Chapter 8

Perspectives for a global biofuels market

Several countries have been interested in the development of bioethanol use and production. Until now the main driver has been the need to cover domestic energy needs, especially for liquid transportation fuels. However, there is also growing interested in creating a global biofuels market, which helps to bring together producer and importing countries, with advantages for both of them. Nowadays, such market is still incipient, but it is expanding because of the increasing demand for a renewable and environmentally friendly fuel. Sugarcane-based bioethanol is a biofuel that presents interesting perspectives for the development of such market, given that it can readily meet straightforward sustainability and energy criteria and that production can be competitive vis-à-vis gasoline, the equivalent fossil fuel. This Chapter analyses factors that are relevant for sugarcane bioethanol to become a global international product, taking into consideration its current and future supply and demand, as well as the policies and trends related to its production and trading.

Although the focus of the book is on sugarcane bioethanol, the general context of biofuel is also analyzed in this chapter, including information on other bioethanols and biodiesel. The first section presents estimates about the potential of bioenergy production, followed by data on the current (Section 8.2) and projected (Section 8.3) demand and supply for bioethanol, and a review of policies and strategies that have been proposed to support bioethanol production and use (Section 8.4). The last sections discuss trade-offs between food and biofuels production (Section 8.5), as well as some critical factors for the creation of a global bioethanol market (Section 8.6), which are related to environmental challenges and strengthening of international agricultural trade.

Based on a study carried out by the Global Bioenergy Partnership (GBEP, 2007), which will be quoted later in the chapter, the following definitions will be used: bioenergy is energy derived from biomass; a biofuel is an energy carrier derived from biomass; and liquid biofuels are liquid fuels derived from biomass, and include bioethanol, biodiesel, biodimethylether, raw vegetable oil, synthetic diesel and pyrolysis oil (biooil).

8.1 Overall potential for biofuels production

Several studies have been carried out to shed light on the main issues governing the future of biofuels, and bioethanol in particular. How much and where can they be made available? This question is not simple, since the potential of biofuel supply is not an absolute and static number, like in the case of a mineral reserve. In fact, it is a very dynamic figure dependant on changing geographic, economic and political scenarios, as well as on technologies of production and conversion that in many cases are still being developed.

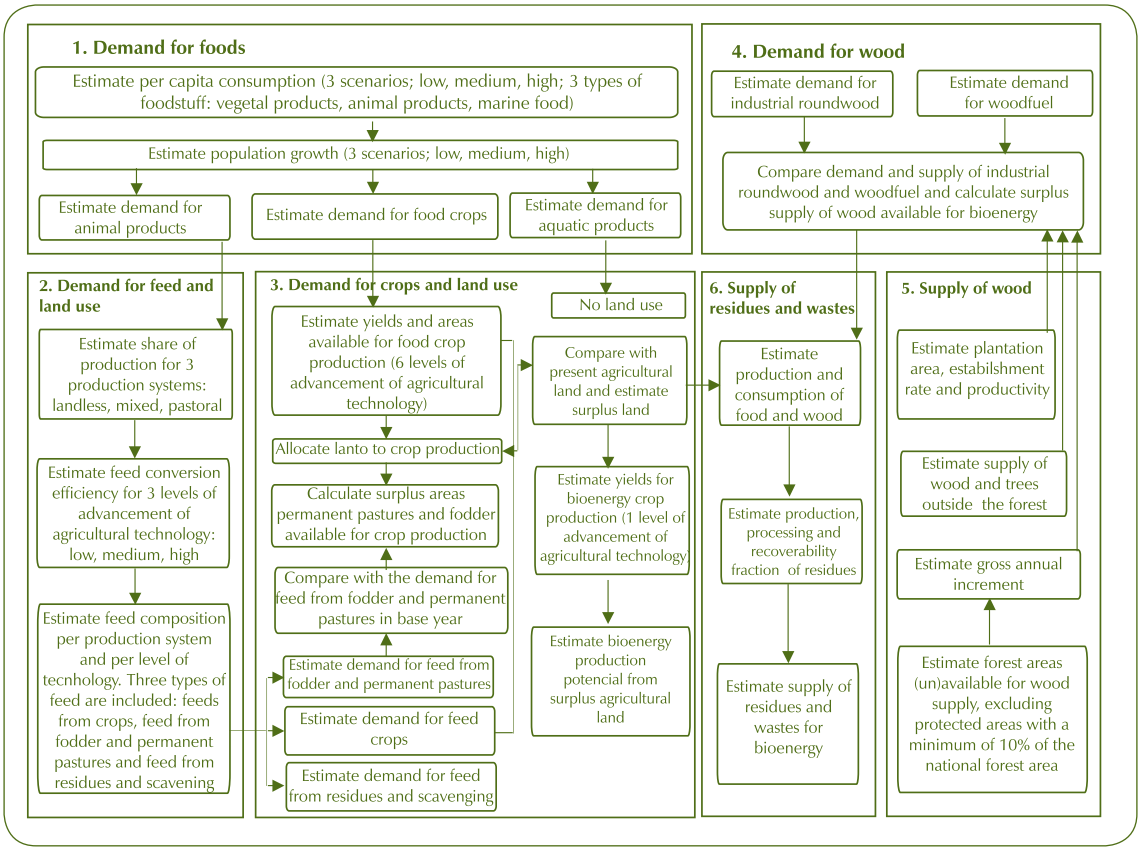
Additionally, the natural resources needed to grow energy crops, like soils and water, are necessarily limited and must be shared with the production of food and feed, industrial inputs (eg, textile fibbers, wood for cellulose and other purposes, hydro energy, etc.) and the protection of nature, among other uses. Such thematic complexity increases because of the relationship between biofuels and the food supply, which makes it relevant to know about the sustainable potential of production, conversion and use of biofuels vs. the concerns with food security.

In this context, establishing the limits and boundaries to biofuel production and, particularly, setting sustainability criteria become complex tasks. As we can see later in this Chapter, analytical and computational models have been developed to face such tasks. These models, which allow to model and simulate different types of impacts, are intended to evaluate policies and to support decision makers in the creation of bioenergy programmes. Figure 30 presents the wide range of issues to be considered in assessing bioenergy potential from energy crops, according to the model suggested by Smeets et al (2006), while also taking into account other agricultural and forestry demands.

Early studies of biomass availability [Berndes et al. (2003)] concluded that in 2050 the possible contribution of biomass to global energy supply could vary from 100 EJ/year to 400 EJ/year, which represents from 21% to 85% of the current total consumption of energy in the planet, estimated in 470 EJ. The interactions between the expanding bioenergy sector and other land uses, such as food and feed production, biodiversity protection, soil and nature preservation and carbon sequestration, were recently evaluated in some studies.

One of the most important works [Smeets et al. (2006)] uses a bottom-up approach to process information about land use, agricultural management systems, estimates of food demand and information concerning possible improvements in agricultural management (both for crops and production of meet and dairy products). Recent studies group the biomass used to produce energy in three categories: energy crops on current agricultural lands; biomass production on marginal lands; and residues from agriculture and forestry waste, manure and other organic wastes [Junginger et al. (2007)]. Based on the approach presented in Figure 30, it is estimated that these categories could supply 200 EJ, 100 EJ and 100 EJ, respectively, corresponding to the higher limit of 400EJ previously presented.

***Figure 30* – Overview of the key elements in the methodology to assess the bioenergy potential from dedicated bioenergy crops**

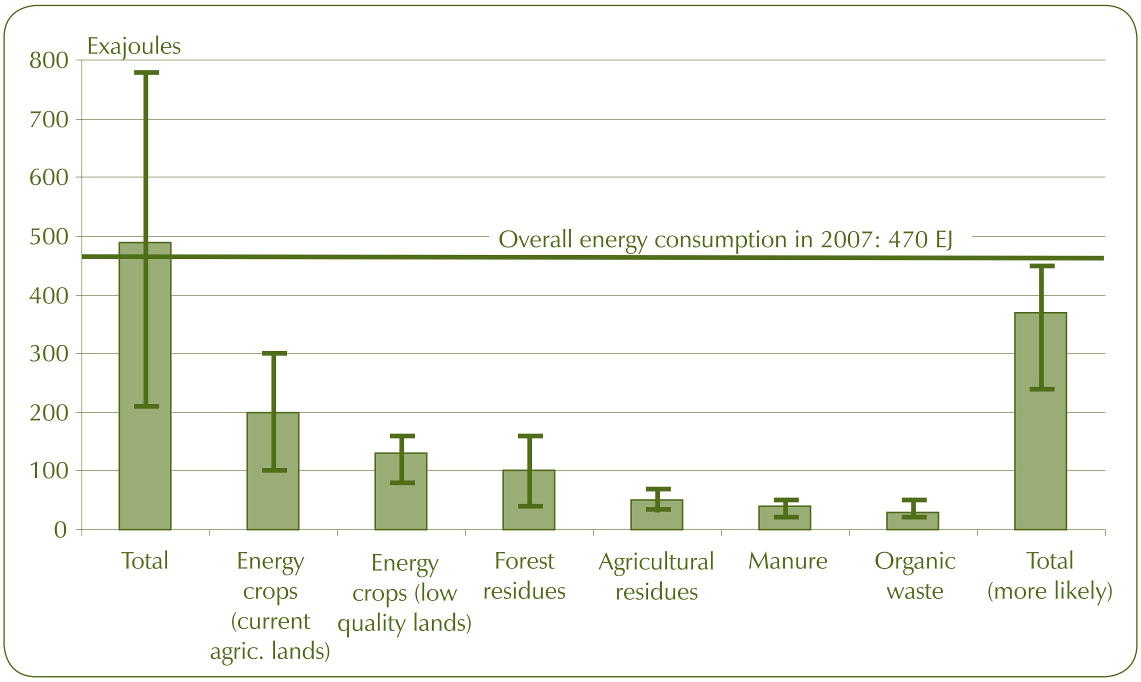


Source: Smeets et al. (2006)

It is difficult to arrive at a single figure representing the overall energy potential from biomass, as it is determined by several factors. Such difficulty is illustrated by Graph 36, which provides an idea of the ranges of biomass supply for energy purposes resulting from various approaches and methods. The estimates vary from 205 EJ to 790 EJ, that is, between 43.6% and 168.1% of the overall energy demand estimated for 2007, also shown in the figure. The main reason for such variations, between upper and lower limits, is the high uncertainty vis-à-vis land availability and productivity levels, the two most critical parameters considered in the estimation. In addition, there are significant variations among studies regarding expectations of future biomass supply from forest wood and from agricultural and forestry residues.

Table 35 presents an assessment of possible variations in the technical potential of biofuels, under four hypothetical agricultural production systems. The estimates consider energy crops and agricultural and forestry residuals, but exclude suet and other fat by-products with bioenergy potential. Food demand data was obtained from the national Food Balance Sheets (FBS) published by FAOSTAT, an FAO (Food and Agriculture Organization of the United Nations) global information system on food and agriculture [FAO in Bruinsma (2003)]. In addition, no food shortages are allowed to occur in all scenarios.

***Graph 36* – Bioenergy potential per biomass type**



Source: Juergens (2007).

Systems 1 to 3 assume medium global population growth between 1998 and 2050 (between 5.9 billion and 8.8 billion people), as well as medium food consumption per capita growth (between 2.8 Mcal to 3.2 Mcal person/day). In the production side they assumed that during the same period a high plantation scenario has been established (from 123 million to 284 million hectares) and that a high technological level for the production of bioenergy crops has been reached. System 4 presumes that advances in research and development permit a 25% increase in yields above system 3. The agricultural production system determines the amount of food crops and feed crops produced, and consequently also the volume of harvest residues generated. System 3 is based on a landless animal production system in which all feed comes from crops and residues. Systems 1 and 2 are based on a mixed production system, in which a significant part of the feed comes from grazing. The production of harvest residues from food and feed crop production is consequently the highest in system 3. Small differences in residue production between systems 1 and 2 are caused by differences in the allocation of crop production. The production system also determines the level of advancement of agricultural technology and therefore influences the crop harvest residue generation fraction.

Table 35 – Total technical bioenergy production potential in 2050, by regions and production system
(EJ per year)

Region	Agricultural production system			
	1	2	3	4
Latin America and Caribbean	89	162	234	281
North America	39	75	168	204
Sub-Saharan Africa	49	117	282	347
North Africa and Middle East	2	2	31	39
Western Europe	13	19	25	30
Eastern Europe	5	13	24	29
Commonwealth of Independent States (CIS) and Baltic States	83	111	223	269
India and South Asia	23	26	31	37
East Asia	22	28	158	194
Japan	2	2	2	2
Oceania	40	55	93	114
Total	367	610	1,273	1,548

Source: Smeets et al. (2006).

The study found that the largest potential for energy crop production is located in Sub-Saharan Africa and Latin America and the Caribbean, with 317 EJ and 281 EJ in scenario 4, respectively. Both regions have large areas that are agro-ecologically suitable for crop production and for sugar cane in particular, and that are not being used presently. East Asia also has a considerable potential for energy crop production, 147 EJ in scenario 4. The Commonwealth of Independent States and Baltic States, North America and Oceania present the most significant potentials among the development countries. Land stressed regions such as Japan, South Asia, North Africa and Middle East have zero or a very limited potential. Highly relevant to the Latin American case is the attention the model gives to the impact of animal production on biofuels development since these products are far more land intensive per kg of product than crop production [FAO in Bruinsma (2003)].

The results are quite optimistic regarding the impacts of bioenergy on food production. An important conclusion is that the technical potential to increase the efficiency of food production is sufficiently large to compensate for the increase in food consumption projected between 1998 and 2050. The total global bioenergy potential in 2050 is estimated to be 78% (367 EJ), 129% (610 EJ), 270% (1273 EJ) and 329% (1548) of the energy demand in 2005, for systems 1 to 4, respectively. The bulk of this potential comes from specialized energy crops grown on surplus agricultural land that would not longer be needed for food production. It is worth noting that variation in surplus agricultural land among the agricultural production systems is mainly dependent on the efficiency with which animal feeds are produced. Residues and wastes account for 76 EJ to 96 EJ per year of the technical potentials. The authors cite other estimates published in the scientific literature [Hoogwijk et al. (2003) and Wolf et al. (2003)], which seem to confirm the results they obtain.

