1 Bioenergy in the Global Energy Context

1.1 Bioenergy Contribution to World Total Energy Supply

Bioenergy provides about 10 percent of the world's total primary energy supply (47.2 EJ of bioenergy out of a total of 479 EJ in 2005, i.e. 9.85 percent).[1] Most of this is for use in the residential sector (for heating and cooking). In 2005 bioenergy represented 78 percent of all renewable energy produced. A full 97 percent of biofuels are made of solid biomass, 71 percent of which used in the residential sector.

Humans have depended on traditional bioenergy for millennia. Currently, over 85 percent of biomass energy is consumed as solid fuels for cooking, heating and lighting, often with low efficiency. Traditional bioenergy (fuelwood, charcoal which can only deliver heat) dominate bioenergy consumption in developing countries where up to 95 percent of national energy consumption relies on biomass.

Modern biomass is becoming increasingly important to countries as a low-carbon, distributed, renewable component of national energy matrices. Utilization of modern bioenergy is growing in OECD countries. Over recent years, especially co-firing of biomass materials in coal fired boilers has increased, and some gasification technologies are nearing commercialisation.

1.2 Bioenergy Overview

A wide range of biomass sources can be used to produce bioenergy in a variety of forms. For example, food, fibre and wood process residues from the industrial sector, energy and short-rotation crops and agricultural wastes from the agricultural sector and forest residues, agroforest residues, and short rotation coppice from the forestry sector can be utilized to generate electricity, heat, combined heat and power, and other forms of bioenergy.

Traditional biomass including fuelwood, charcoal and animal dung, continue to be important sources of bioenergy in many parts of the world. To date, woodfuels represent by far the most common sources of bioenergy and not only for less developed regions. Woodfuels provide energy security service for large segments of society and woodfuels echnology is developing and expanding rapidly. Modern bioenergy relies on efficient conversion technologies for applications at household, small business and industrial scales.

Solid or liquid biomass inputs can be processed to be more convenient energy carriers. These include solid fuels (e.g firewood, wood chips, pellets, charcoal, briquetts), liquid fuels (e.g. bioethanol, biodiesel, bio-oil), gaseous fuels (biogas, synthesis gas, hydrogen) or direct heat from the production process.

[1] IEA database

Bioenergy Terms Defined

Bioenergy: energy derived from biomass.

Biofuels: energy carrier derived from biomass.

Biogas: a gas composed principally of methane and carbon dioxide produced by anaerobic digestion of biomass, comprising:
- landfill gas
- sewage sludge gas
- other biogas e.g. from anaerobic fermentation of animal slurries and of wastes in abattoirs, breweries and other agro-food industries.
- dedicated energy crops such as wheat, maize, etc.

Biohydrogen: hydrogen produced from biomass for use as an energy carrier by several routes e.g.:
- Gasification or pyrolysis of solid biomass
- Reforming of biogas
- Novel technologies based on use of photosynthetic algae or bacteria, or on fermentative bacteria.

First Generation Biofuels: produced from sugar, starch and oil content that is into liquid fuels using conventional technology.

Liquid biofuels: liquid fuels derived, comprising:
- Bioethanol
- biodiesel
- bioethanol
- biodimethylether
- raw vegetable oil
- synthetic diesel
- pyrolysis oil (biooil)

Modern bioenergy: relies on efficient conversion technologies for applications at household, small business and industrial scales.

Second Generation Biofuels: derived from lignocellulosic materials (e.g.agricultural residues, woody crops, grasses, etc.) using advanced processes.

Solid biomass: covers solid non-fossil material of biological origin which may be used as fuel for bioenergy production. It comprises:
- Purpose grown wood (from agriculture or forestry)
- conventional crops (e.g. sugar, oil and starch crops)
- wood wastes (e.g. from forestry or wood processing activities)
- other solid wastes (e.g. straw, rice husks, nut shells, poultry litter, biodegradable fraction of municipal solid waste).

Traditional bioenergy*:* includes fuelwood and charcoal which can only deliver heat.

Woodfuels: (all types of fuels produced directly or indirectly from woody biomass, i.e. fuelwood, charcoal and black liquor (FAO UBET)) are included in IEA's "Primary Solid Biomass" (along with other solid fuels of non-woody origin).

1.2.1 Biomass for Heat and Power

Power (heat and electricity)

A variety of biomass resources are utilized through combustion, to generate bioenergy in the forms of electricity and heat. These biomass sources include residues from agro-industries (bagasse), residues left on the fields post-harvest (corn stalks), animal manure, wood wastes from forestry and industry, residues from food and paper industries, municipal solid wastes (MSW), sewage sludge, dedicated energy crops such as short-rotation perennials (eucalyptus, poplar, willow) and grasses (miscanthus and switchgrass),[2] and biogas from the digestion of agricultural and other organic wastes. Some estimates project that the cumulative residue and organic waste could provide between 40EJ and 170EJ of energy per year, globally.[3]

Biomass can be converted for power generation using several processes. Generally, the majority of biomass-derived electricity is produced using a steam cycle process, in which biomass is burned in a boiler to generate high-pressure steam, that flows over a series of aerodynamic blades causing a turbine to rotate, which in response turns a connected electric generator to produce electricity.[4] [5] Compacted forms of biomass such as wood pellets and briquettes can also be used for combustion. This system is known as the direct-fired system and is similar to the electricity generation process of most fossil-fuel fired power plants. Figure 1.1 illustrates the direct firing process.

Biomass can also be burned with coal in a boiler of a conventional power plant to yield steam and electricity. Co-firing biomass with coal is currently the most cost-efficient way of incorporating renewable technology into conventional power production because much of the existing power plant infrastructure can be used without major modifications.[6] [7] Co-combusting coal and biomass in large-scale coal plants is claimed to have significantly higher combustion efficiency (up to 45 percent) than dedicated-biomass plants (30 to 35 percent using dry biomass and 22 percent for MSW)[8] According to the U.S. Department of Energy and the Coal Utilization Research Council, conventional pulverized coal in modern plants can yield 45 to 50 percent efficiency and have the potential to achieve 70 to 80 percent efficiency with advances in future gasification technologies.[9] [10] Co-firing technology options have been tested in Northern Europe, the United States, and Australia in approximately 150 installations using woody and agricultural residues.[11]

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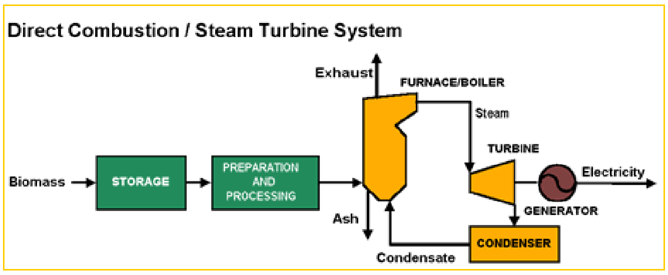
[2] IEA 2007, Energy Technology Essentials, Biomass for Power Generation and CHP, January 2007 (available at http://www.iea.org/textbase/techno/essentials3.pdf)
[3] Utrecht Centre for Energy Research (UCE-UU), Global Restrictions on Biomass Availability for Import to the Netherlands (GRAIN), July 2001 (available at http://www.uce-uu.nl/index.php?action=1&menuId=1&type=project&id=3&)
[4] US Department of Energy, Distributed Energy Program, Biomass Power Fact Sheet. Last updated: May, 2006 (available at http://www.eere.energy.gov/de/biomass_power.html)
[5] US Department of Energy, Energy Efficiency and Renewable Energy: Biomass Program, Electrical Power Generation. Last Updated: 03/15/2007 (available at http://www1.eere.energy.gov/biomass/electrical_power.html)
[6] DOE, d.e.p Biomass Fact Sheet
[7] DOE eere.energy.gov
[8] IEA 2007
[9] U.S. Department of Energy, Fossil Energy, Coal Gasification R&D Program, (available at www.fossil.energy.gov/programs/powersystems/gasification/index.html)
[10] Coal Utilization Research Council, Electricity from Coal: Advanced Combustion Technologies, (available at www.coal.org/facts/combustion.htm)
[11] IEA 2007

Figure 1.1 – Direct Combustion



Source: DOE d.e.p. biomass power

1.2.2 Biogas for Heat and Power

Anaerobic Digestion

Biogas can also be created through *anaerobic digestion* of food or animal waste by bacteria, in an oxygen-starved environment. The final product of this form of digestion is a biogas that contains a high volume of methane along with carbon dioxide. Methane-rich biogas can be used for heating or for electricity generation in a modified internal combustion engine.[12] Advanced gasification technologies are necessary to produce biogas with sufficient energy for fuelling turbines.

The conversion of animal wastes and manure to methane/biogas can bring significant environmental and health benefits. Methane is a GHG that is 22-24 times more powerful as CO_2 in trapping heat in the atmosphere[13]. By trapping and utilizing the methane, GHG impacts are avoided. In addition, pathogens present in manure are killed by the heat generated in the biodigestion process and the material left at the end of the process provides a valuable fertilizer. Biodigestion is employed successfully in various countries, and particularly in China and India where is has contributed to energy provision to rural populations, abatement of negative environmental impacts of livestock production, and the production of organic fertilizer. Its impact on sanitation, clean cooking and heating and in the creation of small and medium enterprises in rural areas is very positive.

