory, Trade and Development Implications, 2006, found at http://www.unctad.org/en/docs/ditcted20064_en.pdf.
12. The Organisation for Economic Co-operation and Development (OECD) groups 30 member countries that represent the most developed economies of the world. More information can be found at www.oecd.org.
13. OECD. Biofuels: is the cure worse than the disease. Paris: September, 2007. Available in http://www.oecd.org/dataoecd/40/25/39266869.pdf.