Pre-requirements to achieving the above levels of the energy crops production are the introduction of advanced agricultural production systems, an increased use of inputs such as fertilizers and agrochemicals and, in particular, and optimization of crop production yields. It is noted that as a result of those improvements, between 15% and 72% of the agricultural area in use could be made available for energy crop production, in systems 1 and 4, respectively.

Table 36 presents similar data on the overall bioenergy production potential from various biomass feedstocks, indicating the general conditions to reach the production levels estimated. In some cases two potential ranges are provided for each biomass category: a) average potential under normal conditions with projected technological progress; and b) average potential in a world aiming for large-scale utilization of bioenergy. A lower limit equal to zero means that the available potential may be zero or negative, which will be the case if agriculture is not modernized so that more land is needed to feed the world [Faiij and Domac, 2006].

In the case of biomaterials the bioenergy potential could be even negative, since the biomass demand to produce bioplastics or construction materials can reduce the biomass availability for energy production. However, the more biomaterials are used the more by-products and organic waste will become available to be used in the energy production. The biomass use will result in a “double” benefit regarding greenhouse gases, avoiding the emission that would have occurred if the materials had been produced using fossil fuels and producing energy from the waste. The energy supply from biomaterials that become waste may vary between 20 EJ to 50 EJ, estimate that does not include the cascade effect (successive uses) and does not consider the time elapsing between production of the material and the release as organic waste [Faiij and Domac, 2006].

In relation to land use and its impact on the availability of lands for agriculture, a report of the International Energy Agency [IEA Bioenergy (2007)] points out that it is realistic to expect a considerable increase in the bioenergy contribution, from the current estimate of 40 - 55 EJ per year to an annual supply of 200 - 400 EJ by 2050. Based on generally accepted data, this report indicates that one third of this energy could be supplied by residues and wastes; one-fourth by the regeneration of degraded or marginal lands; and the remaining by current agricultural lands and pastures. Hence, almost one billion hectares in the world could be used in the production of energy-related biomass, including 400 million hectares of current agricultural lands and pastures, as well as a larger area of degraded and agricultural lands, which account for around 7% of the land surface and less than 20% of the land currently used in agricultural production.

Table 36 – **Potential of several feedstock and production systems for bioenergy**

Context of bioenergy production	Main hypothesis and observations	Potential of bioenergy supply until 2050 (EJ/year)	
		Normal scenario	Optimist scenario
I. Energy farming on current agricultural land	Potential land surplus: 0-4 Gha (more average: 1-2 Gha). A large surplus requires structural adaptation of the agricultural production systems. When this is not feasible, the bio-energy potential could be reduced to zero as well. On average higher yields are likely because of better soil quality: 8-12 dry t/ha/yr is assumed. (Heating value: 19 GJ/t dry matter)	0 to 700	100 to 300
II. Biomass production on marginal lands	On a global scale a maximum land surface of 1.7 Gha could be involved. Low productivity of 2-5 dry t/ha/yr (Heating value: 19 GJ/t dry matter). The supply could be low or zero due to poor economics or competition with food production.	0 to 150	60 to 150
III. Bio-materials	Range of the land area required to meet the additional global demand for bio-materials: 0.2-0.8 Gha (average productivity: 5 dry t/ha/yr - Heating value: 19 GJ/t dry matter). This demand should be come from category I and II in case the world's forests are unable to meet the additional demand. If they are however, the claim on (agricultural) land could be zero.	0 to 150	40 to 150
IV. Residues from agriculture	Estimates from various studies. Potential depends on yield/product ratios and the total agricultural land area as well as type of production system: extensive systems require re-use of residues for maintaining soil fertility. Intensive systems allow for higher utilisation rates of residues.	15 to 70	
V. Forest residues	The (sustainable) energy potential of the world's forests is unclear. Part is natural forest (reserves). Range is based on literature data. Low value: figure for sustainable forest management. High value: technical potential.	0 to 150	30 to 150
VI. Manure	Use of dried manure. Low estimate based on global current use. High estimate: technical potential. Utilisation (collection) on longer term uncertain.	0 to 55	5 to 55
VII. Organic wastes	Estimate on basis of literature values. Strongly dependent on economic development, consumption and the use of biomaterials. Figures include the organic fraction of MSW and waste wood. Higher values possible by more intensive use of biomaterials.	5 to 50	
Total	Most pessimistic scenario: no land available for energy farming; only utilisation of residues. Most optimistic scenario: intensive agriculture concentrated on the better quality soils.	40 to 1,100	250 to 500

Source: Faaij and Domac (2006).

Other reports [Best et al. (2008)] point out that of the 13.2 billion hectares of the world's total land area, 1.5 billion are used to produce agricultural crops and 3.5 billion are used in livestock production. Crops currently used specifically for biofuels, as a result of farmer's choice, use only 0.025 billion hectares. In Brazil, for example, more than 40% of total gasoline demand is supplied by the ethanol produced from sugarcane grown in 1% of the 320 million hectares of agricultural and pasture land and none in the Amazon Rainforest.

It is worth noting that crops used in energy production, in addition to biofuels also provide by-products, such as animal fodder, fertilizers and bioelectricity, in significant volumes. The previous chapter includes information about the diversity of sugarcane co-products that can be produced along with bioethanol, under current and expected future conditions.

In conclusion, it is possible to assert that — although methodologies and tools to assess in detail the global potential of biofuels are still under development and that biomass data is not available in many countries — there is a large and untapped global potential for biofuels. Some relevant preliminary conclusions can be stated: a) the potential bioenergy supply depends on food production patters, particularly concerning land requirements for animal production; b) some regions present a clear comparative advantage; and c) the total potential available is of the same magnitude as the overall energy demand, under optimist assumptions. The following section shows how that potential is being explored in the case of biofuels.

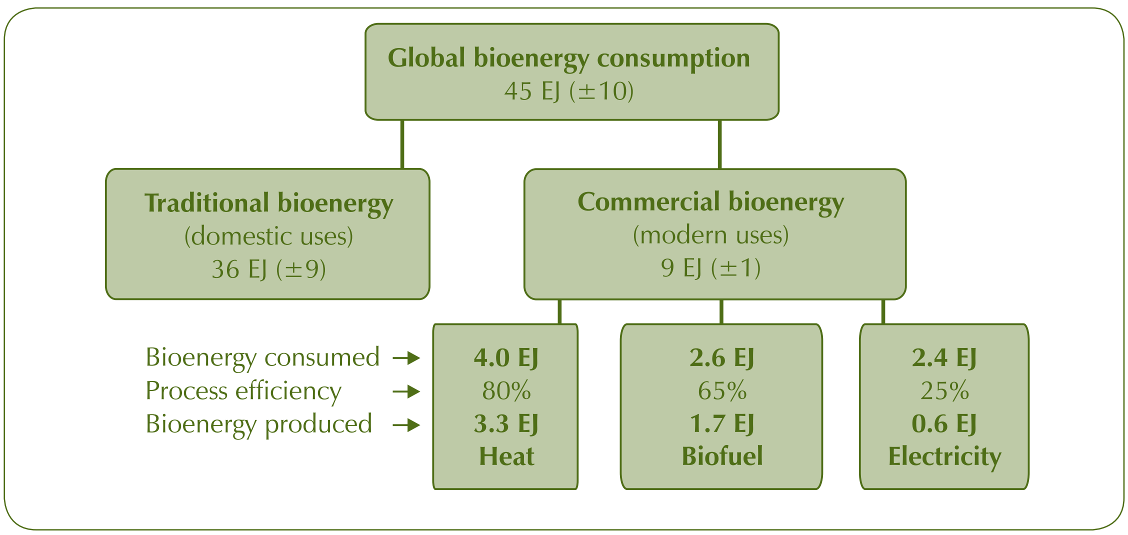
8.2 Biofuel supply and demand: current scenario

Biofuels can indeed play an important role in meeting the global energy demand. Most countries have some level of bioenergy resources potential, making biomass a more widespread energy supply option than any other source across the globe. In fact, biomass is the only renewable energy source that can be used to meet a wide range of energy applications, in the form of electric power, heat, gaseous and liquid fuels. This section presents data on the current contribution of bioenergy to the global energy matrix, considering the main markets and specific conditions of bioethanol supply.

Figure 31 exhibits the contribution of biomass to global primary and secondary energy supplies in 2007. Firewood and sugarcane bagasse must be highlighted as heat and electricity sources, while bioethanol and biodiesel are the main liquid biofuels. Also included are cogeneration systems, in which heat released in thermoelectric systems is used in some thermal process, with a sensible energy gain.

Liquid biofuels, mainly bioethanol produced from sugarcane and surpluses of corn and other cereals, and to a far lesser extent biodiesel from oilseed crops, represent a modest 1.7 EJ (about 1.5%) of transport fuel use worldwide. Global interest in transport biofuels is growing, particularly in Europe, Brazil, North America and Asia (notably Japan, China and India) [IEA (2005)]. Global ethanol production has more than doubled since 2000, while biodiesel production, starting from a much smaller base, has expanded threefold. In contrast, crude oil production has increased by only 7% since 2000 and, indeed, might be reaching its peak of production soon, according to several analysts. In fact, biofuels show a significant expansion when compared with the relative stagnation of oil production. In 2007, production of ethanol and biodiesel was 43% higher than in 2005. Ethanol production in 2007 represented about 4% of the 1.300 billion litres of gasoline consumed globally [REN21 (2008)].

Figure 31 **– Bioenergy contribution to the primary and secondary energy supply in 2007**



Source: Best et al. (2008).

It is interesting to note that in 2006 liquid biofuels accounted for just over 1% of global renewable energy and less than 1% of the global crude oil supply, estimated at 4,800 billion litres (approximately 83 million barrels per day). This scenario is changing very rapidly with most big energy-consuming countries adopting policies that will result in much higher biofuels use by the next decade [ESMAP (2005)]. Based on the origin of supply and raw materials used, today's liquid biofuels can be crudely classified into three main categories, namely, Brazilian ethanol from sugarcane, US bioethanol from corn and German biodiesel from rapeseed, followed by bioethanol form beet and wheat in Europe. Therefore, biofuel production is still concentrated in a few countries: in the last few years Brazil and the United States combined for about 90% of ethanol production, while Germany accounted for over 50% of global biodiesel production [Martinot (2008)].

A study carried out by Global Bioenergy Partnership [GBEP (2007)] shows the biofuels trends in the G8+5 countries, which include some of the most active countries in the bioenergy scene, either as producers, users, exporters or importers. Besides the G8 countries (Canada, France, Germany, Italy, Japan, Russia, the United Kingdom and the United States), the study included five emerging economies ("+5 countries"): South Africa, Brazil, China, India and Mexico. Out from the study, Table 37 shows the contribution of biofuels to Total Primary Energy Supply (TPES). TPES is equal to domestic energy production, plus imports, minus exports, minus international bunkers plus net stock change. China is the most important user of biomass as an energy source with 9,000 PJ per year, followed by India with 6,000 PJ, the United States with 2,300 PJ, Brazil with 2,000 PJ. Consumption trends show that the demand for biofuels is increasing at a quite high pace in Brazil, Germany, Italy and the United Kingdom while it remains stable in other countries like France, Japan, India and Mexico.

***Table 37* – Total primary energy supply from biofuels (In PJ)**

Country	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Canada	409	408	418	437	480	481	451	487	489	510	525
France	440	467	438	453	439	430	437	406	420	419	422
Germany	139	143	195	210	207	229	246	271	312	348	441
Italy	52	51	59	63	69	74	79	76	81	121	123
Japan	191	193	199	183	190	196	180	187	191	190	198
Russia	259	221	190	157	208	163	158	151	149	143	146
United Kingdom	52	54	57	55	56	61	64	70	82	96	115
United States	2,554	2,607	2,531	2,601	2,507	2,551	2,285	2,256	2,474	2,633	2,697
G8 Countries	**4,097**	**4,144**	**4,086**	**4,160**	**4,156**	**4,186**	**3,900**	**3,904**	**4,198**	**4,460**	**4,666**
Brazil	1,728	1,706	1,719	1,756	1,838	1,794	1,823	1,951	2,110	2,277	2,801
China	8,610	8,656	8,703	8,750	8,906	8,973	9,053	9,127	9,202	9,277	9,360
India	5,862	5,918	5,978	6,039	6,144	6,230	6,313	6,389	6,464	6,539	6,620
Mexico	328	329	338	343	337	333	337	333	336	337	348
South Africa	479	487	495	504	516	529	539	545	551	547	564
+5 Countries	**17,006**	**17,095**	**17,233**	**17,392**	**17,741**	**17,859**	**18,064**	**18,345**	**18,662**	**18,977**	**19,693**
G8+5 Countries	**21,103**	**21,239**	**21,319**	**21,552**	**21,897**	**22,045**	**21,964**	**22,249**	**22,860**	**23,437**	**24,359**

Source: GBEP (2007).

Table 38 presents the trends of the percentage of TPES covered by biofuels in the G8+5 countries over the last decade. These data is quite representative of other countries of Europe, Asia and Latin America. In most of African countries, as well as the poorest countries of other regions, data would be quite different since fuelwood and other traditional forms of biofuels would overwhelmingly cover demand data. Biofuels contribution to total energy demand reaches almost 30% in Brazil and India, but only 1% in the United Kingdom and Russia. In some developed countries, such as Canada, France, Germany and the United States such contribution varies from 3% to 4%, but reaches almost 20% in Sweden and Finland. The bioenergy share in India, China and Mexico is decreasing, probably because the increased use of kerosene and LPG (liquefied petroleum gas) by the household sector. On the contrary, the contribution of biofuels is increasing in the G8 countries, especially Germany, Italy and the United Kingdom, where it grew at an annual rate of 4% - 6% during the last few years.