Gasification

Through the process of *gasification*, solid biomass can be converted into a fuel gas or biogas. Biomass gasifiers operate by heating biomass in an oxygen-free, high temperature environment that breaks it down to release a flammable, energy-rich synthesis gas or 'syngas'.[14] This gas can be burned in a conventional boiler, or used instead of natural gas in a gas turbine to turn electric generators. Biogas formed through gasification can be filtered to remove unwanted

[12] DOE d.e.p. biomass power
[13] Intergovernmental Panel on Climate Change (IPCC) Second Assessment Report – Climate Change 1995. as cited in U.S. Environmental Protection Agency (EPA), Methane: Science (last updated 19 October, 2006) (available at http://www.epa.gov/methane/scientific.html)
[14] NREL learning, IEA 2007

chemical compound and can be used in efficient power generation systems known as ‘combined-cycles’, which can combine steam and gas turbines for electricity generation and can yield up to 60 percent efficiency of coal-fired plants.[15] The first integrated gasification combined cycle (IGCC) plant fuelled by 100 percent biomass (from straw) was successfully demonstrated in Sweden from 1996 to 2000[16]. IGCC plants elsewhere could become economically competitive using black-liquor from the pulp and paper industry as a feedstock, but further analysis is required.[17]

Biogas for Transport

Treatment of biogas obtained can make it suitable for use as a transport fuel. Due to a low methane content (60 to 70 percent) and a unsuitably high amount of contaminants, untreated biogas is unsuitable for transportation.[18] Treated biogas (TB) – sometimes called "biomethane" - resulting from processes that remove carbon dioxide, water, and corrosive hydrogen sulphide and enhance the methane content (> 95 percent), and when compressed has properties similar to compressed natural gas (CNG), thereby making it suitable for use in automobiles.[19] Sweden currently leads the world in automotive biogas production, with a total fleet of approximately 4500 vehicles with 45 percent of its fuel supplied by biogas.[20]

1.2.2. Liquid Biofuels for Transport

Bioethanol available in the biofuel market today is produced by processing sugar or starch. Commercial bioethanol production starts by pulverizing the feedstock to facilitate processing. Once the feedstock has been broken down, the sugar content is dissolved out of the material and combined with yeast in an anaerobic chamber to undergo a fermentation process. In the resulting reaction, the yeast secretes enzymes to digest the sugar, deconstructing it into lactic acid, hydrogen, carbon dioxide and bioethanol. For starchy feedstock, an extra step is necessary prior to fermentation in order to break down the large starch molecules into simple sugars. This process, known as saccharification adds extra energy requirements to bioethanol production. After the fermentation stage, the product must be distilled to remove the yeast and byproducts and then dehydrated in order to reduce the 5 to 12 percent solution into a concentrated output of 95 to 99.8 percent bioethanol.

A variety of common sugar crops such as sugar cane, sugar beet and sweet sorghum, which contain a large proportion of simple sugars, are used as feedstock for bioethanol production. Common starchy feedstocks include corn, wheat, and cassava. The relative bioethanol yields of various crops are provided in Figure 1.2.

[15] DOE eere.energy.gov
[16] IEA 2007
[17] IEA 2007
[18] Worldwatch Institute, Biofuels for Transport: Global Potential and Implications for Energy and Agriculture (London: Earthscan, 2007), chapter 15, p259.
[19] Ibid.
[20] Jönsson, O., M. Persson, 'Biogas as Transportation Fuel', Swedish Gas Center, Fachtagung 2003.

Bioethanol can be blended with gasoline or burned in its pure form in slightly modified spark-ignition engines. A litre of bioethanol contains approximately 66 percent as much energy as a litre of gasoline. However, it has a higher octane level and when mixed with gasoline for transportation, improves the performance of gasoline by reducing the occurrence of engine knock problems that arise when the fuel combusts too soon during vehicle acceleration. Fuel bioethanol is referred to as an 'oxygenate' since its oxygen content improves fuel combustion in vehicles, thereby helping to reduce the emission of carbon monoxide, unburned hydrocarbons and carcinogens.

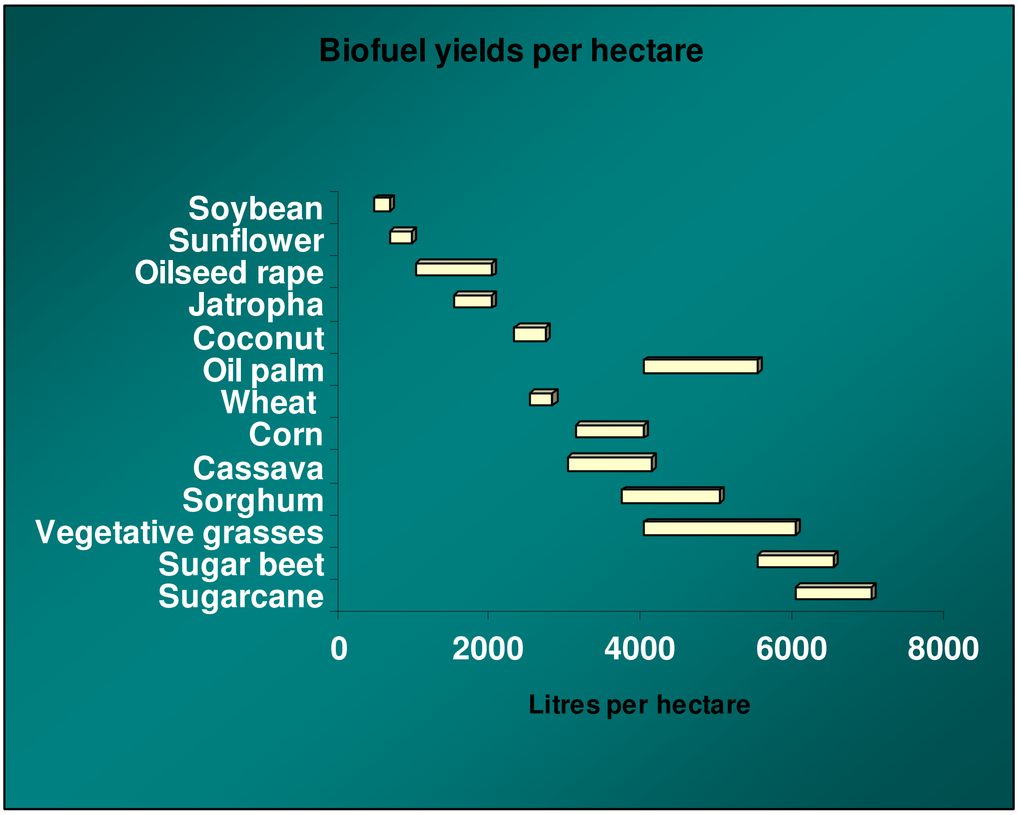
Consequently, the combustion of bioethanol also causes a heightened reaction with nitrogen in the atmosphere which can result in a marginal increase in nitrogen oxide (NO_x) gases. In comparison to gasoline, bioethanol contains only a trace amount of sulphur. Mixing bioethanol in gasoline therefore, helps to reduce the fuel's sulphur content and thereby lowers emissions of sulphur oxide (SO_x), a component of acid rain and a carcinogen. However, due to bioethanol's higher vapour pressure, at low level blends evaporative emissions are higher.

As the biomass fed into bioethanol production is created by the capture of carbon dioxide during photosynthesis, the emissions during bioethanol fuel combustion is generally recycling carbon back into the atmosphere. However, bioethanol's net reduction of GHG emissions will vary depending on the amount of fossil fuel energy used during the entire bioethanol production process.

The United States is currently the largest producer of fuel bioethanol with a production capacity of 13.17 billion litres a year with corn as its primary feedstock[21]. Sugar cane is used as bioethanol feedstock by Brazil, currently the world's second largest producer.

[21] Renewable Fuel Association (RFA), U.S. Fuel Bioethanol Industry Biorefineries and Production Capacity, August 1, 2007. (available at http://www.bioethanolrfa.org/industry/locations/)

Figure 1.2– Estimated per-acre bioethanol yields for various crop types



Source: The energy content of biodiesel (~34-36MJ/l) is greater than that of ethanol (~21MJ/l). So readers should not directly compare biodiesel (top half of diagram) with ethanol (bottom half) purely on a l / ha basis

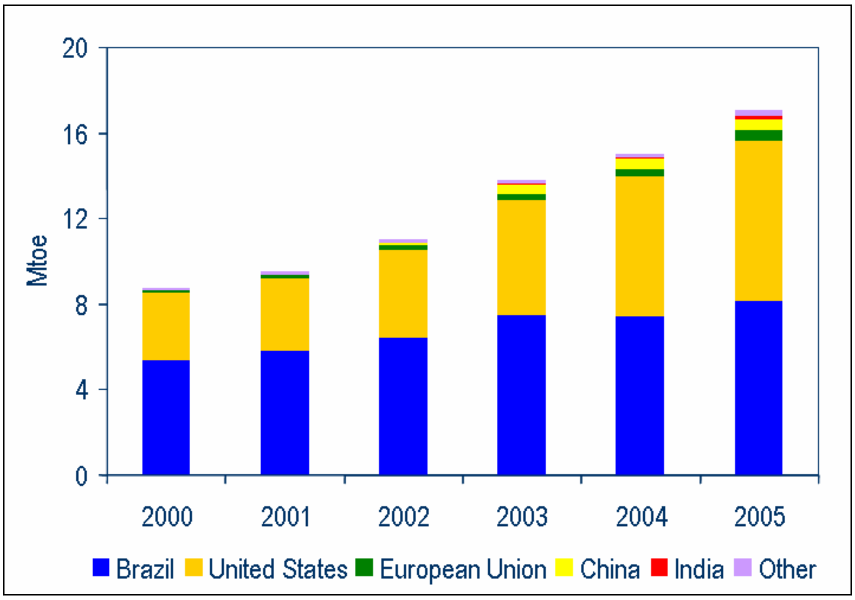
In 2006, total world bioethanol production reached 51.3 billion litres.[22] The United States continued as the leader in global bioethanol production with an output of 20 billion litres in 2006 and an expected 26 billion litres by the end of 2007.[23] As the world's second largest bioethanol producer, Brazil produced about 17.8 billion litres of bioethanol derived from sugar cane in 2006 with a projected 20 billion litres for 2007.[24] Jointly, the United States and Brazil produce almost 90 percent of the world's fuel bioethanol.[25] As regional leaders in bioethanol production for 2007, China and India are projected to produce 3.7 billion litres and 2.3 billion litres respectively. Production in 2006 for Asia was recorded at 6.5 billion litres with 2007 numbers likely to reach 7.4 billion litres. In the EU, fuel bioethanol production is forecast to rise to approximately 2.3 billion litres in 2007 from 1.6 billion litres in 2006. As the largest producer of fuel bioethanol in the EU, France is set to produce an estimated 1.2 billion litres in 2007 followed by Germany at 850 million litres. Table 1.1 summarizes regional output of bioethanol, and key producers from the period of 2000-2007.

[22] F.O. Licht, May 09 2007, World Bioethanol and Biofuels Report. Vol.5, No.17
[23] Ibid.
[24] Ibid.
[25] Rodrigo Pinto and Suzanne Hunt, Worldwatch Institute, 2007, Vital Signs, "Biofuel Flows Surge"

Table 1.1 – World Production of Bioethanol – Top Producers by Region 2000-2007 (billion litres)[26]

	Year						
Country/Region	2000	2001	2002	2003	2004	2005	2006
Canada	0.21	0.22	0.23	0.23	0.23	0.25	0.57
U.S.A.	7.6	8.12	9.59	12.06	14.31	16.21	19.85
N & C America	8.2	8.75	10.22	12.7	14.96	16.86	20.85
Brazil	10.61	11.5	12.61	14.73	14.66	16.06	17.82
S. America	11.07	11.95	13.04	15.18	15.14	16.57	18.59
France	0.81	0.81	0.84	0.81	0.83	0.91	0.95
Germany	0.28	0.29	0.27	0.28	0.23	0.35	0.76
E.U.	2.42	2.58	2.51	2.47	2.45	2.79	3.44
China	2.97	3.05	3.15	3.4	3.5	3.5	3.55
India	1.72	1.78	1.8	1.77	1.23	1.1	1.65
Asia	5.79	5.96	6.14	6.47	5.93	5.81	6.43
World	29.41	31.32	34.07	39.01	40.71	44.29	51.32

Figure 1.3 - Global Bioethanol Production



Source: F.O. Licht, May 09 2007, World Bioethanol and Biofuels Report. Vol.5, No.17

Biodiesel is made by combining vegetable oil or animal fat with an alcohol and a catalyst through a reaction known as *transesterification*. A mixture of 80 to 90 percent oil, 10 to 20 percent alcohol and an acid or base catalyst are heated to produce a volume of biodiesel equivalent to the original volume of oil/fat. Oil for biodiesel production can be extracted from nearly any oilseed crop. Globally, the most popular oilseed sources are rapeseed in Europe and soybean in the United States. In tropical and sub-tropical nations, palm, coconut and jatropha

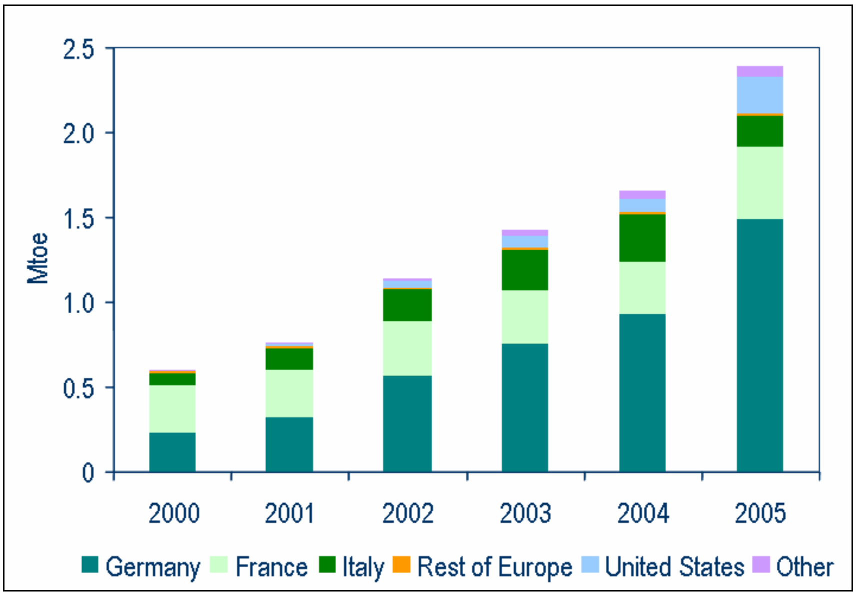
[26] F.O. Licht, May 09 2007, World Bioethanol and Biofuels Report. Vol.5, No.17

oils are utilized for biodiesel production. A small amount of animal fat, from fish and animal processing operations, is also used to make biodiesel. As a wide variety of oils can be used to produce biodiesel, resulting fuels can have a greater range in physical properties, like viscosity and combustibility, than bioethanol.

Biodiesel can be blended with traditional diesel fuel or burned in its pure form in compression ignition engines. Biodiesel contains 88 to 95 percent as much energy as diesel. However, biodiesel improves the lubricity of diesel and raises the cetane value, thereby making the fuel economy of both generally comparable. The higher oxygen content in biodiesel aids in the completion of fuel combustion, which reduces particulate air pollutants, carbon monoxide and hydrocarbons. Similar to bioethanol fuel, biodiesel contains a negligible amount of sulphur thereby contributing the reduction of sulphur oxide emissions from vehicles.

World biodiesel production surpassed 6 billion litres in 2006. Europe led biodiesel production in 2006, producing 3.96 million tons of fuel using rapeseed, sunflower and other oilseeds. The EU is projected to produce 4.72 million tons for 2007. As the leader in biodiesel production, Germany produced 3.8 million tons (2.5 billion litres) of biodiesel in 2006 and its production capacity is set to rise by 40 percent to 5.4 million tonnes by the end of 2007.[27] The United States is currently the second largest producer of biodiesel and is estimated to produce about 1.8 million tons in 2007, up from 1.3 million in 2006.[28] France, Italy and several small suppliers also grew their biodiesel output.[29] Production rates increased rapidly in Malaysia, China, Colombia and Brazil in 2006 contributing to world biodiesel expansion.[30] Figure 1.4 summarizes Global Biodiesel Production 2000-2005.

Figure 1.4 – Global Biodiesel Production 2000-2005



Source: F O Licht (2006). World Ethanol Markets: The Outlook to 2015. Special Report No 138, Adapted as Fig 14.3 in IEA World Energy Outlook, 2006

[27] F.O. Licht, August 08, 2007, World Bioethanol and Biofuels Report. Vol. 5, No.23
[28] F.O. Licht, March 2007, World Bioethanol and Biofuels Report.
[29] Rodrigo Pinto and Suzanne Hunt, Worldwatch Institute, 2007, Vital Signs, "Biofuel Flows Surge"
[30] Rodrigo Pinto and Suzanne Hunt, Worldwatch Institute, 2007, Vital Signs, "Biofuel Flows Surge"

Straight vegetable oil (SVO) is a potential fuel for diesel engines that can be produced from a variety of sources. These include oilseed crops such as rapeseed, sunflower, soybean and palm. Used cooking oil from restaurants and animal fat from meat processing industries can also be used as fuel for diesel vehicles.

Due to its high viscosity in temperate climates, pure SVO is not suitable for normal diesel engines. Conventional engines must be refitted with a second fuel system including a mechanism for pre-heating the oil in order to use SVO as fuel. Modern engines are developing to be increasingly electronic with combustions systems that are incompatible with SVO. As SVO thickens at colder temperatures, its blending with diesel has been problematic. However, characteristics of SVO are particular to the choice of oilseed and different types of plant oil are known to affect engine performance differently.

Advanced Fuels – "Second Generation Fuels"

As the most abundant biological material on Earth, cellulosic biomass such as wood, tall grasses, and forestry and crop residues are projected to greatly expand the quantity and variety of feedstock available for biofuel production. In comparison to the conventional starch and oilseed crops that can contribute only a fraction of the plant material towards biofuel production, cellulosic energy crops can produce more biomass per hectare of land since the entire crop is available as feedstock for conversion to fuel, and can be grown on land that is not prime agricultural land.