***Table 38* – Relative participation of biofuels in total primary energy supply (In %)**

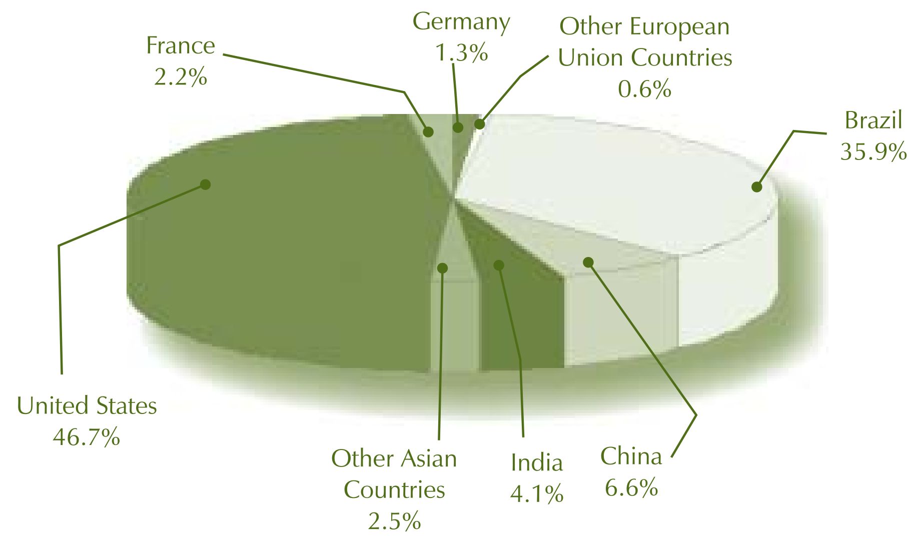
Country	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Canada	4.2	4.1	4.2	4.4	4.6	4.6	4.4	4.7	4.5	4.5	4.6
France	4.4	4.4	4.2	4.2	4.1	4.0	3.9	3.6	3.7	3.6	3.6
Germany	1.0	1.0	1.3	1.4	1.4	1.6	1.7	1.9	2.1	2.4	3.1
Italy	0.8	0.8	0.9	0.9	1.0	1.0	1.1	1.0	1.1	1.6	1.6
Japan	0.9	0.9	0.9	0.9	0.9	0.9	0.8	0.9	0.9	0.9	0.9
Russia	1.0	0.8	0.8	0.6	0.8	0.6	0.6	0.6	0.6	0.5	0.5
United Kingdom	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.8	1.0	1.2
United States	2.9	2.9	2.8	2.8	2.7	2.6	2.4	2.4	2.6	2.7	2.8
G8 Countries	**2.2**	**2.2**	**2.2**	**2.2**	**2.2**	**2.1**	**2.0**	**2.0**	**2.1**	**2.2**	**2.3**
Brazil	26.6	25	23.9	23.7	24.1	23.1	23.3	24.3	26	26.5	29.8
China	19.6	19	19.1	19.2	19.4	19.4	19.6	18.2	16.2	14.0	13.0
India	36.1	35.3	34.3	33.9	32.5	32.4	32.3	31.9	31.5	30.0	29.4
Mexico	5.9	5.7	5.7	5.5	5.4	5.3	5.3	5.1	5.0	4.9	4.7
South Africa	10.9	11	11.1	11.1	11.3	11.4	11.8	12.4	11.1	10.2	10.7
+5 Countries	**22.2**	**21.6**	**21.4**	**21.3**	**21.3**	**21.2**	**21.4**	**20.6**	**19.2**	**17.4**	**16.9**

Source: GBEP (2007).

Data on bioethanol production shows important trends in terms of expansion and diversification. In 2006, total world bioethanol production was 51.3 billion litres and it reached 55.7 billion litres in 2007. In recent years the United States has been the leader in global production, with an output of 26 billion litres of corn-based ethanol in 2007, followed by Brazil, with approximately 20 billion litres of sugarcane-based bioethanol [REN21 (2008)]. The main bioethanol producers in Asia are China and India, which produced 3.7 billion and 2.3 billion litres in 2007, respectively. Production for all Asian countries reached 7.4 billion litres in

2007. In the European Union, bioethanol production rose to approximately 2.3 billion litres in 2007 from 1.6 billion litres in 2006. The largest producer in the European Union is France, which produced an estimated 1.2 billion litres in 2007, followed by Germany with 850 million litres [F. O. Licht (2007)]. Graph 37 synthesizes the distribution of bioethanol production among the main producers; developing countries account for half of observed production.

Graph 37 **– Distribution of ethanol production by region in 2007**



Source: Prepared based on REN21 (2008) e F. O. Licht (2007).

It is noticeable how rapidly the scenario has evolved, with elevated growth rates every year. Indeed, bioethanol production data presented in this section represent a small portion of the existing production potential that must be developed in the coming years, as analyzed in the next section.

8.3 Bioethanol supply and demand projections for 2010-2015

This section focuses on bioethanol supply and demand estimates for the 2010-2015 timeframe, the period in which the biofuels market is expected to start developing and consolidating. The section analyzes the situation of North America (except Mexico, which is analyzed as part of the Latin American region), the European Union, Latin America and the Caribbean, Asia and Oceania. In all cases the focus is on countries that have already implemented — or are expected to start to implement — policies to stimulate biofuels production and consumption. Most data used is from studies developed by the Global Biofuel Center, an institution that carries strategic studies of the biofuel market. Estimates for Brazil will be presented in Latin America's section, based on the foreseen evolution for its domestic fuels market and installed processing capacity in the sugarcane industry. Estimates for Africa — where some initiatives to foster biofuels are making a start — are presented aggregated. A general outlook is presented at the end.

North America, except Mexico

Both the United States and Canada are developing nationwide renewable fuel standards that would require biofuels in a certain percentage of the gasoline and diesel pools. In the United States the current federal public policy framework for biofuels is the Renewable Fuels Standard (RFS) programme. The Energy Policy Act of 2005 established the framework for the RFS programme that the US Environmental Protection Agency (EPA) then developed and issued a rulemaking upon it which began on September 1st, 2007. The programme required that a certain percentage of all gasoline sold or used by motorists be renewable fuel. The measure was accomplished without difficulty because the United States already consumed more renewable fuels than was required by the RFS [White House (2008)].

Then, on December 2007 "The Energy Independence and Security Act" (EISA, HR6) was signed into law by the US President. The new law increases the RFS requirements between 2008 and 2022. Starting in 2008 the requirement is set at 34 billions litres gallons of renewable fuel, which progressively increases to 136 billion litres in 2022 [USDA (2008)]. This law defines new biofuels categories based on GHG-lifecycle impact:

> *Conventional Biofuel* is defined as cornstarch bioethanol. In addition, new conventional ethanol-producing facilities that begin construction after the enactment of this law must achieve a lifecycle GHG emission reduction of 20% compared to baseline emissions. The GHG emission reduction requirement may be lowered to as low as 10% if EPA determines that the requirement is not feasible.
>
> *Advanced Biofuels* are defined as renewable fuels other than cornstarch-based bioethanol, derived from renewable biomass and that achieve lifecycle GHG emission reductions of 50% below the baseline. This definition includes cellulosic biofuels (including ethanol from cellulose, hemicellulose, or lignine; sugar or starch other than corn; and animal, food, crop or yard waste material); biomass-based diesel, biogas (including landfill and sewage-based gas); butanol and other alcohols produced from biomass; and other fuels derived from cellulosic biomass.
>
> *Cellulosic Biofuels* are renewable fuels derived from any cellulose, hemicellulose, or lignin that is obtained from renewable biomass and achieves a lifecycle GHG emissions reduction of 60% below the baseline.

The new provision requiring renewable fuels to meet lifecycle GHG emission reduction thresholds is inclusive of emissions from all stages of fuel and feedstock production and distribution, counting direct and indirect emissions and including those emissions resulting from land use changes. According to Global Biofuel Center estimates, the new RFS targets set out in the EISA legislation are largely expected to be met, with bioethanol supply reaching around 70 million of cubic meters in 2015 [Global Biofuel Center (2008)].

Similarly, Canada will require a 5% volume of renewable content in gasoline starting in 2010 and the Federal Government is developing a regulation to implement its RFS. According to the proposed RFS regulation (ie, 5% blend) 2.2 billion litres of bioethanol will be demanded by 2010, with supply expected to be about 2.9 billion litres (not counting proposed ethanol facilities, some of which are expected to be constructed and begin operating by 2015). Moreover, a 10% blend (E10) by 2015 would require more than 4.7 billion litres and additional bioethanol production facilities would be needed to meet demand.

European Union

In the European Union (EU-27) a few countries became interested in biofuel during the 1990s; however, the EU as a whole became interested much later, in 2001. On the other hand, the industry really became involved with the induction of favourable policies or fiscal incentives in different Member States. Currently, the two countries where biofuels used in road transportation have achieved the greatest penetration in the motor fuel pool are Germany and Sweden. Countries with large areas of arable land and protective of their farming industries such as France have also implemented specific tools to promote the use of biofuels. It is important to note that in 2006 European bioethanol-related investments to comply with the goals established for 2010 exceed biodiesel-related investments for the first time.

Other members-states, such as Spain, have started production without having large domestic biofuels markets but aim to export their production. The Netherlands and the United Kingdom adopted more cautious approaches and see second-generation biofuels as a more sustainable alternative than existing first-generation biofuels. These two countries, however, have set up mandatory systems for biofuels use. The case of Czech Republic, which became a Member State in 2004, is also of interest because of the rapid biofuels developments that have been taking place there since 2006, when the crude oil price peaked.

The two main directives setting the use of biofuels in the UE are the Biofuels Directive, which sets biofuels use targets, and the Fuels Quality Directive, which sets fuels specifications. The targets established by the Biofuel Directive are indicative non-binding targets, set as energy percentages of fossil fuel use in the UE. For 2005 the target was 2% and for 2010 is 5.75% by energy content.

Recently, in January 2008, the European Commission published its proposed Renewable Energy Directive, which should take over the Biofuels Directive after 2010. The proposal includes a biofuels mandate of 10% by energy content by 2020. In fact, this target should be achieved through the use of sustainable fuels defined against parameters set out in the proposed directive and with the use of second-generation biofuels, which will count double against the 2020 target. The proposal is being discussed in the European Parliament and Council of Ministers and a decision is expected by June 2009.

According to the European Bioethanol Producers Association (eBIO), ethanol production in 2007 increased at a modest pace of 13.5% compared to 70% in 2006 and 2005. The association reports that ethanol imports were a record high in 2007 at one billion litres. Table 39 shows the evolution of EU ethanol capacity, production and consumption from 2005 to 2007 and the growing volume of imported ethanol.

Table 39 **– Bioethanol capacity, production and consumption in the European Union (In million litres/year)**

Year	2005	2006	2007
Installed Capacity	–	2,876	3,344
Production	913	1,593	1,770
Consumption	1,150	1,700	2,700
Import	237	107	930

Source: Global Biofuel Center (2008).

Based on the assumptions seen in the moderate scenario of the Refuel Research project — sponsored by the European Union in a joint effort with several institutions to promote biofuel use — bioethanol should achieve a target of 5% by energy content in 2010, 7.5% in 2015 and 10% in 2020 [Refuel (2008)]. In comparison, the increase in production calculated as a fraction of existing and announced ethanol plants shows whether there would be a market for imported ethanol should all the existing plants work at 70% of capacity in 2010 and 80% capacity in 2015 and 2020 [Global Biofuel Center (2008)].

Based on the 10% ethanol target in 2020, 17.7 billion litres of ethanol will be required. Local production capacity may reach 12.16 billion litres in 2015 and could then remain constant as no new first generation projects are initiated but rather cellulosic ethanol starts entering the market [Global Biofuel Center (2008)]. In short, as a result of mandated targets in the EU and several countries implementing individual targets for ethanol and biodiesel, the growth of demand should be significant and above internal production capacity. Imports will continue to make up the difference between domestic supply and demand in the EU.

Latin America and Caribbean, including Brazil

Biofuels production and use has a great potential in the Latin America and Caribbean (LAC) region. Most countries have a heavy dependence on imports of petroleum products, coupled with growing demand for transport fuels and abundant feedstock potential to produce ethanol and biodiesel. These countries share the desire for the energy security and economic and social development that they see has occurred in Brazil in relation to biofuels production. In fact, many countries see the development of a biofuels programme as a way to achieve both goals. For example, several countries in the LAC region are currently working to introduce bioethanol blending targets, usually between 5% to 10% on gasoline volume and 2% to 5% on biodiesel volume. Among the several initiatives in place Colombia and Costa Rica can be highlighted because of their advances [Horta Nogueira (2007)].

The implementation of ethanol production and use started in Colombia in 2001 with the enactment of Law 693. The main purposes of the law are: reduction of hydrocarbons and carbon monoxide emissions; creation and maintenance of agricultural employments; development of the agroindustrial sector; and contribution to energy self-sufficiency as a strategic objective. The first article of the law establishes that gasoline used in urban centers of more than 500 thousand inhabitants must contain fuel alcohol starting in September 2006. The law defines as oxygenated a gasoline with a 10% biofuels content [UPME (2006)]. The introduction of the programme was preceded by a careful process of planning and informing consumers, which continues in place.

The first Colombian sugarcane bioethanol plant started operation in 2005, with a production of 300 thousand litres/day. In 2006 other five sugarcane bioethanol plants began operation in the Cauca River Valley with a combined production capacity of 357 million litres/year. Sugarcane production in the Cauca Valley is well established and production can be carried out during the entire year, which allows the operation of an elevated number of distilleries. The Colombian government expects that in 2010 the country reaches an annual production of 1.7 million litres of bioethanol; such volume would be needed for a blend of 10% of bioethanol in gasoline and generate an exportable surplus equivalent to 50% of total production [Horta Nogueira (2007)].