Second generation liquid biofuels are attractive from a sustainability standpoint for a number of reasons. By using cellulosic biomass, fossil fuel use is displaced by feedstock that is not directly competing with its use for food production. Waste biomass can be used, which would not require additional land for production as it is readily available from present forests and agricultural land uses and would otherwise decompose. However, it is important to consider that decomposing biomass plays a crucial role in maintaining soil fertility and texture. Excessive withdrawls for bioenergy use could have negative effects. Additionally, the greatest potential for reducing GHG emissions lies in the development of advanced second-generation feedstock and biofuels (See Figure 2.1 in chapter 2). Most studies project that future, advanced fuels from perennial crops, woody and agricultural residues could dramatically reduce life cycle GHG emissions relative to petroleum fuels. Some options hold the potential for net emissions reductions that exceed 100 percent — meaning that more CO_2 would be sequestered during the production process than the equivalent emissions released during its life cycle — if fertilizer inputs are minimized, and biomass or other renewable sources are used for process energy.[31] In addition, fast-growing perennials such as short-rotation woody crops and tall grasses can

[31] Lew Fulton et al., Biofuels for Transport: An International Perspective, Paris, International Energy Agency, 2004), pp. 61-62; Eric D. Larson, Liquid Biofuel Systems for the Transport Sector: A Background Paper, Draft for discussion at the Global Environment Facility Scientific and Technical Advisory Panel Workshop on Liquid Biofuels, New Delhi, 29 August – 1 September 2005; Mark A Delucchi, Research Scientist, Institute of Transportation Studies (ITS), University of California at Davis, e-mail to Janet Sawin, Worldwatch Institute, 10 March 2006; and Delucchi, A Multi-Country Analysis of Lifecycle Emissions from Transportation Fuels and Motor Vehicles (Davis, CA: Institute of Transportation Studies, University of California at Davis, May 2005), p. 44, all cited in Worldwatch Institute, Biofuels for Transport: Global Potential and Implications for Energy and Agriculture (London: Earthscan, 2007), chapter 11

grow on a wide variety of soils and often so, on poor, degraded soil where production of food crops is not optimal due to erosion concerns and other limitations.

Due to its tensile strength, cellulose biomass is harder to break down for conversion to liquid fuels. However, this property makes it more robust for handling, reducing costs for maintaining biomass quality compared to food crops. Additionally, storage is easier for cellulosic biomass as it resists deterioration, especially when compared to sugar-based crops. Cellulosic biomass can often be bulky and require developed transportation infrastructure to deliver it to processing plants after harvest. Loss of dry cellulosic biomass (and hence energy content) during the harvest and transportation process if moisture content and exposure to oxygen are kept at a minimum in order to retard decomposition. [32]

Cellulosic biomass is made up of three main constituents: cellulose, hemicellulose and lignin. Cellulose is a robust molecule formed of long chains of glucose. Hemicellulose, with comparatively less carbon content than cellulose, is easier to break down with heat or chemicals. Lignin is responsible for providing the rigidity to the structure of plants and trees. Different plants and trees can have varying mixes of these three components, with a typical range of 40 to 55 percent cellulose, 20 to 40 percent hemicellulose and 10 to 25 percent lignin.[33]

Production of biofuels from cellulosic feedstock uses a variety of technologies that target different components of the biomass. As cellulosic biomass is more resistant to being broken down when compared to starch, sugar and oils, the difficulty of converting it into liquid fuels inherently makes the conversion technology more expensive even though the cost of the cellulosic feedstock itself is lower than for current, first-generation feedstock. The two primary methods of procuring liquid fuels and energy from cellulosic biomass are *thermo-chemical conversion* and *biochemical conversion*.

The most common thermo-chemical conversion process used to developed advanced fuels currently includes *gasification* and *Fischer-Tropsch (F-T) synthesis*. In gasification, biomass is converted to synthesis gas, or 'syngas' (see Biomass for Heat and Power) that contains carbon monoxide, carbon dioxide, hydrogen and methane. Syngas can be converted to an assortment of fuels such as hydrogen, bioethanol (dimethyl ether, DME) as well as synthetic diesel and synthetic gasoline. The gasification pathway converts all of the biomass into syngas which can be converted into liquid fuel, thereby producing more fuel per ton of biomass.[34]

Hydrolysis is a form of biochemical conversion for transforming biomass into liquid fuel. Hydrolysis can convert biomass to bioethanol by using acids that break the bonds of the larger cellulose molecule to form smaller sugar molecules ready for fermentation. The process is currently expensive and a drawback of using it for cellulosic feedstock is the low fuel yield

[32] International Energy Agency (IEA), Good Practice Guidelines, Bioenergy Project Development and Biomass Supply, March 2007

[33] Worldwatch Institute, Biofuels for Transport: Global Potential and Implications for Energy and Agriculture, London: Earthscan, 2007, chapter 4

[34] Darmouth College and Natural Resources Defense Council (NRDC) The Role of Biomass in America's Energy Future (RBAEF), Sponsored by DOE, the Energy Foundation and the National Commission on Energy Policy, (available at http://engineering.dartmouth.edu/other/rbaef/index.shtml)

caused by the over-disintegration of the hemicellulose sugar before fermentation. Hydrolysis using enzymes and microbial digestion is also currently being developed that look to optimize sugar extraction from cellulose and hemicellulose.[35]

Pyrolysis, a process that heats biomass in anoxic conditions, although well-established in small plants, has yet to be used on a large scale. Pyrolysis can be classified as conventional, fast or flash depending on the temperature, heating rate, particle size and solid residence time of the process. Fast pyrolysis of biomass yields a liquid product called pyrolysis oil or bio-oil that can readily transported and stored. Most forms of cellulosic biomass maybe used as pyrolysis input. In laboratory conditions, nearly 100 types of plant biomass have been tested such as agricultural wastes (straw), olive pits, nut shells, forestry wastes such as bark and thinnings.[36] However, large scale pyrolysis facilities are yet to be developed and in most instances, it may be desirable to use a combination of different conversion methods for different types of biomass in one production facility in order to optimize and regulate the amount of required process energy.

Algae

Micro-algae are unicellular aquatic plants that produce vast amounts of plant oil that can be used for the sustainable production of biodiesel. Although categorized currently as a first-generation feedstock due to conventional conversion technologies used for its processing, algae holds great potential as a prolific next-generation feedstock with its long-term economic capacity yet to be tested. Microalgae can be cultivated in a wide variety of conditions ranging from arid regions with poor soil quality, to salt water and water from polluted aquifers.[37] The per hectare yield is estimated to be many times greater than tropical oil seeds.

The primary necessities of algae production are carbon dioxide and nitrogen oxide (NO_x), which creates the opportunity for the development of integrated systems where micro-algae are 'fed' by the emissions of coal, petroleum and natural gas power plants. In recent developments, the Massachusetts Institute of Technology (MIT) has demonstrated a new technology for utilizing micro-algae to absorb power plant emissions. Large enough algal colonies could reduce NO_x levels by about 80 percent and CO_2 by 30 to 40 percent, while simultaneously producing raw plant oil for its use in producing bioenergy.[38] Species of algae that are optimal for such functions, have the capacity to produce 40 to 50 percent oil by weight.[39] The economics of algae as an energy feedstock are still challenging, however recent research and innovation are like to make algae a cost-effective option in the future.[40]

Future Biofuel Production: The 'Biorefinery Concept'

A 'biorefinery' is a conceptual model for future biofuel production where both fuels and high value co-product materials are produced. Akin to chemicals produced in petroleum refineries, biorefineries would simultaneously produce biofuels as well as bio-based chemicals. Fuels would represent the bulk of total biorefinery production, while chemicals and other materials

[35] Mark Laser and Lee Lynd (2006) Report to Worldwatch Institute, Mark Laser and Lee Lynd, Thayer School of Engineering, Dartmouth College, 13 January 2006. as cited in Worldwatch Institute, Biofuels for Transport: Global Potential and Implications for Energy and Agriculture (London: Earthscan, 2007), chapter 5
[36] Mohan. Dinesh, Chalres U. Pittman, Jr., and Philip H. Steele, Pyrolysis of Wood/Biomass for Bio-oil: A Critical Review. American Chemical Society. March 10, 2006
[37] John Sheehan et al (1998) A Look Back at the US Department of Energy's Aquatic Species Program: Biodiesel from Algae, Golden, CO, NREL.
[38] 'Algae – like a breath of mint for smokestacks', USA Today, 10 January 2006;
[39] Ibid.
[40] Sheehan et al, op cit. note xxxii

would generate the bulk of the profits.[41] A limited market exists for organic chemicals that are currently considered high-value, 'specialty' products and are processed in separate plants. Biorefineries would present more economical option where bio-based chemicals are co-products of liquid fuel.

Future biorefineries would be able to mimic the energy efficiency of modern oil refining through extensive heat integration and co-product development. Heat that is released from some processes within the biorefinery could be used to meet the heat requirements for other processes in the system. This is already being done in some bioenergy production facilities.

Advanced Fuels Outlook

Conversion of cellulosic biomass into advanced fuels is likely a decade or two away from contributing a significant proportion of the world's liquid fuels. Currently there are a number of pilot and demo plants either operating or under development around the world. Biochemical and thermochemical conversion pathways are likely to expand commercially in the next 8 to 15 years depending upon the speed and success of pilot projects currently underway, sustained research funding, and other support from governments over this period, as well as world oil prices and private sector investment. The emergence of cellulosic biofuels as the forerunner of liquid fuels will also depend greatly on government support provided to risk-averse investors to build cellulosic-conversion facilities. This is especially crucial as compared to conventional biofuel plants, large capital expenditures are inherent in building new cellulosic fuel plants and investors lack guarantees that advanced fuels will remain competitive in the long-run due to high petroleum prices. Even though next generation fuels may very well be cheaper than gasoline if petroleum prices remain consistently high, in the near future, they are still likely to remain more expensive than conventional first-generation production technologies. Even though it is likely to take many years before cellulosic fuel can compete with conventional fuels, in the near future they could supply a growing share of the global fuel mix.

Biohydrogen

Biomass can be converted into biohydrogen (that is the first step of the biogas production). Biohydrogen can have better energy efficiency than biogas in end use in fuel cell technology. Another interesting route to biohydrogen is the water photolysis assisted with bio-organisms and solar radiation. Extracting hydrogen from biomass is a long term option. Basic research and development projects are still needed to move towards commercialized industrial processes.