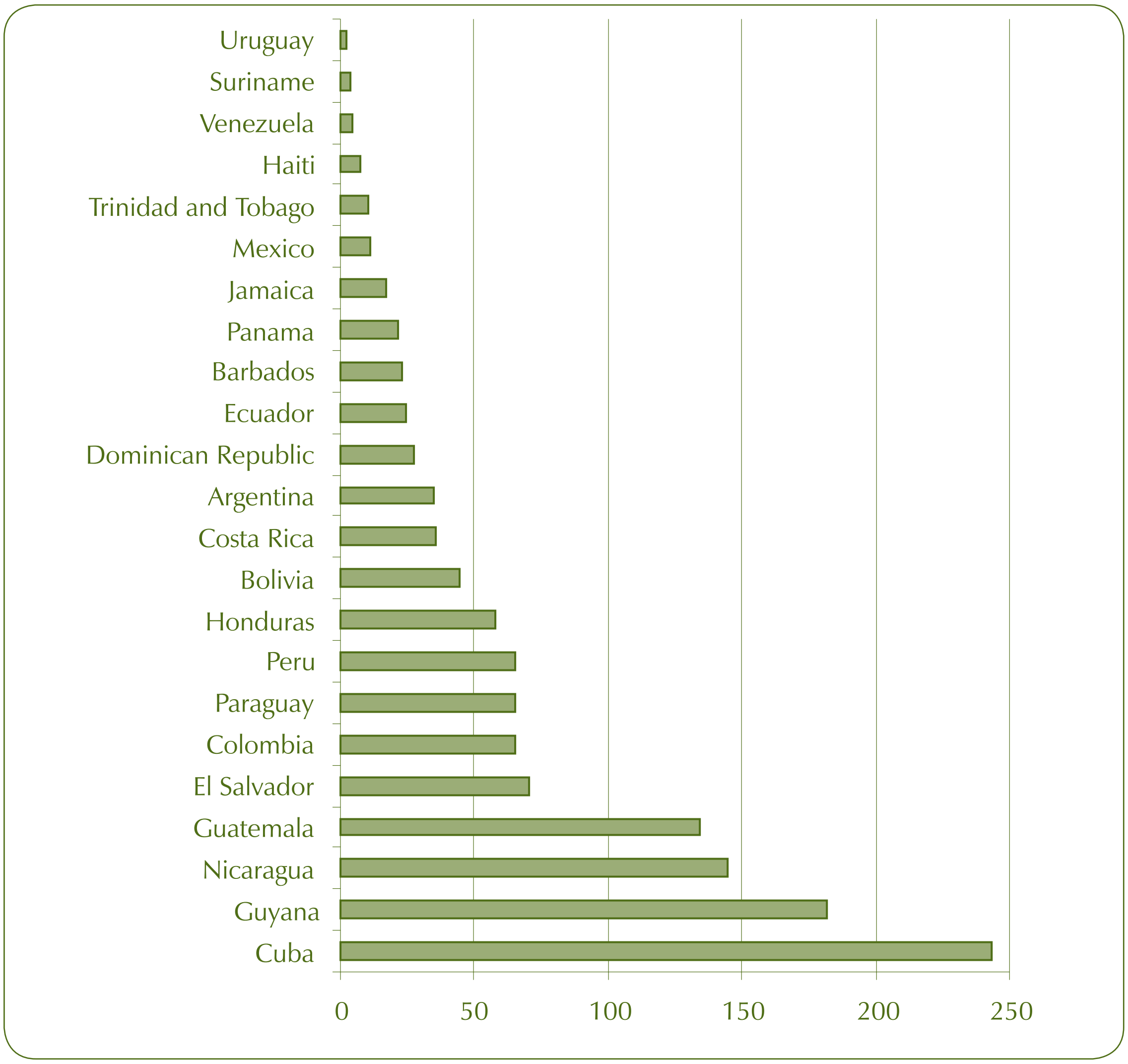
In Costa Rica the first experiences with bioethanol fuel were developed in the early 1980s, but they were interrupted in 1985, because low fossil fuel prices made ethanol production economically unfeasible. However, in 2003 the Costa Rican government created a new bioethanol programme in the context of an scenario favourable to biofuels, because of high petroleum prices. The programme was launched in May 2003 by Executive Decree No. 31.087-MAG-MINAE, which created a Technical Commission to «formulate, identify and elaborate strategies for the development of nationally distilled anhydrous ethanol and local feedstocks to produce substitutes for MTBE in gasoline". The main objectives of that Decree were agroindustrial development (economic reactivation, added value production) environmental improvement (eg, MTBE replacement), and energy diversification and reduction of fossil fuels import dependence. The programme, which initially established a 7.5% blend of ethanol in gasoline, has been carried-out in phases to allow consumer to assimilate operating procedures and provide for gradual infrastructure expansion. In the initial phase several successful vehicle tests were conducted using the same blend, followed by sales of the bioethanol-gasoline blend in limited markets. Adding 10% of bioethanol to the entire gasoline used in the country would yield an estimated bioethanol demand of 110 million litres in 2010. Recope, the Costa Rican state oil company, has played an important role for the appropriate introduction of bioethanol in the country [Horta Nogueira (2007)].

A recent study [Cepal (2007)] tried to determine the potential of Latin American countries to produce sugarcane bioethanol for a 10% blend with gasoline, considering two main restrictions: availability of suitable lands and dimension of the local sugarcane industry. Two scenarios were analyzed: a) bioethanol production from the conversion of molasses, assuming a production of 78 litres of bioethanol per ton of produced sugar; and b) exclusive production of bioethanol, considering a sugarcane yield of 75 ton/ha and an industrial production of 80 litres of bioethanol per ton of sugarcane, that is, 6 thousand litres of bioethanol per sugarcane hectare. The first scenario determines the percentage of bioethanol demand that could be fulfilled out of molasses, a by-product of sugar processing. The second scenario estimates the sugarcane area required both as a percentage of total agricultural land and current sugarcane area, based on Faostat data (2008a). Gasoline demand data and therefore bioethanol demand, correspond to 2004 [Olade (2006)]. The results of the study are presented in Graphs 38 and 39, which include countries with more than one thousand hectares of planted sugarcane. Brazil is excluded because it already has a large bioethanol programme and bioethanol is widely used and produced. Brazilian data is presented later in the chapter.

Graphs 38 and 39 show that sugarcane bioethanol production can allow meeting national blending needs without significant impacts, especially in terms of land use conversion. On average, the LAC region can reach a 35% blend through the use of existing molasses, with most countries being able to achieve the 10% blend (Graph 38). On the other hand, the 10% blend can be reached with a 22% increase of the current sugarcane cultivated area, which is equivalent to an increase of about 0.4% of the current agricultural area. In the second case there is remarkable country variation.

Cuba, Guatemala, Guyana and Nicaragua present an elevated bioethanol production potential from molasses conversion, well above the 10% blending target. On the other hand, Haiti, Surinam, Uruguay and Venezuela can not reach the 10% target. When land availability is considered most countries in the region can meet the 10% blending target: with the exception of Barbados, Jamaica, Trinidad and Tobago, Surinam and Venezuela, the rest of countries can produce ethanol for a 10% blend with an increase of less than 1% over the current agricultural land.

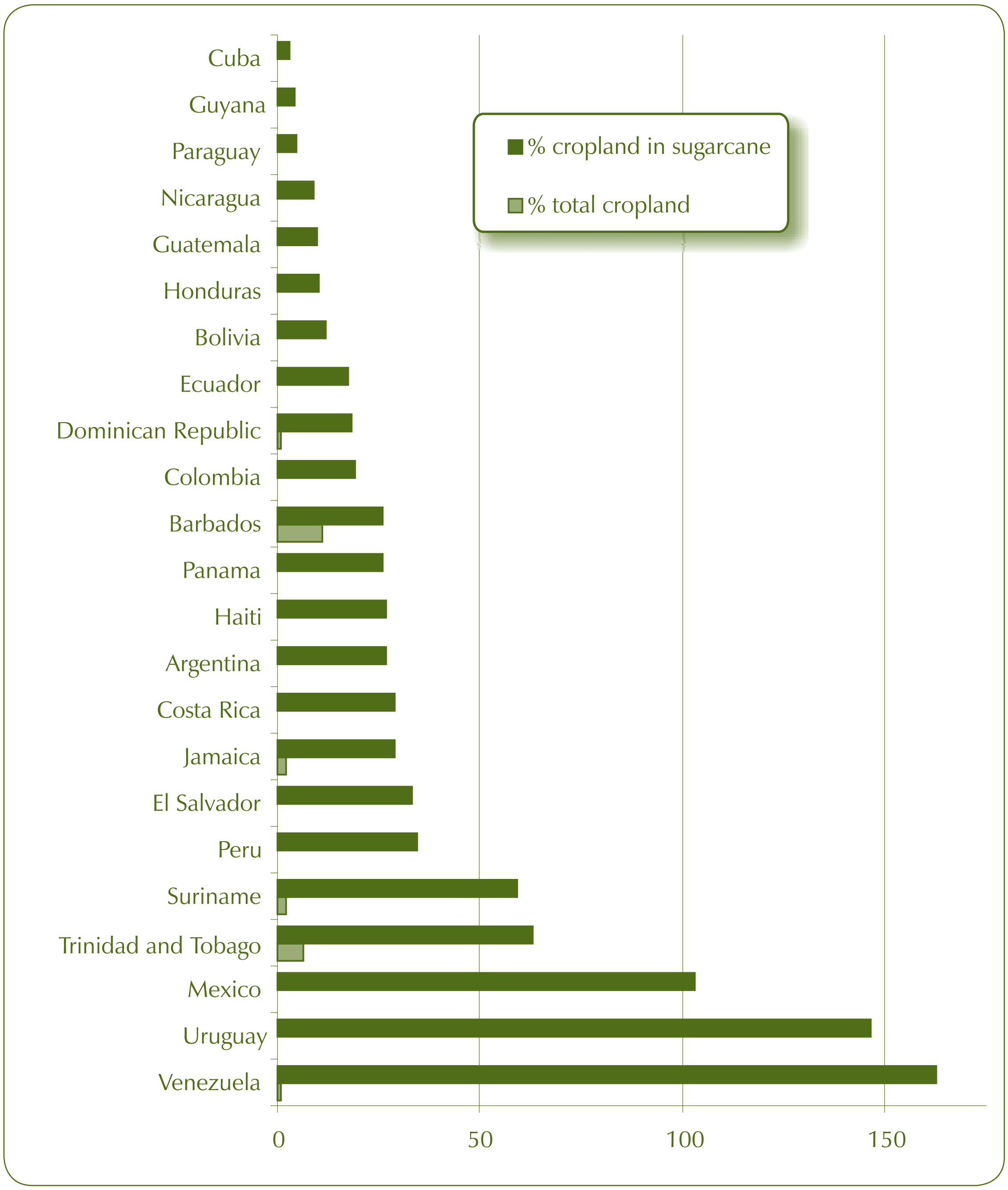
***Graph 38* – Bioethanol-gasoline blend that can be produced from the conversion of molasses available out of sugar production (percentage of gasoline use)**



Source: Cepal (2007).

Another important driving force for bioethanol production in LAC countries is the revision of the sugarcane regime by the European Union within the Common Agricultural Policy, which will reduce price support by 36% in four years. Some countries, especially in the Caribbean, such as Barbados, Belize, Jamaica and Guyana, are considering to convert the sugar they produce into ethanol as a way to respond to both the new sugarcane regime and the increase in the fossil fuels bill. Jamaica is the most developed country, since it intends to implement the 10% mandatory bioethanol blend.

Graph 39 **– Agricultural land requirements to produce bioethanol for a 10% gasoline blend (percentage of total agricultural land and planted sugarcane)**



Source: Cepal (2007).

In addition to supplying their internal fuel markets, which in general are limited, LAC countries are also interested in the possibility of exporting bioethanol, especially to the United States. This interest is supported by some agreements signed between the United States and countries in the region, such as the US-Dominican Republic–Central American Free Trade Agreement (DR-Cafta), ratified by the US Congress in 2005, as well as the Caribbean Basin Initiative (CBI), established by the US Congress in 1983.

The CBI exempts beneficiary country products from import duties under certain conditions. Beneficiary countries are Antigua and Barbuda, Aruba, Bahamas, Barbados, Belize, British Virgin Islands, Costa Rica, Dominica, Dominican Republic, El Salvador, Granada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Montserrat, Netherlands Antilles, Nicaragua, Panama, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and Grenadines, and Trinidad and Tobago. Under the CBI hydrated ethanol is usually shipped from Brazil to beneficiary countries where it is dehydrated and exported to the United States. The main ethanol exporters under the CBI are Jamaica, Costa Rica, El Salvador and, recently, Trinidad and Tobago. According to rules bioethanol may be exported in the following cases: a) up to 7% of the US market without origin restrictions; that it, ethanol processed (but not necessarily produced) in beneficiary countries; b) a supplementary quote of 132 million litres of bioethanol containing at least 35% of the local product; and c) no volume restrictions to biofuel with more than 50% of local content. The US market imported 4.6 billion litres of bioethanol in 2006 and 2007. In fact, most imports (about 75%) were carried under the CBI, with only a minor part imported directly from Brazil, Canada and other countries [Global Biofuel Center (2008)].

A bioethanol supply and demand estimate was obtained for the LAC region, excluding Brazil. The estimates include countries that are implementing or expected to implement biofuel programmes by 2010, namely, Argentina, Colombia, Costa Rica, Dominican Republic, Ecuador, Jamaica, Mexico, Paraguay, Peru, Trinidad and Tobago, Uruguay and Venezuela. The supply estimate considers production facilities currently in operation along with those under construction and expected to be in operation by 2010. It is also assumed that by 2015 most of the currently proposed facilities will be constructed. Bioethanol production potential estimates are based on current nominal capacity data, while demand is estimated considering expected gasoline demand and implementation of blending targets [Global Biofuel Center (2008)].

The analysis showed that several countries should increase their production capacity to be able to meet the proposed blending targets. Several countries will remain or even can become bioethanol exporters; such is the case of Costa Rica, Jamaica, Paraguay, Peru, Trinidad and Tobago and even Uruguay. Exports from these countries, except Peru, will enter the US under some of the agreements mentioned above. In the case of Peru ethanol can be exported to the US market under the auspices of the US – Peru Free Trade Agreement. [Global Biofuel Center (2008)].