1.2.3 Bioenergy Trade

Bioenergy trade is expected to become more important in the next decades driven by sustained high and increasing fossil fuel prices, concerns regarding domestic energy security, and the

[41] Worldwatch Institute, Biofuels for Transport: Global Potential and Implications for Energy and Agriculture, London: Earthscan, 2007, chapter 5

goal to create a diversified energy supply mix and a consequent strong political motivation to enhance bioenergy and other renewables. Most producers of transport biofuels today are producing for domestic use. However, world bioethanol trade over the last few years has been growing substantially and is projected to continue increasing in the coming years. (See also section Import/Export Trends).

Some processed biomass trade is occurring, indicating prospective growth in the world market for biomass for energy production. International trade of wood pellets has occurred in several countries in the EU including Sweden, Netherlands and nations of the Baltic Sea. The major trade flows over the last few years have occurred from Estonia, Latvia, Lithuania and Poland to Sweden, Denmark, Germany and Netherlands. Austria remains the strongest trader in Central Europe.

Swedish imports of biomass in 2003 were estimated to be between 18 to 34 PJ.[42] Sweden imported tall oil and pellets from North America and the Baltic States, pellets and logging residues from Belarus, and MSW and recovered wood from mainland EU. Additionally, Canada and Finland exported approximately 350 000 tonnes of pellets to Sweden in 2003.[43] The Netherlands imported an estimated 1.2 million tonnes of biomass for use in power plants. These included palm kernel shells (residue from palm oil production) from Malaysia and wood pellets from other EU nations.[44] According to the IEA, these examples and various analyses show that biomass can be economically transported over longer distances, provided that transport occurs in bulk (such as by train or ship), and that biomass can be increased in density to reduce its volume and make transport more cost-effective.

While biomass tends to be quite bulky, it can be densified to make transport more efficient. Compact, densified biomass can take the form of wood pellets, charcoal briquettes and manufactured logs that can be readily fed into a combustion system. Pellets can be made from dehydrated wood wastes, waste paper and agricultural residues that can be mechanically compressed into a product that has less than one-third the original volume.[45]

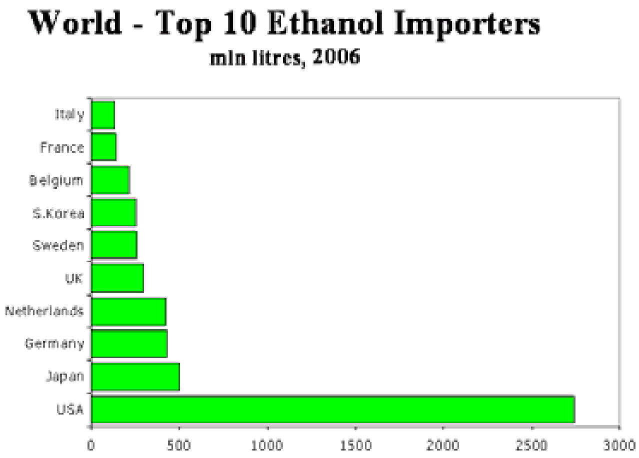
Import/Export Trends[46]

The volume of bioethanol traded worldwide grew to around 7.814 billion litres in 2006, compared with 5.9 billion in 2005 and 3.2 billion in 2002. The rise was mostly attributed to the noticeable increase in trade reported in Brazil when 2006 exports reached 3.5 billion litres, up 0.9 billion litres from 2005, a threefold increase over 2002 figures. Record alcohol prices resulted as China shipped more than 1 billion litres in 2006, mostly in response to higher demand in the United States. Despite record levels of shipments from Brazil, the world market share of the North and South America remained 60 percent, while Asia-Pacific gained market

[42] available at http://www.bioenergytrade.org/downloads/t40opportunitiesandbarriersforbioenergytradefi.pdf and http://www.bioenergytrade.org/downloads/schlamadingeretal.optionsfortradingbioenergy.pdf and EUBIONET Biomass EU trade summary
[43] Ibid.
[44] Ibid.
[45] Cornell U. (available at http://www.grassbioenergy.org/downloads/Bioenergy_Info_Sheet_7.pdf)
[46] Global ethanol and biodiesel trade flow and trend data obtained from analyst F.O. Licht's World Bioethanol and Biofuels Report.46

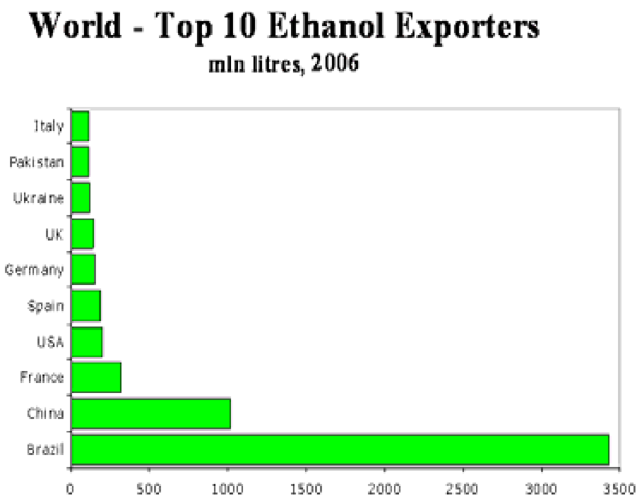
footing to 17 percent, up 7 percent from 2005. European exports accounted for less than 20 percent of the world market while Africa contributed 4 percent of all bioethanol shipments. Analysts estimate that United States' bioethanol import demand is unlikely to be as strong in 2007 in comparison to the year before. In comparison Brazil sales are projected to reach approximately 3.8 to 3.9 billion litres in 2007. Figure 1.5 and Figure 1.6 show the top 10 bioethanol importers and exporters in 2006. Table 1.2 and Table 1.3 summarize world bioethanol imports and exports from 2002 – 2006 by region.

Figure 1.5



Source: F.O. Licht

Figure 1.6



Source: F. O. Licht

North and South America

An ethanol deficit on the United States market and record sugar cane production between 2005-2007 resulted in an all time high in Brazilian bioethanol exports. In 2006, Brazil's total shipments amount to over 3.4 billion litres compared to 2.6 billion litres in 2005 and 800 million litres in 2002. Additional dehydration capacity being developed in Central America and the Caribbean due to the Caribbean Basin Initiative (CBI) is likely to contribute towards the United States' duty-free import quota. According to analyst F.O. Licht, CBI countries will be allowed to ship 1.3 billion litres of duty free alcohol this year compared with 1.015 billion in 2006. In 2006, total imports from CBI countries in the CBI Group amassed to 780 million litres or 77 percent of the total tariff rate quota which was an improvement of 43 percent in 2005 and 37 percent in 2004.

European Union

Total exports from the EU rose to 1.31 billion litres in 2006. France continued to be the largest European exporter with a total of 320 million litres. Spain was the second largest in 2006 with a more than fivefold increase of shipments to almost 190 million litres due to domestic oversupply. Germany was the largest importer of bioethanol in 2006 with 430 million litres. With a trend of growing imports and the largest gasoline market, Germany is likely to develop into the most active bioethanol consumer in the coming years. In 2002, Germany's imports were 200 million litres with exports of 69 million litres and in 2005 the shipments and increased to 150 million litres. Sweden also realized a growth in its bioethanol imports with total 2006 arrivals of 257 million litres in 2006, compared to 169 million litres the year before.

Asia-Pacific

In 2006, Asian exports doubled to 1.3 billion litres from 615 million litres in 2005. This surge was mostly attributed to a six-fold increase in Chinese shipments which reached 1.02 billion litres in 2006, compared to 162 million litres in 2005. Pakistan was the next largest exporter with bioethanol shipments of around 116 million litres. The largest importers in Asia for 2006 were Japan with 500 million litres, and South Korea whose imports reached a record high of 252 million litres compared to 242 million litres in 2005.

Table 1.2 - World Bioethanol Imports 2002-2006 (billion litres)

	Year				
Country/Region	2002	2003	2004	2005	2006
Total Americas	0.86	1.32	1.59	1.57	3.72
Total Africa	0.09	0.1	0.16	0.22	0.15
E.U.	1.05	1.13	1.60	2.00	2.36
Asia	0.86	0.86	1.25	1.55	1.05
World	2.86	3.40	4.62	5.35	7.29

Table 1.3 - World Bioethanol Exports 2002-2006 (h litres)

Country/Region	Year 2002	2003	2004	2005	2006
Total Americas	1.48	1.57	3.20	3.54	4.66
Total Africa	0.18	0.2	0.17	0.38	0.33
E.U.	0.90	1.09	0.98	1.26	1.31
Asia	0.58	0.84	0.50	0.61	1.34
World	3.22	3.81	4.96	5.93	7.81

Most of the reviewed biomass products are mainly consumed locally in the countries where they were produced, but in the case of products such as sawn timber, paper and paperboard, palm oil and wood pellets, remarkable shares of the total production are exported.