The perspectives of the Brazilian bioethanol market are obviously different because of the maturity of its biofuel programmes and the large expansion observed in bioethanol consumption and production capacity (see previous chapter). The estimation of future scenarios is not an easy task because of the intense dynamics observed in the bioethanol agroindustry, in which new projects are frequently implemented to meet the growing internal demand. However, some conservative production and consumption estimates are obtained for the period of interest. The bioethanol production estimate is based on the expected production for 2008 (around 26.1 billion litres) and considers an annual growth rate of 8%, which is consistent with the evolution observed in recent harvests and the number of projects currently under implementation and expected to become operative (35 new plants in the 2008/2009 sugarcane crop season and 43 units in the next season) [Nastari (2008)]. That yields a bioethanol production estimate of 30.5 billion litres in 2010. During the years that follow the foreign market should become more important allowing bioethanol production capacity to reach about 47 billion litres by 2015, which is equivalent to a 9% annual growth rate [Milanez et al. (2008)].

Regarding bioethanol demand, it is important to point out that previous estimates for the Brazilian market underestimated real consumption, because the market expansion caused by the introduction of flex-fuel vehicles. This new technology is a source of uncertainty for demand estimates because drivers can choose using pure bioethanol, gasoline mixed with bioethanol in different proportions, or the gasoline-bioethanol available in the market. In addition, the government can change the bioethanol blend between 20% and 25%. Finally, the margin of error of consumption estimates increases because of the uncertain petroleum price scenario.

Based on the evolution of the small-size vehicle fleet and fuel consumption patterns, internal bioethanol demand for Brazil is estimated to be in the range of 28 - 34.3 billion litres by 2015. The estimate considers that 50% and 70% of consumption by flex-fuel vehicles, respectively, is met by hydrated bioethanol [Milanez et al. (2008)]. The study presents several estimates of the Brazilian bioethanol market which show reasonable dispersion. Also following a conservative approach, it was assumed that bioethanol production will be used to meet the needs of the domestic market; exports are estimated at 5 billion litres by 2010 (which is equivalent to exports in 2008) and 10 billion litres in 2015, when the international bioethanol market should be better structured. It is important to stress that the domestic bioethanol demand estimates correspond to vehicular uses and industrial applications, segments that have shown significant expansion in Brazil during the course of the last few years.

Africa

The relatively small size of the African fuels market and the limited information base about biofuels national projects do not mean this region is of less interest as part of prospective bioethanol assessments. Actually, there is significant bioenergy potential, especially in the southern regions, which can be used to support other social and economic development goals.

In fact, since the 1980s there have been interest in promoting bioethanol use in Africa. Two pioneer initiatives were the Ethanol Company of Malawi (ETHCO), which has operated since 1982 producing ethanol from sugarcane molasses for fuels purposes; and a bioethanol-fuel programme implemented in 1980 in Zimbabwe, which was cancelled in the early 1990s because of a serious drought, but that can be re-implemented [Gnansounou et al. (2007)]. In Nigeria testing of bioethanol-gasoline blends have been performed since 2006 and South-African businessmen have shown interest in implementing bioethanol production facilities in light of the possibility that gasoline-biofuel blends are introduced [Alexander (2005)]. In Ghana, a production facility with an installed capacity of 150 million litres/year of sugarcane bioethanol is being implemented, following a model that can be replicated in Tanzania and Mozambique [F.O.Licht (2008b)]. Nowadays, at least 11 African countries are creating rules for bioethanol production and trading, including South Africa, Angola, Mozambique and Benin. Most countries are considering to adopt 10% (E10) bioethanol blends [Exame (2007)].

African sugarcane-bioethanol production reached 439 million litres in 2006, with 89% of production coming from South Africa. A conservative preliminary aggregate estimate is for 1 billion and 1.5 billion litres by 2010 and 2015, respectively, based on information about potential internal gasoline consumption and considering export-related production perspectives. Production and demand are expected to be similar by 2010, while exports of 500 million litres are anticipated by 2015.

Certainly, in the medium term Africa will become an important player within the bioenergy scenario. In light of that development, the Brazilian Government has stimulated sugarcane planting and the implementation of distilleries in several countries, such as Botswana, Congo, Gabon and Tanzania, as part of a recent joint effort between the Ministries of Foreign Affairs and Agriculture. Considering land availability and weather conditions the southern African countries with the most important potential to develop bioenergy production programmes are South Africa, Zambia, Angola, Mozambique, Zimbabwe, Malawi and Madagascar. Basically, such programmes can be developed through the diversification of the sugarcane agro-industry already in place in the countries [Gnansounou et al. (2007)].

Asia and Oceania

Asia and Oceania have been active in implementing biofuel programmes and promoting the use of agricultural raw materials to produce biofuel, not only to meet the expanding domestic demand, but also for eventual foreign markets. However, some Asian countries were not able to reach ambitious biofuel goals in the proposed time or were cautious in introducing biofuel into their markets, because of concerns about prices, long-term supply, logistic and infrastructure, as well as vehicle-fuel compatibility issues.

Biofuels are stimulated for a variety of reasons. Developed countries such as Australia, Japan, New Zealand and South Korea are aiming to achieve Kyoto Protocol targets to reduce CO2 emissions by 2012, regardless of whether they are mandatory or voluntary. Programs to promote biofuels have been introduced in these countries mainly by setting production or sale targets. However, Japan, South Korea and Taiwan do not have sufficient land to grow biofuel-crops because of high population density. As a result, biofuels are only produced on a small-scale from recycled oils and waste material. Long-term feedstock supply is a primary issue in these countries. Japan has taken a systematic and progressive approach to its biofuel programme, which can serve as an example to follow for other countries in the region. The country has set a target to add bioethanol to gasoline in a volume equal to 0.6% on the vehicular fossil energy consumption by 2010, the equivalent of 500 million biofuel litres. It is still a modest programme but it indicates a favourable intention. The programme started in 2007 with the introduction of 7% ETBE blend in gasoline traded in the Tokyo area. Furthermore, it is expected that bioethanol penetration in the energy transport demand reaches 30% by 2030.

The Japanese government, supported by the local automotive industry, has carried out tests of 3% bioethanol blends in the cities of Osaka and Miyakojima, located in the Okinawa Island, where sugarcane is cropped [Global Biofuel Center (2008). Recently, Petrobras (the Brazilian Petroleum Company) and Mitsui (a Japanese international business organizer and a provider of integrated trade facilitating services worldwide) created a company in Brazil to support bioenergy projects to produce ethanol for the Japanese market.

On the other hand, Asian developing countries like China, India, Indonesia, Philippines and Thailand are mainly looking to reduce their dependence on conventional fuels by using surplus agricultural feedstocks to produce biofuels and at the same time, reduce ambient emissions and provide stability to farmers. Indonesia and the Philippines are further looking at biofuels as an alternative to increase economic activity and reduce their foreign debt. Programmes to promote biofuels have been implemented in these countries either by setting production targets or requiring biofuels blends at certain percentages.

In the case of China, it has an informed 10% bioethanol blending target for gasoline sold in five provinces, corresponding to an annual demand of 1.6 billion litres, which will gradually increase with the inclusion of other provinces into the programme. India and Thailand, on the other hand, intended to implement a 10% blend, equal to an initial estimated consumption of 400 million and 300 million litres/year, respectively, but faced logistic barriers in implementing the programmes. They are now also more cautious with their biodiesel programmes [Global Biofuel Center (2008)].

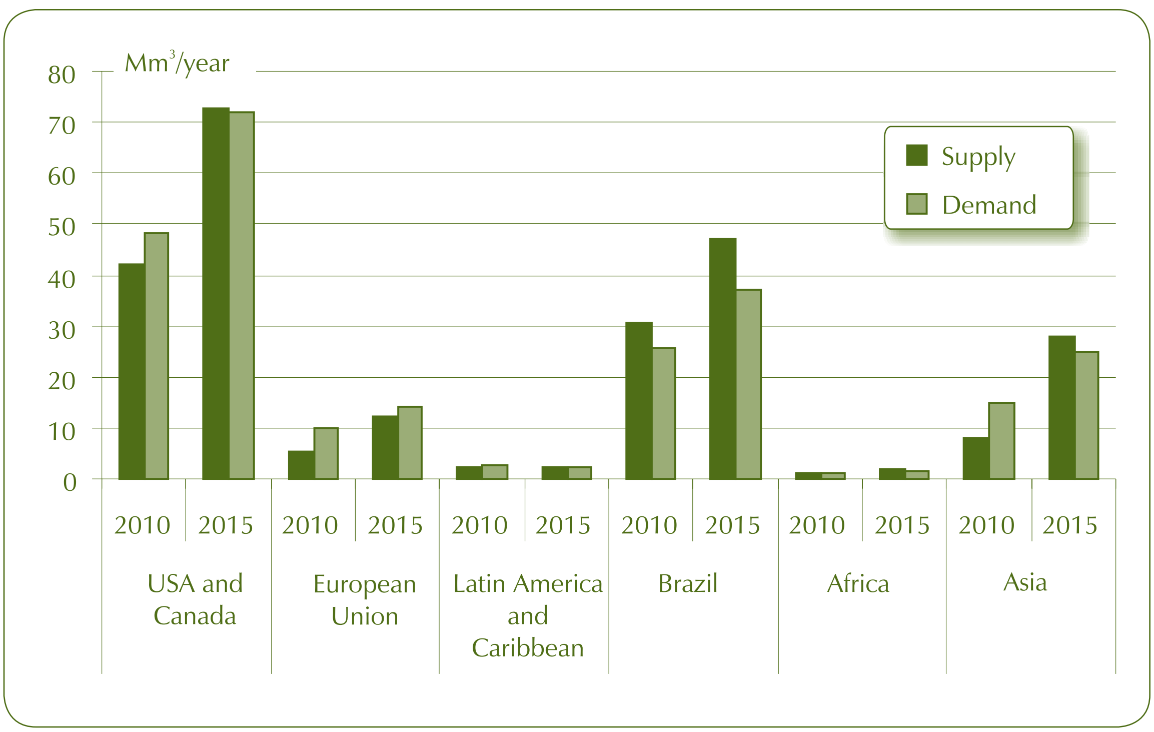
As petroleum products in this region are generally heavily subsidized, countries are looking towards biofuels to replace conventional fuels. As a result, most of countries are moving toward 5% to 10% ethanol blends, including Australia, China, India, Indonesia, Japan, New Zealand, Philippines and Thailand. Significant bioethanol production currently exists in Australia, China and India, but they will need to add more to meet their targets.

A regional supply and demand estimate was calculated [Global Biofuel Center (2008)] considering Australia, China, India, Indonesia, Japan, New Zealand, Philippines and Thailand. The analysis assumes that all countries will meet the ethanol targets set for 2010 and 2015. The calculations point out that the region will be supply constrained by 2010; however, the situation is expected to improve by 2015. Australia, India and China need to bring new ethanol production facilities on line to meet their targets. They will lag behind by 2010, having to rely on imports to comply with targets, but will largely catch-up with local production by 2015. Japan will need to rely almost exclusively on imports. Japan, China, and potentially Australia and New Zealand will be major ethanol importers in the region. However, India, Indonesia and Thailand will be able to export by 2015 [Global Biofuel Center (2008)].

General outlook for bioethanol supply and demand in 2010 and 2015

Graph 40 shows a summary of bioethanol market perspectives in different regions for 2010 and 2015. There are significant regional differences regarding conditions and capacities to participate in a future international biofuels market. Globally, by 2010 bioethanol demand is estimated at 101 billion litres and bioethanol supply at 88 billion litres. The imbalance should have been closed by 2015, with supply close to 162 billion litres and demand around 150 billion litres.

Graph 40 **– Biofuels supply and demand estimates for 2010 and 2015**



Source: Modified based on Global Biofuel Center (2008).

A significant demand increase is expected in the coming years in the US, as new legislation to be implemented requires more than 57 billion litres of bioethanol in the gasoline supply by 2015. In the US meeting the proposed blending targets will possibly require import, unless new conversion routes become feasible soon. However, taken together the US and Canada could be self-sufficient by 2015.

In Europe, ethanol demand should increase significantly if the target blends of 5% in 2010 and 7.5% by 2015 are implemented. In fact, meeting those targets might require importing biofuels. In Brazil, local production should allow to met the expanding internal demand without difficulty and to generate a sizeable exportable surplus. That is, Brazil has a significant potential to participate in the international bioethanol market if it eventually takes-off. A moderate growth is expected in other regions included in the study. Other LAC countries will need to add capacity to meet expected national targets and be able to export to the US; that is particularly the case of countries that can access such market under preferential conditions.

Countries in Asia and Oceania will possibly face constraints to meet demand by 2010, but improvements should allow supply to increase significantly, above demand, by 2015. As indicated previously, Japan, China, and potentially Australia and New Zealand will be the major ethanol importers in the region. On the other hand, India, Indonesia and Thailand will be in a position to export, but certainly without the capacity of Brazil [Global Biofuel Center (2008)]. In Africa, despite significant uncertainties a moderate domestic market growth can be expected, as well as the possibility of exporting to the European market, especially if it expands rapidly.

It must be stressed that theses estimates were developed around the end of 2007 and beginning of 2008, a period of major uncertainty and volatility with regard to petroleum prices. If fossil-fuel prices stabilize at higher than recent historical level it would be difficult to foresee how the bioethanol demand will behave, as bioethanol is currently one of the few available alternatives to substitute gasoline demand.

Finally, it must be mentioned that estimating and keeping track of global bioethanol flows are not easy tasks, because of restrictions in access to information. However, international cooperation can contribute to broaden the base of information and data on bioethanol markets and to bring more transparency to that information, which can benefit all countries

The next section reviews policies that have been proposed to promote biofuels in some of the most important producer and consumer countries.