Table 1.4 - An overview of world biomass production and international trade in 2004

Product	World Production in 2004	Volume of international trade in 2004
Industrial wood and forest products		
Industrial round wood	1 646 Mm^3	121 Mm^3
Wood chips and particles	197 Mm^3	37 Mm^3
Sawn timber	416 Mm^3	130 Mm^3
Pulp for paper production	189 Mt	42 Mt
Paper and paperboard	354 Mt	111 Mt
Agricultural products		
Maize	725 Mt	83 Mt
Wheat	630 Mt	118 Mt
Barley	154 Mt	22 Mt
Oats	26 Mt	2.5 Mt
Rye	18 Mt	2 Mt
Rice	608 Mt	28 Mt
Palm Oil	37 Mt	23 Mt
Rapeseed	46 mt	8.5 Mt
Rapeseed oil	16 Mt	2.5 mt
Solid and liquid biofuels		
Ethanol	41 Mm^3	3.5 Mm^3
Biodiesel	3.5 Mt	<0.5 Mt
Fuel wood	1 772 Mm^3	3.5 Mm^3
Charcoal	44 Mt	1 Mt
Wood pellets	4 Mt	1 Mt

Source: FAOSTAT. 2006. On-line database of FAO (available at http://faostat.fao.org/)

2 Policy Overview

Bioenergy markets are largely policy driven in most of the world, therefore decision makers today need a thorough understanding of: government priorities; the forces driving bioenergy development; the policies that are being used and what impacts they are having (both intended and unintended) on the market, socially and environmentally; and what related policies (agricultural for example) are influencing biofuels markets. Governments are trying to understand and weigh the pros and cons of various bioenergy options and begin to deal with the environmental and social implications.

This chapter provides an overview of national policies influencing bioenergy development, and outlines the sustainability issues and strategies for ensuring that production can be sustained over time. It summarizes the current policy situation related to bioenergy trade and highlights regional policies which impact bioenergy industries. Section 2.6 details bioenergy production and consumption in the G8 +5 Countries, and the chapter ends with main conclusions on the policies and implementing mechanisms used by the G8 +5 Governments.

2.1 Key Drivers

There are four key factors driving interest in bioenergy: rising energy prices, in particular oil prices; energy security; climate change; and rural development.

2.1.1 High Energy Prices

Soaring energy costs, especially oil prices, are motivating nations to find energy alternatives for their transport, heat and power sectors. In 2006, oil prices rose for a fourth consecutive year as a result of increasing global demand, and production declines in many nations – in some of them due to political disruptions. To appreciate the speed with which prices rose during only a few years, one needs to consider that the average price of oil was $62 per barrel in 2006, $58 per barrel in 2005, $52 per barrel in 2004, $32 per barrel in 2003, and $27 per barrel in 2002.[47] In September of 2007, oil prices peaked at over $80 per barrel, not far from the record inflation adjusted price of $90 per barrel in 1980.

2.1.2 Energy Security

A second driver of bioenergy growth is the aim of many nations to reduce their vulnerability to price increases and supply disruptions thereby increasing their energy security. Increased oil and gas prices are putting great strain on national budgets in import-dependent nations. Bioenergy is seen as a key mean of diversifying energy supplies and reducing dependency on a few exporters of oil and natural gas.

[47] 2005 price from Janet Sawin and Ishani Mukherjee, Worldwatch Institute, 2007, “Fossil Fuel Use Up Again”; 2004 and 2003 prices from Janet Sawin and Ishani Mukherjee, Worldwatch Institute, 2006, “Fossil Fuel Use Continues to Grow”; 2002 price from Energy Information Administration, Spot Prices (available at http://tonto.eia.doe.gov/dnav/pet/pet_pri_spt_s1_a.htm)

In European G8 Countries, for example, dependence on natural gas from Russia is seen as a serious energy security risk, and Japan is working to develop ethanol imports as a means of energy source diversification. The United Kingdom is facing the depletion of its North Sea oil fields in the next two decades, as well as reductions in natural gas yields. China also views biomass as a means of increasing energy security.

2.1.3 Climate Change

The third factor driving bioenergy development relates to the commitments of nations to reduce their GHG emissions to mitigate global climate change. There is a small, but growing group of nations working towards GHG neutrality and many are incorporating bioenergy as a key element of their efforts to develop new economic models based on low-carbon emissions. Also of note is that in a March 2007 Council Decision, the EU committed to a 20 percent GHG reduction by 2020.

As described in Section 2.4.1, depending on the feedstocks and production pathways chosen, and future advancements in processing technology, energy derived from biomass to produce power, heat and fuels for transport has the potential to significantly reduce life-cycle GHG emissions when compared to fossil fuels – and at costs which could well become lower than various other GHG reduction options (e.g., solar PV).

2.1.4 Rural Development

A fourth key driver in many contexts is the potential for rural development and especially the revitalization of agricultural sectors. Although it is still unclear how resource poor farmers might participate in bioenergy schemes, biomass energy systems could contribute to maintaining employment and creating new jobs in rural areas, avoiding land abandonment and reducing in-country migration to cities. New crop types, improved farming practices and the ability to use agricultural and forestry residues provide the potential for new and diversified income streams for farmers and landowners. Local production and use of modern bioenergy could contribute to rural development and poverty alleviation, if countries establish a favourable context.

2.1.5 Other Drivers

Air Pollution

Burning biomass with modern technologies or using liquid biofuels in engines may result in lower emissions of regulated air pollutants compared to the use of fossil fuels. For example, solid biomass and liquid biofuels results in minimal emissions of sulphur oxides (SOx), which in turn results in lower particulate matter (PM) emissions. Use of biofuels as liquid fuel oxygenates can reduce emissions of carbon monoxide (CO, an ozone precursor), and control pollutants contributing to photochemical smog. Biofuels also have lower emissions of heavy metals as well as a number of carcinogenic substances. Furthermore, biofuels can be used to replace lead in gasoline. Still, liquid biofuels such as ethanol can increase emissions of volatile organic compounds (VOC) if not controlled properly in car tanks, and fuelling stations.

Soil Protection and Land Reclamation

Growing biomass feedstocks can help restore degraded land and reclaim land through the use of energy crops for bioremediation. Short rotation woody crops and other perennials can also be used for recovering abandoned lands and restoring their ecological functions, increasing soil cover and organic content of soils, thus increasing water retention and carbon stocks.

Residues and Waste treatment

Hundreds of million tons of residues and wastes are produced every year. Even after considering other uses of some of these, such as animal feed, compost, traditional energy and other industrial uses, there is still a significant resource which can be used, and in many cases needs to be disposed of in an environmentally sound way. In dry climates, recovery of residues from logging and thinning could reduce fire risks in forests. Straw, rice husk, sawdust, bark, animal wastes, black liquor, bagasse, pruning and thinning residues, municipal solid wastes and many other wastes, can be used as source of energy. For example, in the EU, recovery of energy from the biodegradable fraction of municipal solid waste could be a valuable means for reducing the volume of wastes sent to landfill, as required by the Landfill Directive. Increasingly strict waste legislation in many industrialized countries and increasing urbanization in developing countries will lead to waste treatment becoming a stronger driver for bioenergy production.

2.1.6 Objectives Stated in Country Policy Frameworks

Table 2.1 summarises the key objectives as stated in the main policy documents of the countries considered in this report.

Table 2.1 - Main Objectives of Bioenergy Development[A]

Country	Objectives						
	Climate Change	Environment	Energy Security	Rural Development	Agricultural Development	Technological Progress	Cost Effectiveness
Brazil	X	X	X	X	X	X	
China	X	X	X	X	X		
India			X	X		X	X
Mexico	X	X	X	X		X	
South Africa	X		X	X			
Canada	X	X	X			X	
France	X		X	X	X		
Germany	X	X		X	X	X	X
Italy	X		X		X		
Japan	X	X			X	X	
Russia	X	X	X	X	X	X	
UK	X	X	X	X			X
US		X	X	X	X	X	
EU	X		X	X	X	X	

[A] As stated in country summaries and key policy documents

Energy security and climate change are the most important objectives and nearly all countries report these as drivers of their bioenergy development activities. No country highlights less than three key objectives. This renders successful bioenergy development a challenge as it tries to reach multiple goals, which are not always compatible. For instance, energy security considerations favour domestic feedstock production (or at least diversified suppliers), whereas climate change considerations and cost-effectiveness call for sourcing of feedstocks with low emissions and costs, and for G8 Countries this often means importing feedstocks and/or fuels from developing countries.

Overall there are few differences between the policy objectives of G8 Countries and the +5 countries. Rural development is more central to the +5 countries' focus on bioenergy development, and this is often aligned with a poverty alleviation agenda. Bioenergy development is also seen as an opportunity to increase access to modern energy, including electrification, in rural areas. The rural development objectives of the wealthier G8 Countries focus more on rural revitalization. Similarly, in the +5 countries, agricultural objectives envisage new opportunities not just for high end commercialised energy crop production, but also for poorer small scale suppliers.

2.2 Overview of Bioenergy Policies Across Countries

Current policies are strongly influencing bioenergy production levels, production methods and types of bioenergy carriers and feedstocks in a number of countries. Support policies for different forms of bioenergy take different forms, the most prevalent of which are outlined below, followed by a brief overview of other related policy areas that influence bioenergy production and use, as well as a discussion of patterns, similarities and differences between the objectives set by countries and the policy instruments developed. (For summaries of individual country policy situations related to bioenergy, see Annex I.)