8.4 Policies to support and promote biofuels

Policies and legal frameworks for biofuels, which have been defined and implemented in several countries with different degrees of clearness and objectivity, are relevant elements that explain and justify the evolution of the global bioethanol demand presented in the previous sections. Table 40 shows the main purposes and motivations behind biofuels public-policy programmes and projects, based on official documents from several countries and European Union [GBEP (2007).

***Table 40* – Main objectives of bioenergy development**

Country	Objectives						
	Mitigating Climate Changes	Enhancing the Environment	Improving energy Security	Promoting rural development	Promoting agriculture	Fostering technological Development	Profiting from comparative advantages
+5 Countries							
South Africa	X		X	X			
Brasil	X	X	X	X	X	X	X
China	X	X	X	X	X		
India			X	X		X	X
Mexico	X	X	X	X		X	
G8 Countries							
Germany	X	X		X	X	X	X
Canada	X	X	X			X	
United States	X	X	X	X	X	X	
France	X		X	X	X		
Italy	X	X	X		X		
Japan	X	X			X	X	
United Kingdom	X	X	X	X			X
Russia	X	X	X	X	X	X	
European Union	X		X	X	X	X	

Source: GBEP (2007).

According to the survey, improving energy security and mitigating climate changes are among the most important bioenergy drivers in most countries. Environmental concerns are usually considered in developed countries, while rural development issues are key factors in developing countries, usually linked to the rural poverty reduction agenda. Increased biofuels use is also seen as an opportunity to increase access to modern energy, including electrification in rural areas. Rural development-related objectives in developed countries focus on agriculture's multi-functionality in terms of environmental and cultural good and services.

In developing countries, agricultural objectives envisage new opportunities not just for high-end commercialised energy crop production, but also for poorer small scale suppliers. All countries stress at least three main and concurrent purposes in their policies, which can make bioenergy development more complex vis-à-vis the need to reach multiple purposes not always mutually compatible. Furthermore, it is important to recall that the stress on agricultural conservation and development in some OCDE countries has led to unsustainable biofuels programmes [UN-Energy (2007)]. Summarizing, biofuel promotion policies tend to focus on multiple and challenging objectives that eventually go beyond the possibilities for a transition of the energy base, which is complex in itself.

In many countries bioenergy development and use are guided mainly through policies in the energy sector, as presented in Table 41 [GBEP (2007)]. Voluntary measures for biofuels refer to the authorization of blending with conventional fuels and its progressive introduction into the market. Direct incentives include those financed by government agencies, such as the reduction of taxes, allowances, and support and guarantee loans. The table presents separate bioenergy policies according to different final uses, such as heating, electricity production, transport, and ethanol and biodiesel production. European Union policies are valid for Member States and can be complemented by national measures, as illustrated in the cases of Germany, France and Italy.

As illustrated by Table 41, most energy policy measures for bioenergy promotion relate to uses in electricity generation, heating and transportation, with specific trade and fiscal measures to encourage ethanol and biodiesel production. Yet, policy measures in the transport sector have an immediate effect in terms of fostering biofuels. It is also evident that an important number of measures are under development or awaiting approval. In short, the instruments to promote bioethanol are well known and are being progressively implemented.

Reviews such as the one conducted by the Worldwatch Institute [REN21 (2008)] confirm that there is important on-going progress in developing normative frameworks to broaden bioethanol use. During the last three years normative instructions were promulgated in at least 17 countries, in most cases mandating 10% to 15% ethanol blends or 2% to 5% biodiesel blends. Subnational normative bioethanol instructions enacted by local governments were found in 13 Indian states; 9 Chinese provinces; 9 US states; 3 Canadian provinces; and 2 Australian states. Such decisions confirm the relevance of local conditions, possibilities and interests.

Table 41 – Main bioenergy policy instruments in selected countries

Country	Energy Policy							
	Mandatory targets	Voluntary targets	Direct Incentives	Grants	Feed-in tariffs	Compulsory Grid Connection	Sustainability Criteria	Tariffs
+5 Countries								
Brazil	T	E	T					Et
China		E,T	T	E,T	E, H	E,H		n/a
India	T, (E*)		E	E,H,T	E			n/a
Mexico	(E*)	(T)	(E)			(E)		Et
South Africa		E, (T)	(E),T					n/a
G8 Countries								
Canada	E**	E**,T	T	E,H,T				Et
France		E*,H*,T	E,H,T		E			Et ; B
Germany	E*,T		H	H	E	E	(E,H,T)	Et ; B
Italy	E*	E*,T	T	E, H	E	E		Et ; B
Japan		E,H,T				E		Et ; B
Russia		(E,H,T)	(T)					n/a
United Kingdom	E*,T*	E*,T	E,H,T	E,H	E		T	Et ; B
United States	T	E**	E,T	E,T				Et
European Union	E*, T	E*,H*, T	T	E,H,T		E	(T)	Et ; B

Conventions

Bioenergy technology
E: electricity
H: heating
T: transport use
Et: ethanol production
B: biodiesel production

*: target applies to all renewable energy sources
**: target is set at a sub-national level
(..) : policy instrument still under development or awaiting approval
n/a : non-available or non-informed

Source: GBEP (2007).

8.5 Food – bioenergy linkages

Understanding food-bioenergy interactions is key to future production, conversion, marketing and use of biofuels. The fast and strong increase in food prices observed during 2007 and early 2008 confirmed the importance of adequately assessing the implications of increasing biofuels production on food availability and prices of food-related agricultural commodities.

This section analyses food – bioenergy interactions relevant to both bioenergy-support policies and food security concerns. The section starts with a review of the food security concept and an evaluation of its requirements vis-à-vis the expansion of bioenergy production and dynamics relevant for an adequate balance between food demand and supply. The analysis continues with a review of analytical models that have been proposed to deal with the complexity involved in analyzing the consequences of bioenergy expansion on food security. The section closed with an analysis of agricultural commodity prices that distinguishes whether the different commodities are directly, indirectly or not related with bioenergy production.

Food security and bioenergy production

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 « [Faurès (2008)]. The definition considers four dimensions: food availability, food access, food use and food stability. These dimensions are appraised next with regard to bioenergy production expansion.

Food availability refers to having sufficient quantities of food of appropriate quality, supplied through domestic production or imports (including food aid). Regarding the impact of biofuels expansion of food availability it is important to point that the use of agricultural lands for bioenergy feedstock production is quite low relative to total agricultural land area. Currently only 1% of the world's agricultural land is used for biofuels production; the figure could increase up to 3% or 4% in 2030 [BFS/FAO (2008)].

Furthermore, it is difficult to assert that there are effective land restrictions to produce both food and biofuels, considering that the world's total agricultural areas (roughly 1.5 billion hectares) currently represent about 12% of world's surface. Additionally, an important portion of current agricultural land is used to produce animal feed (eg. grains for animal feeding), which is an inefficient way to meet the food needs of the world's population. That is the case, for example, with the production of corn in the US and soybeans in Brazil, which are widely used as feeds in animal production systems (ie, to produce protein and edible fats for human consumption) with a 15% ratio between caloric consumption and production.

A similar low efficiency ratio is found in the production of animal protein in livestock pasture systems. Pasture areas for livestock production occupy an estimated 3.5 billion hectares globally, which basically include native pastures of limited productivity. Indeed, 35 million hectares would be released if pasture productivity increased by 1%, through adequate livestock handling and the introduction of better fodders. Such land-saved area is larger than the estimated 23 million hectares required to produce sugarcane bioethanol for the equivalent of 10% of the global gasoline market (ie, for a global 10% bioethanol blend).

In fact, it is not the availability of agricultural land what structurally affects food security and constrains biofuels production. Likewise, the recent increase in food prices is not caused by insufficient food production. Globally, food production has systematically increased allowing a 24% increase in the per capita food supply over the last 40 years, along with an increase from 2,360 to 2,803 calories per capita per day, while global population increased from three to six billion people [FAO in Ricupero (2008)].

It must be recognized, however, that in recent years there have been important imbalances between supply and demand, especially in grains, which has been simplistically attributed to expanding biofuels production. In fact, the recent increases in food inflation and agricultural commodity prices are part of a more complex process affected by many structural and transitory factors [Rodríguez (2008a), FAO (2008), Trostle (2008) e Best et al. (2008)]. On the demand side it is noticeable how cereal and animal protein consumption per capita have grown in important markets, especially in Asia (India and China). On the supply side production has been constrained by structural (eg, a reduction in the rate of growth of cereal yields) and transitory phenomena (eg, adverse weather conditions), as well as by increases in production costs caused by direct and indirect effects of high petroleum prices, especially on fertilizers and transportation costs. Those supply-demand dynamics have led to a reduction in cereal stocks that started around 2000. The situation has been compounded by additional aggravating factors that have contributed mainly to the price volatility observed during the last two years and intensified over the last few months. Such factors include the devaluation of the US dollar; the low interest rates policy followed by the US Federal Reserve (to face the financial distress caused by the so called subprime mortgage crisis), which has motivated investors to seek for investment alternatives in commodity markets; and related to both, the eventual increase in speculative movements in international agricultural commodity markets [Frankel (2008a and 2008b) e Calvo (2008)]. The explanation for the acceleration in the growth of commodity prices as the result of the low interest rate policy followed by the US Federal Reserve rests on an analytical framework developed by Frankel (2006).

Some numbers illustrate the scenario just described. China, one of the current main food importers, with approximately 20% of the world's population and less than 10% of world's agricultural land, was able for decades to reasonably provide itself with cereals produced out of its own agricultural resources. However, food imports have significantly increased since 2004 along with increases in purchasing power and diet diversification, especially an increase animal protein demand. China's meat consumption per capita increased from 20 kg/year in 1985 to 50 kg in 2000 and it is expected to reach 85 kg in 2030 [SOW-VU (2007)], a level representative of a medium-to-high development country. This increase in animal protein demand has significantly increased grain demand, since as much as 5 - 8 kg of feed-grain are required to produce one kilogram of pork or beef.

In 2007 Brazil exported 11 million tons of soybean to China. Considering the soybean average productivity of 2.5 tons per hectare, it means that Brazil devoted 4.4 million hectares to meet soybeans demand in the Chinese market [Abiove (2008)], an area larger than the area currently cropped with sugarcane to produce bioethanol.

As indicator of inflation in international food-related agricultural commodities markets, between 2000 and 2007 nominal cereal prices increased 225%, below the increase of about 330% in oil prices. The increase of food prices intensified in recent years, especially in the case of some important cereals: from January 2007 until March 2008 the nominal prices of corn, wheat and rice increased by 40%, 130% and 82%, respectively [Faostat (2008b)]. The evolution of agricultural commodity prices is analyzed at the end of the chapter. The increase in food-related agricultural commodity prices has stronger impacts in poor energy and food importing countries and describes a scenario that can be a reflection of deeper long-lasting structural changes in the world [World Bank (2008)].

The contribution of sugarcane bioethanol to higher volatility and increase in agricultural commodity prices is marginal, given how sugarcane production is structured, especially in Brazil. As indicated previously, the area required to replace 10% of global gasoline consumption is approximately of 23 million hectares, which is equivalent to 1.5% of the world's cultivated land area, or 0.2% of the world's arable land. The argument is also supported by the limited impact of bioethanol production on sugar prices, which have remained stable over the last few years vis-à-vis the evolution of other agricultural products, as it will presented latter in this chapter.

The same is not true of other biofuels produced out of food-related agricultural commodities. A study carried out by the International Monetary Fund (IMF) on the growing demand of agricultural products indicates that corn, soybean and rapeseed markets will be strongly influenced by bioenergy production. An good example is US corn-based bioethanol production, responsible for 60% of the increase in the global corn demand, with direct effects on corn prices. The US, the largest corn producer and exporter, is expected to devote approximately 30% of its annual corn production to bioethanol, until 2011. Similarly, the increase in European biodiesel production can affect vegetable oils markets [IMF (2007)].

Therefore, it is important to recognize that domestic low-productivity biofuels production in the US and EU present limitations, because they involve the use of production niches, especially agricultural surpluses, which allow to meet only a small fraction of their internal liquid fuels consumption. Such reality creates an opportunity for a more sustainable and economically rational biofuels production in humid tropical countries of Latin America and the Caribbean, Africa and Asia. That could progressively enable high energy-consuming countries to reach fossil fuel replacement rates from 20% to 30% without affecting the production of other agricultural products and a considerable boost to development in producing regions.

Therefore, biofuels clearly have different impacts depending on the origin of the raw materials used. Sugarcane bioethanol produced in countries that have adequate conditions in terms agricultural productivity and climate has little impacts on other agricultural sectors. On the other hand, biofuels largely produced in the US and the EU have direct an increasing effects on food availability and prices. Impacts on the demand of agricultural products are aggravated by protectionist practices widely adopted in developed countries, which have severe implications in at least two domains. First, price support policies to farmers work as an effective trade barrier that limits the entry of agricultural products from developing countries, discouraging export-led production. And second (and worse), surplus-subsidized production unbalances global agricultural markets, depressing international prices and dislocating agricultural production in low income countries.

An eloquent example is subsidized corn production in the US. Subsidized corn surpluses exported from the US at prices below production cost have promoted a gradual reduction in corn production in traditional LAC corn producer countries such as Mexico, Colombia and Guatemala. Adequate coordination of national agricultural policies and harmonization with the objectives of energy policies will take some time, but the role of coherent public policies will continue to be fundamental to the sustainable development of biofuels [Rodriguez (2007)].

Subsidies can certainly be legitimate public policy instruments to support agricultural production. However, a large portion of the US$ 280 billion allocated annually by OCDE countries to support their farmers [OCDE (2007b)] (a 30% equivalent of the gross revenue generated by rural activities) has contributed to reduce food production in developing countries. The revision of subsidies is one of the most complex issues in the international trade agenda, and it needs to be readily addressed to bring more rationality to global agricultural production. The same argument can be extended to biofuels subsidies that obstruct international trade and encourage inefficient biofuel production systems that end up wasting food commodities with insignificant energy and environmental gains. In short, food availability may be adversely affected if biofuels are produced with low energy productivity and making an unsustainable use of natural resources. Certainly, that is not the case of sugarcane bioethanol.

The other dimensions of food security are not expected to be significantly affected by the production of biofuels. Food access relates to individuals having adequate resources (entitlements) for acquiring appropriate foods for a nutritious diet. It depends on purchasing power of the population as well as the availability of adequate transport, storage and distribution infrastructure. Food access can be favoured in contexts where bioenergy production stimulates the development of rural production system and increases household disposable income. On the other hand, food access can be negatively affected if biofuels development leads to significant food prices increases that reduce purchasing power among the population. This effect would be higher in poor countries or regions where a significant portion of disposable income is spent on food.

Food utilization relates to how food is used through adequate diet, clean water, sanitation and health care to reach a state of nutritional well-being where all physiological needs are met. Food utilization brings out the importance of non-food inputs in food security; therefore, it is not expected to be meaningfully impacted by biofuels development.

Finally, stability refers to the possibility that a population, household or individual has access to adequate food at all times. They should not risk losing access to food as a consequence of sudden shocks (eg, an economic or climatic crisis) or cyclical events (eg, seasonal food insecurity). The concept of stability can refer to both food availability and food access. Biofuels development can therefore affect the stability dimension of food security through the effects it can have on food availability, if fuel uses of agricultural commodities prevail over food uses or production of other food-related agricultural goods is displaced to produce biofuel feedstocks. Biofuel development can also affect food stability through the effect on food access, negatively if it leads to significant food price increases that reduce purchasing power, or positively if it increases purchasing power among farmers and the general population in biofuels producing regions.

Sugarcane production for biofuel conversion in Brazil is a good concrete example of how biofuels can enhance the stability dimension of food security. Sugarcane can be used in both sugar and ethanol production. The final use depends on relative prices and arbitrage among uses is facilitated because the industry has developed the technological capacity to jointly produce both final products, in different mixes within certain ranges (recall from Chapter 6 that several plants can jointly produce sugar and ethanol). Therefore, there is always the possibility of using a portion of sugarcane to produce sugar if the price is sufficiently attractive, even if the original intended used was in bioethanol. This arbitrage — at the plant level and driven by relative prices — then provides a mechanism to stabilize sugarcane farmers' income. The positive stability effects tend to be more effective when bioenergy and food markets are integrated and not affected by trade restrictions.

Concluding, the earth's base of natural resources allows sustainable bioenergy production in reasonable volumes. Impacts can be reduced if rational technological routes are adopted, such as sugarcane bioethanol. Broadly speaking, the use of more efficient technologies that reduce losses and rationalize farming production systems is more important than the large availability of natural resources vis-à-vis the mitigation of the food-feed-fuel trade offs.

Productivity increase can therefore provide an immediate alternative to the increasing demand for agricultural energy-related feedstocks derived from the bioenergy expansion. A good example of the positive impacts of technological improvement also comes from Brazil, where productivity increases and densification is the livestock sector led to increases in meat and milk production without increasing pasture land area. Data for the last 20 years indicates that cattle and the milk production increased by 32% and 67%, respectively, while the pasture area decreased by almost 4% [IBGE (2008)]. Moreover, average bovine density in the Brazilian livestock sector is approximately one head per hectare, while in the State of São Paulo it is 1.4 heads per hectare (ie, 40% higher). If the entire Brazilian livestock sector had a productivity level similar to São Paulo an area between 50 to 70 million hectares would be released for other agriculture uses [Jank (2007)]. Such area would be two to three times the surface required to produce enough bioethanol to substitute 10% of global gasoline consumption.

Models to assess the impact of bioenergy production on the food security and food prices

One way to evaluate the feasibility of expanding bioenergy production, broadly speaking, is the use of analytical models that take into account the multiple production and socioeconomic dimensions involved. In these models production and demand functions are represented by mathematical equations that replicate historical data and information. The models are used to simulate the effects of biofuel production in contexts and scenarios defined *a priori*, in order to support policy decision-making and implementation in the agricultural and bioenergy fields.

One of the most relevant initiatives is FAO's Bioenergy and Food Security Project (BEFS) launched in 2007 [FAO (2008)]. The project has been developing an analytical structure to assess the bioenergy and food security linkages and will be applied in specific countries. It is expected that the project will contribute with a strong and scientifically-based tool to the ongoing international debate on the possible benefits and problems of expanding bioenergy use.

The main objective of the analytical framework is to analyze the impact of different bioenergy production and utilization schemes on food security, which are specific for each country. The focus of the bioenergy and food security nexus analysis is on income and price changes that depend mainly on variation in land use patterns, on bioenergy and food production levels and on food and energy market prices. After a specific country scenario in selected, five steps are needed to carry-out the required analysis:

i) definition of bioenergy "technical biomass potential" using the model proposed by Smeets et al. (2006)] (see Graph 30);

ii) estimation of cost supply curves for food and biomass production;

iii) estimation of the "economic biomass potential";

iv) estimation of macroeconomic impacts of additional biomass on income, employment and prices; and

v). evaluation of the impact of income, price and employment changes on food security.

The evaluation looks at population groups that can be affected differently by bioenergy development. The selection of population groups is specific to countries and bioenergy scenarios. The project is currently active in Peru, Tanzania and Thailand and should be expanding to other countries.

Similar models have been developed by the International Food Policy Research Institute (IFPRI) and the United States Department of Agriculture (USDA).

IFPRI developed the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT), which has been used to project global food supply, food demand and food security to the year 2020 and beyond. The model contain three categories of commodity demand: food, animal feed and other uses, including biofuels. The bioenergy-commodities considered are corn, sugarcane, sugar beet, wheat and cassava for bioethanol and soybean and other oilseed crops for biodiesel. Drawing on biofuels demand projections for the relevant countries and regions, IMPACT models three scenarios with regard to productivity and technology.

One of the main conclusion reached in the study is that there will be significant increases in world feedstock crops prices, especially for cassava under the scenario of aggressive biofuels growth without productivity change. That conclusion confirms the importance of efficiency in bioenergy development [IFPRI (2006)].

The Economic Research Service (ERS) of the USDA carried out a study to evaluate the impact of biofuels production on agricultural and food prices. In this study the impact of climatic effects and energy price increases on food prices is more important vis-à-vis the increase in biofuels production. In fact, it was estimated that only 3% of the increase in food prices can be attributed to corn-based bioethanol production; moreover, it points out that high oil prices have played a more important role. Data on the evolution of nominal prices from 1992 to 2008 indicates that oil prices increased by 547%, commodities prices (basically metals) by 286% and food by 98%. The study estimates that in the coming years the market can reach an equilibrium at a more adequate price level [ERS (2008)].

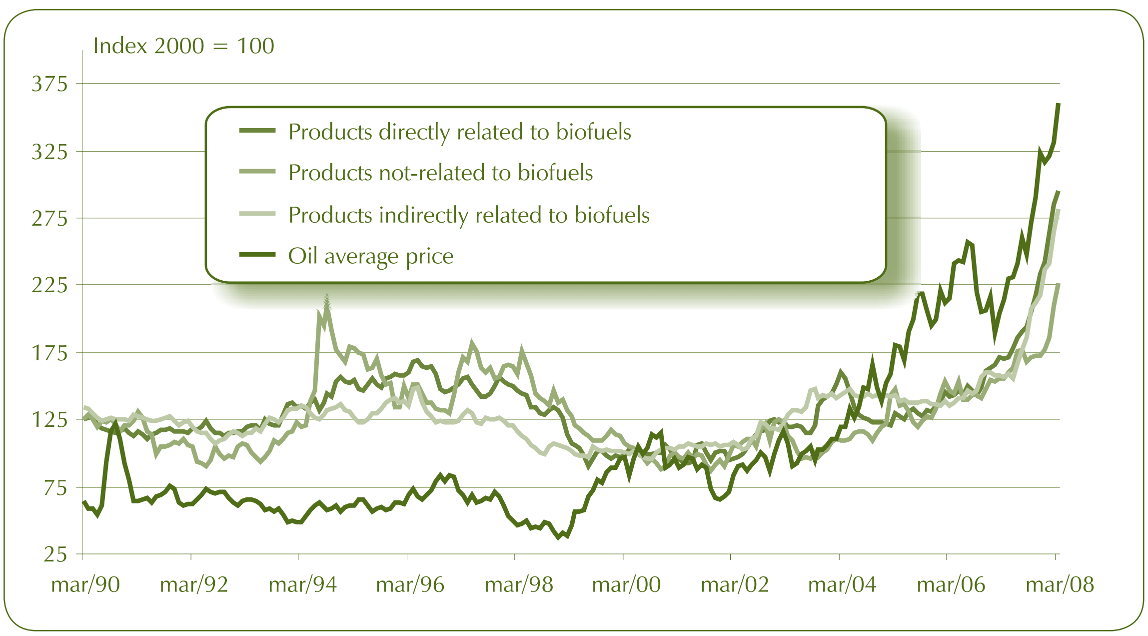
The significant difference in results between the IFPRI and USDA studies illustrates the limitations of modeling complex dynamic systems that are subject to stochastic behaviour. The usual approach is to broaden the complexity of the matrixes used, increasing the number of variables; however, such approach is restricted because the lack of detailed data for an adequate model calibration and implementation. Therefore, approaches are usually static with limited possibilities for application to more varied contexts. Nevertheless, such models are useful devices that compensate low predictive capacity with their use as tools for scenario exploration, in many cases following an approach more qualitative than quantitative. It must be recognized, however, that in the future more elaborated models could be developed, including adaptive logics and capable of simulating dynamic interactions between socioeconomic and bioenergy systems.

Evolution of international food and bioenergy commodities

This section presents an analysis of the evolution of nominal agricultural commodity prices between 1990 and 2008, using World Bank Data. The objective is to strengthen the discussion on the linkages between biofuel production and food prices and to characterize eventual relationships among the prices of different agricultural commodities. Agricultural commodities are classified in three groups, depending on whether they have a direct (sugar, corn, soybean oil and palm oil), indirect (meat and wheat) or no relationship (Arabica and Robusta coffee, tea and bananas) with biofuels production. The analysis does not intend to assess cause-effect relationships. The only objective is to illustrate that there is an increasing price interconnection between international oil and agricultural markets, which may be explained by several factors, including bioenergy expansion. However, determining the relative impact of different explanatory factors goes beyond the scope of this book. The analysis includes a series of figures that go from a general to more specific cases.

Graph 41 shows the evolution of a crude oil price index and three simple unweighed agricultural commodity price indexes. Since around the beginning of 2002 commodity prices have followed the general trend of crude oil prices. The relationship is more clear after March 2007, as both biofuel and biofuel-related commodities have increased at a rate similar to that of crude oil and significantly faster than non- biofuel related commodities.

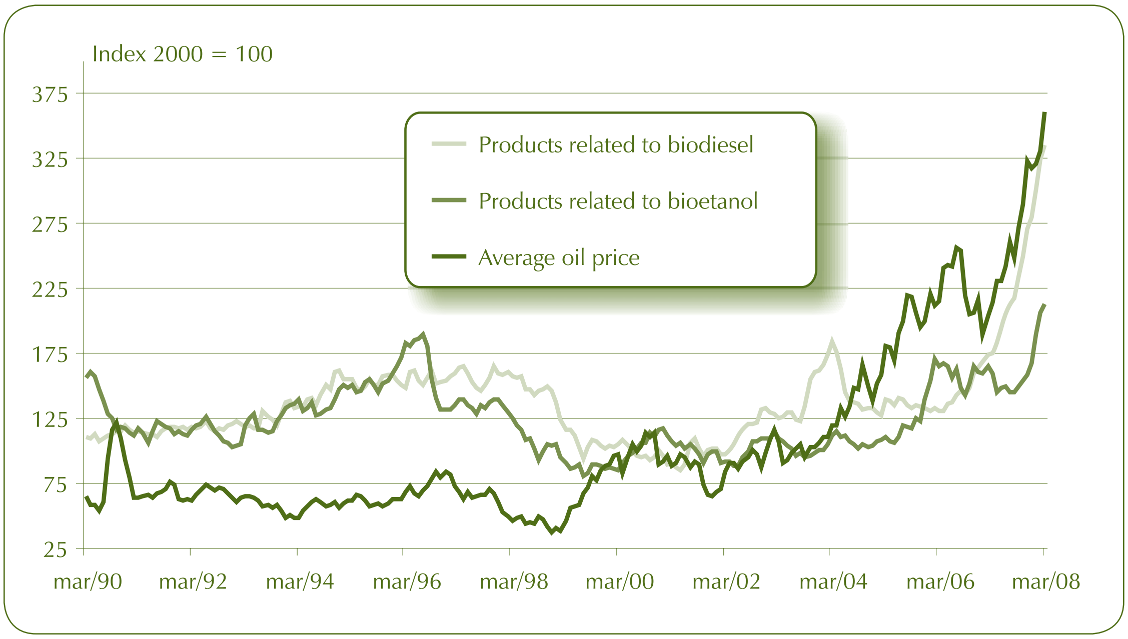
Graph 41 **– Price indexes for crude oil and agricultural commodities (January 1990 – March 2008; Average 2000 = 100)**



Source: Rodríguez (2008b).

Graph 42 distinguishes between biodiesel (vegetable, soybean and palm oils) and bioethanol (sugar and corn) commodities. Both sets of commodity prices show a general upward trend since the beginning of 2002; however, during the last two years biodiesel commodities have risen at a significantly faster rate than bioethanol commodities, very closely to the growing rate of crude oil prices.