2.2.1 Direct Bioenergy Policies

Key Policy Mechanisms

Feed-in Tariffs – Pricing: A feed-in tariff is a regulatory, minimum guaranteed price per kWh that an electricity utility is obliged to pay to private producers of renewable power that is fed into its existing grid. A feed-in tariff could also refer to the total payment per kWh received by an independent producer of renewable power, including any production subsidies and/or refunds from taxes. In a few cases, a feed-in tariff signifies only the premium paid over and above the market price of electricity.[48]

Feed-in tariffs can be based on the 'avoided costs' of the non-renewable power producers or the utility price charged to the consumer, supplemented by a premium to account for the socio-environmental benefits of renewable electricity. In some countries, feed-in tariffs are differentiated depending on the renewable technology used (i.e. wind, solar, biomass, etc.). Additionally, the system of setting these tariffs can be either fixed in order to provide long-term certainty of investment to renewable energy producers or, they can be periodically adjusted to allow for flexibility in the event of unforeseen costs.[49]

Feed-in tariffs are currently the world's most widespread national renewable energy policy instrument[50] and are in use in over half of the G8 +5 Countries. Feed-in tariffs encourage investment in renewable energy production generally and in bioenergy when focused on bioenergy, but may result in higher electricity prices. However, transaction costs can be lower

[48] Monthorst, P. E. (1999), "Policy Instruments for Regulating the Development of Wind Power in a Liberated Electricity Market", in: Larsen, G., K. Westermann, and P. Noergaard, eds. (1999), Contributions from the Department of Wind Energy and Atmospheric Physics to *EWEC '99 in Nice France,* Riso National Laboratory, Roskilde, Denmark, pp. 7-12.; Haas, R., T. Faber, J. Green, M. Gual, C. Huber, G. Resch, W. Ruijgrok, and J. Twidell (2001): Promotion Strategies for Electricity from Renewable Energy Sources in EU Countries, Institute of Energy Economics, Vienna University of Technology, Austria.; Huber, C., T. Faber, R. Haas, and G. Resch (2001): *Promoting Renewables: Feed-In Tariffs or Certificates*, IEW 2001, Institute of Power Systems and Energy Economics, Vienna University of Technology, Vienna, all cited in Sijm, J.P.M., The Performance of Feed-in Tariffs to Promote Renewable Electricity in European Countries. November 2002, Energy Research Center of the Netherlands (ECN) (available at http://www.ecn.nl/docs/library/report/2002/c02083.pdf)

[49] Sijm, J.P.M., The Performance of Feed-in Tariffs to Promote Renewable Electricity in European Countries. November 2002, Energy Research Center of the Netherlands (ECN) (available at http://www.ecn.nl/docs/library/report/2002/c02083.pdf)

[50] Rickerson, Wilson, and Robert C. Grace. "The Debate over Fixed Price Incentives for Renewable. Electricity in Europe and the United States: Fallout and Future Directions." A White Paper Prepared for The Heinrich Böll Foundation. February, 2007.

due to the fact that feed-in tariffs create a guaranteed price for renewable energy, which often significantly reduces the time necessary to negotiate a power purchase agreement.

The main criticism of feed-in tariffs has been their shortcoming in ensuring minimum-cost electricity generation and to foster innovations. But some G8 Countries use dynamic feed-in tariffs and offer specific tariff elements for innovations to address that problem.

The cost of this policy is generally paid by utilities that then pass the cost on to consumers. In China, however, there is an explicit cost sharing policy which spreads the costs between the utilities and the customers.

Taxes: A variety of tax incentives and penalties are used by governments to foster bioenergy development. Taxes are one of the most widely used bioenergy support instruments. Taxes have a dramatic affect on the cost competitiveness of bioenergy vs. substitutes, and therefore dramatically impact their viability in the marketplace. In theory at least, taxes can be gradually increased or decreased as markets evolve. Governments either forgo some tax revenue – in the case of tax breaks – or gain revenue, from added taxes on competing, non-renewable fuels, or on CO_2 emissions from competing fuels for example. If net revenue flows into government coffers are decreased, it is ultimately tax payers who pay the cost. Using tax breaks for bioenergy can be quite costly. Another downside is that tax policy can be difficult politically to modify. However, all of the European countries and several of the other G8 +5 Countries have started gradually abolishing tax breaks they have been offering to promote biofuels, and are moving to obligatory blending.

Guaranteed Markets - Renewable Energy and Fuel Mandates, Preferential Purchasing: National targets and public incentive systems are key drivers in the development and growth of most modern bioenergy industries, in particular in liquid biofuels for transport. Russia is the only country among the G8 +5 Countries that has not created a transport biofuel target. Voluntary quota systems or targets are common for biomass energy for heat, power and transport fuels in the G8 Countries, however, blending mandates enforceable via legal mechanisms are becoming increasingly utilized. Blending targets are less common in the +5 countries, although Brazil has a mandatory ethanol blending requirement, India is creating mandatory transport biofuel targets, and Mexico and China seem to be moving towards bioenergy targets (see Table 2.2).

The distinction between voluntary and mandatory is critical since voluntary targets can be influential, but do not have the impact of legally binding mandates. This was evident in the EU, for example, when all but two of the EU member countries failed to achieve the voluntary biofuels for transport blending target of 2 percent by 2005.

Other means of guaranteeing a market for bioenergy have been commonly used by the G8 +5 Governments and have proven to be powerful tools where properly implemented. For example, renewable portfolio standards (RPS) for bioelectricity and blending mandates for transport biofuels have proven highly effective in stimulating production. In comparison to feed-in tariffs which offer a long-term, fixed price payment to renewable energy generators, an RPS seeks to create price competition between renewable energy generators to meet defined targets at the lowest cost. (A maximum cost is typically set through a price cap instrument.)[51] With blending mandates, the cost is carried by the industry and consumers. Governments do not need to provide direct funding.

In a few countries, green certificates have been created so that utilities can buy and sell them if they have renewable energy generation in excess of the mandate or if they cannot meet the mandated level. In Italy for example, electricity suppliers can generally fulfill the obligation by buying green certificates from authorized new renewable energy plants, by building new renewable energy plants, or by importing electricity from new renewable energy plants from countries with similar instruments on the basis of reciprocity.

Preferential purchasing by governments can also be a powerful tool when considering the purchasing power of governments. The Canadian Government, for example, committed to purchasing 20 percent of its electricity from renewable energy sources. The importance of effective implementation of purchasing practices is highlighted by the United States' experience with a federal preferential bio-products purchasing policy that has been implemented very slowly.

[51] Rickerson, Wilson, and Robert C. Grace. "The Debate over Fixed Price Incentives for Renewable. Electricity in Europe and the United States: Fallout and Future Directions." A White Paper Prepared for The Heinrich Böll Foundation. February, 2007.

Table 2.2 - Voluntary and Mandatory Bioenergy Targets for Electricity, Heat and Transport Fuels

Country	Targets (M= mandatory; V= voluntary)		
	Electricity	Heat	Transport Fuels
Brazil	Inclusion of 3.300 MW of energy into National Energy Grid supplied in equal amounts from wind, biomass and small hydroelectric is required (M)	no targets	mandatory blend of 20 to 25% anhydrous ethanol w/ gasoline; minimum blending of 2% (B2) biodiesel to diesel by 2008 and 5% (B5) by 2013
China	China is finalizing a revised target for 16% of primary energy from renewables by 2020, including large hydro, plans include a target for 30 GW of biomass power by 2020	no targets	15% of its transportation energy needs through use of biofuels by 2020
India	no targets	no targets	A 5% blending mandate for ethanol will be established before end of 2007, and Planning Commission proposed to raise mandate to 10%. Regarding biodiesel, Committee for the Development of Biofuels has decided 20% of diesel consumption as blending target for 2011/2012.
Mexico	>1,000 MW of RES by 2006 (M)	no targets currently, (targets under consideration)	Regarding biodiesel, Committee for Development of Biofuels has decided 20% of diesel consumption as blending target for 2011/2012.
South Africa	4% by 2013 (V)	No targets	up to 8% by 2006 (V), (10% target under consideration)
Canada	no targets	no targets	5% renewable content in gasoline by 2010 & 2% renewable content in diesel fuel by 2012
France	21% RES by 2010 (M)	50% increase from 2004 until 2010 in heat from RES (M)	5.75% by 2008, 7% by 2010, 10% by 2015 (V); 10% by 2020 (M =EU target)

Germany	12.5% by 2010, 20% by 2020 (M)	no targets	6.75% for 2010, which is set to rise to 8% by 2015; 10% by 2020 (M =EU target)
Italy	25% by 2010 (V)	no targets currently, (targets under consideration)	5.75% by 2010 (M); 10% by 2020 (M =EU target)
Japan	biomass power generation & waste power generation in the amount of 5,860,000 kl, as converted to crude oil, by 2010 (V)	biomass thermal utilization in the amount of 3,080,000 kl (this amount includes biomass-derived fuel – 500,000 kl – for transportation), as converted to crude oil, by 2010 (V)	500,000 kl, as converted to crude oil, by 2010 (V)
Russia	No targets in place, considering a 7% RES target by 2020	no targets	no targets
UK	10% by 2010, 15.4% by 2016 (M)	> 10,000 MWe of installed combined heat and power (CHP) capacity by 2010 w/ > 15% of government buildings using CHP	5% biofuels by 2010 (M); 10% by 2020 (M =EU target)
US	no targets	no targets	7.5 billion gallons (28 billion liters) by 2012 including 250 million gallons from cellulosic biomass (M); Mandatory Fuel Standard of 35 billion gallons (132.5 billion litres) of "alternative fuels" which includes biofuels by 2017, roughly equivalent to 15% of annual U.S. gasoline use
EU	20% RES as overall target for all Member States by 2020 (M)	no targets	10% by 2020 (M =EU target)

RES= Renewable Energy Source

Compulsory Grid Connections: Compulsory grid connection policies for renewable energy producers – or specifically bioenergy producers in some cases – are in place in less than half of the G8 +5 Countries. The EU countries and China, Mexico and Japan require that utilities grant access to the grid system to private renewable energy producers. (see Table 1.2.4.1). This is a policy tool for overcoming the grid access barrier that is common for small and/or private energy producers. By itself, it is not a critically important policy, and often it is paired with feed-in tariff policies or other policies requiring that utilities compensate renewable energy producers appropriately.