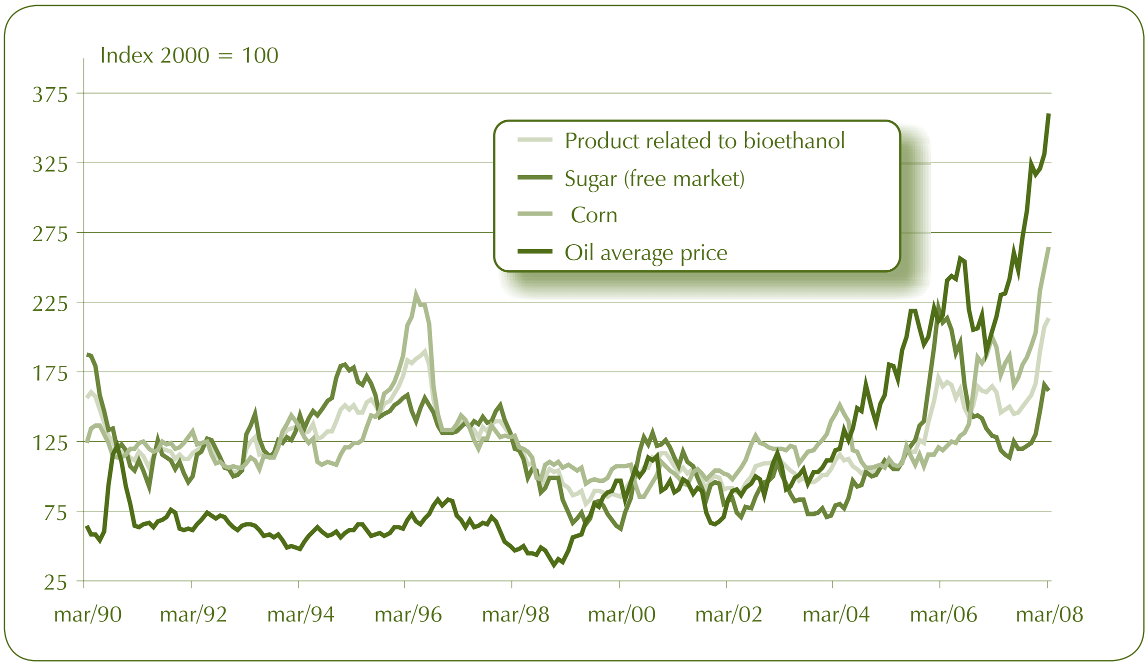
Graph 42 **–Price indexes for crude oil and agricultural commodities used in the production of bioethanol and biodiesel**
(January 1990 – March 2008; Average 2000 = 100)



Source: Rodríguez (2008b).

Graph 43 identifies each component of the bioethanol-commodity price index. The prices of corn and sugar — the two bioethanol commodities included in the analysis — evolved in opposite directions since 2002 and up to the middle of 2007. Since then both prices have increased steadily, following the growth in crude oil prices. The price of crude oil peaked in July 2006, dropped until January 2007 and increased at a sustained rate ever since. Both the prices of sugar and corn dropped after that peak; however, the reduction was more significant and lasted longer for sugar than for corn. The prices of both commodities started to increase again, following the escalation in crude oil prices that started in February 2007. However, the increase was significantly higher for corn, which reached its highest nominal average monthly price in March 2008, 14.4% higher than the previous historical peak in May 1996. On the other hand, the average price of sugar in March 2008 was 27% below the level reached in the historical peak of February 2006. In other words, the price of sugar, which is directly related to sugarcane, increased less than the price of corn.

Graph 43 – Price indexes for crude oil and agricultural commodities used in bioethanol production
(January 1990 – March 2008; Average 2000 = 100)



Source: Rodríguez (2008b).

Table 42 summarizes the relationship between the evolution of crude oil prices and agricultural commodity prices. It is clear that the strength of the relationships increase with time. Relationships are evaluated using simple correlation coefficients, which are statistical measures that indicates how strongly related are two variables: a positive value indicates that the variables evolve in the same direction; a zero value indicates no relationship and a negative value indicates that the variables evolve in opposite directions. As the values approach 1 or -1 the strength of the relationships increases. Table 42 shows that for bioethanol commodities there are important differences between sugar and corn prices. In the case of corn the strength of the relationship clearly increases with time; while in sugar it decreases after 2005.

In biodiesel commodities there is a change in the direction of the relationships, from negative and weak during the 1990s toward strong and positive after 2000, a tendency that further strengthened after 2005.

As Graphs 41, 42 and 43 and Table 42 show, there is a clear relationship between the evolution of petroleum and agricultural bioenergy-related commodities. The relationship, however, is lower in the case of sugar, which competes with bioethanol production from sugarcane. The international debate on this field will be enriched as more research is developed and better data becomes available. More research and better data can provide for a better understanding of the multiple factors that affect international food prices, reducing current speculation on the subject.

***Table 42* – Simple correlation coefficient between crude oil prices and biofuels-commodity prices, in different periods from January 1990 to March 2008**

Product	Period			
	1990 to 2008	1990 to 1999	2000 to 2008	2005 to 2008
Corn	0.43	0.04	0.76	0.74
Sugar	0.21	0.03	0.68	0.22
Soybean oil	0.61	-0.41	0.82	0.89
Palm oil	0.42	-0.44	0.81	0.86

Source: Rodríguez (2008b), using World Bank Data.

8.6 Key factors to induce a global bioethanol market

Adopting bioethanol as a component of the global energy matrix requires addressing a variety of issues. Previous sections in this chapter indicate there are solid production potential, expanding demands and strengthening markets for biofuels, with limited impacts on the availability and prices of food. In particular, the role of public policies is highlighted as strategic to foster advantages, mitigate risks and protect societal interests. Considering that context, this section provided some complementary comments on issues that are relevant for the emergence of an international biofuels market, emphasizing the role of sugarcane bioethanol in the global environmental agenda and the context of international negotiations on agricultural trade and environmental issues.

Global environmental challenges and bioethanol

Biofuels, including bioethanol, are explicitly discussed in global environmental negotiations, especially in the Convention on Biological Diversity (CBD) and in the United Nations Framework Convention on Climate Change (UNFCCC).

Biofuels production was the subject of a specific recommendation by the 12th Session of the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTA) of the CBD [CBD (2008)]. The recommendation applies to both the positive and adverse effect of liquid biofuels production and use on «biodiversity and human well-being». The recommendation indicates that beneficial effects arise when biofuels production and use are associated with, among other: a reduction of fossil fuels consumption; a decrease in land use for agricultural purposes associated with the increase in energy output per area; a reduction in water used for irrigation and increased water use efficiency in crops; a reduction in the conversion of agricultural lands to other uses; and an increase of the income-base and economic opportunities in rural areas.

The recommendation also indicates that adverse effects arise when biofuels production and use are connected with: loss, fragmentation and degradation of valuable habitats such as natural and semi-natural forests, grasslands, wetlands and peatlands and carbon sinks, their biodiversity components and the loss of essential ecosystem services and leading to increase in greenhouse gas emission from these changes; competition for land managed for the production of alternative crops, including land managed by indigenous and local communities and small-holder farmers, and competition for the commodity prices potentially leading to food insecurity; increased water consumption, increased application of fertilizers and pesticides, increased water pollution and eutrophication, soil degradation and erosion; uncontrolled cultivation, introduction and spread of genetically modified organisms; uncontrolled introduction and spread of invasive alien species; and emissions from burning biomass and potential adverse effects on human health.

Thus, CBD/SBSTA recommendations converge with many of the sustainability points raised in other chapters (eg, Chapter 7), such as those related to the energy and carbon balances (local and global), natural resources and biological diversity, agricultural yields, land use and social criteria.

Biofuels also have been discussed in the context of UNFCCC fora because of the impact of climate change on agriculture and forest yields and the role of biofuels on GHG emissions, carbon balances, afforestation/reforestation, land use change, and other climate change mitigation and adaptation activities [UNFCCC (2008)]. The Kyoto Protocol identifies three mechanisms that allow industrialized countries to earn and trade emission credits through projects implemented in other developed countries or in developing countries, which they can use towards meeting their commitments. One of those, the Clean Development Mechanism (CDM), promotes projects that in addition to furthering sustainable development goals, involve activities that would not otherwise have occurred and result in real and measurable emission reductions.

The two most common type of CDM projects tend to be land use and energy related, which demonstrate there is potential for bioethanol production and use related projects. Despite such potential has not been sufficiently explored, there are examples of ongoing and planned CDM bioenergy projects, related to electric co-generation with sugarcane bagasse, with information available on methodologies to calculate emission reductions [CDM (2008)].

Certainly, an expanded bioethanol market, if promoted with sustainability criteria, should contribute to the objectives of the CBD and UNFCCC.

International bioethanol trade

As noted in this chapter, there are many challenges associated with the creation of an international bioethanol market. For example, Legal Tariff settings and production quality standards can affect the opportunities of developing countries in the international bioethanol market. Potential trade opportunities are reduced by measures that focus exclusively on enhancing production in industrialized countries, or by protectionist measures designed to limit market access. There are concerns that tariff escalation on biofuels in industrialized country markets force developing countries to export energy raw materials, such as unprocessed molasses and crude vegetable oils, leaving the more profitable value-added industrial phase of biofuel production to the importer countries. Two example of such protectionist policies are the current ad valorem duty of 6.5% on imports of biodiesel to the European Union and the duty of 0.54 US$/gallon (0.142 US$/litre) on most imported ethanol to the United States.

To address these concerns, a number of EU and US preferential trade promotion initiatives and agreements have been developed in recent years, offering new opportunities for developing countries to benefit from the increased global demand for biofuels. Preferential trade with the EU for developing countries falls under the EU's Generalised System of Preferences (GSP). Within that system there are provisions that affect the bioethanol sector provisions in the Everything But Arms (EBA) initiative and the Cotonou Agreement (that replaced the Lomé Convention). Under the current GSP, in effect until December 31st, 2008, duty-free access to the EU is provided to denatured or un-denatured alcohol. The GSP also has an incentive programme for ethanol producers and exporters who adhere to sustainable development and good governance [European Commission (2005)]. The EBA initiative provides least developed countries with duty free and quota-free access to ethanol exports, while the Cotonou Agreement provides duty free access to certain imports from Africa, Caribbean and Pacific low-income countries. Similarly, the Euro-Mediterranean Agreement has provisions for preferential trade in biofuel for certain countries in the Middle East and North Africa.

In the US ethanol may be imported duty free from certain Central American and Caribbean countries under the Caribbean Basin Initiative (CBI), although there are specific quantitative and qualitative restrictions depending on the country of origin of the feedstock, as previously observed. Provisions for duty-free ethanol imports are also included in the Free Trade Agreement between the US, Central America and the Dominican Republic.

It is important to note that despite these agreements do not change the general context of restrictions to biofuels trade, they represent important exceptions that must be valued.

Key issues for promoting bioethanol international trade include: the classification for tariff purposes of biofuel products as agricultural, industrial or environmental goods; the role of subsidies in increasing production; and the coherence between various domestic measures and World Trade Organization (WTO) standards. Since the biofuels industry did not exist when the current WTO rules were written, biofuels are not subject to the Harmonized Standard (HS) classification system, a situation that creates uncertainty because the HS affects how products are characterized under specific WTO agreements. For example, bioethanol is considered an agricultural product and is therefore subject to Annex 1 of the WTO Agreement on Agriculture (AoA). Biodiesel, on the other hand, is considered an industrial product and it is therefore not subject to AoA rules.

Some WTO members have suggested that renewable energy products, including bioethanol, should be classified as "environmental goods" and therefore subject to negotiations under the "Environmental Products and Services" cluster [Steenblik (2005)]. In this context, the Doha Development Agenda has launched negotiations on "the reduction or, as appropriate, elimination of tariff and non-tariff barriers to environmental goods and services". However, disagreement remains among countries on the identification of environmental goods, on the scope and approach to take for liberalizing trade in such products, and on mechanisms for regularly updating the list of products.

Biofuels will remain an important factor in Doha negotiations with some analysts even proposing that because of their impact on agricultural markets, they have the potential to rescue the failed round of agricultural trade negotiations held at the WTO [Turner (2006)]. Others are more pessimistic and consider that the new trade opportunities opening up in industrialized developed countries with the strong interest in biofuels are not likely to be protected by the rules-based system of the WTO. Instead, they foresee that taking advantage of such opportunities will be subject to less reliable unilateral decisions by countries to allow more imports to meet a given domestic demand [IIED (2007)]. Thus, a tariff could remain in place but not be applied or a lower tariff would be applied to a given volume of imports before the maximum tax went into effect. It is then possible that if imports are politically sensitive, because local producers or processors were threatened, or because the environmental standards in place in the production of imported biofuels were deemed inadequate by consumers, then the border could immediately close again without recourse for the exporting country of firm.

The conditions surrounding the Doha negotiations reproduce well the difficulties for global negotiations in the construction of healthy biofuels market. It is in the context of such difficulties that producing countries will have to make decisions and define strategies for bioethanol promotion, aiming to meet their development goals as well as energy, agriculture and trade demands. The strategies must be validated in light of their economic, social and environmental merits, national energy and carbon balances and opportunities for international trade, aiming toward participation in an eventual future international biofuels market, or prioritizing bioethanol production to meet national energy demand and promote rural development goals, for example.

Decisions of that nature will depend basically on how countries approach bioethanol development. A short-term view from producer and consumer countries could lead to a focus on exports and enhancing energy security. On the other hand, a long-term view would probably stress equity in the distribution of the economic and global environmental benefits from biofuels production. However, it is worth noting that national markets can pave the way for international biofuels trade through the establishment of infrastructure, logistics and managerial skills required in well developed biofuels production systems.

It is also important to indicate that developing proposals for biofuels programmes, especially bioethanol, in countries where biofuels do not exist, require detailed assessments and studies (eg, land use, biomass potential, demand) that allow to establish coherent goals. Certainly, bioenergy is not a panacea as it is not going to solve by itself global energy demands. Its advantages should be measured in specific contexts, as it has been repeatedly stressed in this book. Probably, the most important recommendation at this point is to valorize knowledge aggregation and to carry-out careful assessments of energy, environmental, economic and social implications.

Concluding, it is possible to foresee that a global bioethanol market could be a reality in a few years. Trade volumes and country participation will depend on several elements yet being defined, such as country's political decisions regarding their internal markets, discussions about sustainability criteria, international trade negotiations, as well as civil society responses in developing and developed countries. Indeed a complex and dynamic equation. Undoubtedly, bioethanol presents an global potential and therefore it demand global cooperation.