Other Direct Support: Governments issue grants, loan guarantees, subsidies and other forms of direct support for bioenergy production and use systems. It is common for state/province or local governments wanting to create jobs and economic activity to give incentives for building bioenergy production plants in their area. Direct supports are used in a number of G8 Countries to help accelerate the commercial development of second generation biofuels for transportation.

Most countries are using some form or forms of direct loan or grant supports. Direct financial supports have the advantage of easily quantified results, however, their outcomes tend to be limited to individual projects, as opposed to further reaching support instruments. These supports are generally paid for directly by governments.

Research, Development, & Demonstration (R,D,&D)

Basically all of the G8 +5 Governments are conducting research and development in their own laboratories and institutes and many are supporting public private partnerships and various forms of demonstration projects. Some governments fund companies to do bioenergy R&D. For example, the United States funded a private company to work to dramatically reduce the cost of advanced enzymes for second generation liquid transport fuel production. In addition to working on second generation liquid transport fuels, some countries are also working on Hydrogen as a transport fuel.

Bioenergy R&D has generally been aimed at developing technology for increasing conversion efficiency, identifying sustainable feedstock and developing cost-effective conversion methods for advanced fuels[52] however, the Canadian Government provides support for cross-sector research networks conducting scientific R&D on modeling and impact scenarios for a bio-based economy in Canada (see Canada summary in Annex II).

Publicly funded R&D produces information and technology that, in contrast to private sector R&D, is publicly available. The downside is that limited, and/or inconsistent budgets can be a problem for government research initiatives. Also, in some instances, losing top talent to higher paying private sector jobs is a problem. In the case of government sponsored R&D, obviously it is the government (and thus tax payers) who pays, but joint public-private R&D efforts are becoming more common where private companies contribute resources.

2.2.2 Indirect Policy

Bioenergy development is influenced by more than bioenergy-specific policies. This section will elaborate on the significance of policy measures in other policy arenas for bioenergy markets.

[52] Pacheco, Michael A., National Renewable Energy Laboratory (NREL), The National Bioenergy Center and Biomass R&D Overview. May 20, 2004. (available at http://www.nrel.gov/docs/gen/fy04/36831c.pdf)

Energy

In some countries, broader energy policies influence bioenergy. For example, phasing-out (subsidized) domestic coal - as in the United Kingdom and Germany - and phasing-out nuclear (as in Germany) indirectly favour bioenergy by restricting electricity generation choices.

General energy access policies, like Brazil's "Luz para todos" may indirectly encourage bioenergy production. The Chinese national renewable energy law, intended to significantly increase the overall production of renewable energy, will likely encourage investment in modern bioenergy.

Agricultural and Forestry Policy

Agricultural and forestry policies have had a significant influence on the bioenergy industry. In the United States and EU, the agricultural industries drove the development of bioenergy. Agricultural subsidies, for example, influence both the production levels of bioenergy feedstocks but also the price. In the EU, farmers are paid 45 €/ha/yr if they produce bioenergy crops. Agricultural policies also commonly influence production systems and methods of feedstock production, for instance through environmental provisions to ensure sustainable production methods and/or to control expansion of cropland into pristine areas. Many agricultural and forestry policies are oriented towards creating or maintaining domestic employment in these sectors. In Canada, for instance, there is a bioenergy initiative of the agriculture section of the government designed to provide an opportunity for agricultural producers to diversify their economic base and participate in the biofuels industry through equity investment/ownership in biofuels production facilities (see Canada country summary in Annex I for details). Agricultural policies have been subject to controversy, especially related to international trade issues. Agricultural supports can also be extremely expensive (see Table 2.1).

Climate Change Policy

All of the G8 +5 Countries except for the United States cite climate change as a motivation for their interest in bioenergy. Climate change policy is influencing bioenergy policy in a number of countries. Some blending mandates and other support policies have minimum life-cycle GHG reductions requirements for bioenergy to be counted towards the mandate, to receive the tax credit, and/or to receive other supports. This raises the challenge of developing and harmonizing GHG accounting methodologies for different bioenergy types and production systems. GBEP is in the process of developing a framework for the harmonization of methodologies in collaboration with outside partners.

The most important policy development related to bioenergy in the transport sector is the trend towards emissions results focused policy rather than bioenergy quantity goals. In the United Kingdom, for example, cars are now taxed based on their CO_2 emissions. In some states within the United States too, there are GHG reduction focused policy developments in the transport sector (see Text Box below). While there is still no national climate change policy, a lot of climate policy innovation which is happening at the state, region and local levels is having ripple effects throughout the country.

California's Low Carbon Fuel Standard

California is the fifth largest economy in the world[53] and is an acknowledged leader in environmental policy, a status enshrined in the United States Clean Air Act. Thus, it is not surprising that early in 2007, Governor Schwarzenegger signed an Executive Order that established a Low Carbon Fuel Standard (LCFS) for transportation fuels in California, calling for at least a 10 percent reduction in their carbon-intensity by the year 2020.[54] The LCFS is the first significant climate policy in the U.S. designed specifically to reduce GHG emissions from transportation fuels and to stimulate innovation in new, low-carbon fuels.[55] The LCFS requires fuel providing companies in the state to supply a mix of fuels that meet a declining standard of GHG intensity (measured in CO_2 grams per unit of energy in their fuel). Measured for lifecycle emissions of fuels, the LCFS includes all emissions from fuel consumption and all intermediate steps of processing and production. Furthermore, the LCFS will utilize market-based mechanisms to extend choices to suppliers for reducing emissions while responding to consumers. More specifically, fuel providers may buy and blend a low-carbon ethanol into gasoline products or purchase credits from power utilities supplying low-carbon electronic units for electric vehicle. A LCFS is currently under serious discussion in several American states and Canadian provinces, is part of several bills in the current United States Congress, and has been proposed for adoption in the EU.

The LCFS has potentially dramatic implications for the global bioenergy industry as it provides a substantive and broadly-supportive rationale for supporting bioenergy, along with a new focus on GHG emissions. This policy has the potential to both dramatically expand the bioenergy sector, induce major technological innovations, and allow the agricultural sector to be part of the solution to climate change.

Environment Policy

Environment policies are relevant to bioenergy in two key ways: on the one hand in providing support for bioenergy as a pollution reduction strategy, and on the other in regulating the bioenergy production and use practices. The promotion of bioenergy can be proposed as a measure in environmental policy, for instance in combating climate change by mandating blending targets for transport fuels to reduce overall GHG emissions from transportation. An example for environmental regulation of bioenergy practices is the requirement by the State Government of Sao Paulo to phase out the practice of burning the cane fields before harvest in order to reduce air pollution, and to directly control the environmental impacts of the bioenergy industry itself.

2.2.3 Cross-Country Overview of Key Policy Instruments

Countries not only state multiple goals for bioenergy development, they also employ a great variety of policy instruments to strengthen and shape the growth of bioenergy markets. Table 2.3 summarizes the key policy instruments used by the G8 +5 Countries in the context of their

[53] SJ Business Journal, "California now world's fifth-largest economy", June 15, 2001, (available at http://sanjose.bizjournals.com/sanjose/stories/2001/06/11/daily58.html)
[54] "Executive Order S-01-07: Low Carbon Fuel Standard" which is on a different URL on the Governor's website. Probably the most informative website to provide for the reader is the Air Resources Board site on the LCFS. (available at www.arb.ca.gov)
[55] "A Low Carbon Fuel Standard for California." (available at http://repositories.cdlib.org/its/tsrc/UCB-ITS-TSRC-RR-2007-2/ and http://repositories.cdlib.org/its/tsrc/UCB-ITS-TSRC-RR-2007-3/)

energy policy frameworks today and indicates some of the new policy instruments under development or awaiting approval.

Table 2.3 - Key Policy Instruments

Energy Policy								
Country	**Binding Targets/Mandates[1]**	**Voluntary Targets[1]**	**Direct Incentives[2]**	**Grants**	**Feed in tariffs**	**Compulsory grid connection**	**Sustainability Criteria**	**Tariffs**
Brazil	E, T		T					Eth
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)		Eth
South Africa		E, (T)	(E),T					n/a
Canada	E**	E**,T	T	E,H,T				Eth
France		E*,H*,T	E,H,T		E			as EU below
Germany	E*,T		H	H	E	E	(E,H,T)	as EU below
Italy	E*	E*,T	T	E, H	E	E		as EU below
Japan		E,H,T				E		Eth, B-D
Russia		(E,H,T)	(T)					n/a
UK	E*,T*	E*,T	E,H,T	E,H	E		T	as EU below
US	T	E**	E,H,T	E,T	E			Eth
EU	E*, T	E*,H*, T	T	E,H,T		E	(T)	Eth.;B-D

Based upon information provided by the countries and summarized in the country annexes.

E: electricity
H: heat
T: transport
Eth: ethanol
B-D: biodiesel

** target applies to all renewable energy sources*
*** target is set at a sub-national level*
(..) *policy instrument still under development/awaiting approval*
[1] *blending or market penetration*
[2] *publicly financed incentives: tax reductions, subsidies, loan support/guarantees*

2.2.4 Comparative Analysis – Patterns, Effectiveness, & Impacts

Trends – Heat and Power

The feed-in tariff is the policy tool that has been most effective in stimulating renewable energy markets. Feed-in tariffs have thus far driven rapid renewable energy capacity expansion in several EU member nations while RPS polices have not. The problem for biomass is that when the feed-in tariff is focused broadly on renewable energy, the lowest cost renewable energy source will be developed first, and this is generally wind. When feed-in tariffs are differentiated by technology and biomass is treated individually, they have been effective in promoting bioenergy (heat or power or CHP depending on the way the policy is written).

Trends – Transport Fuels

In policies relating to biofuels for transport, there is a trend away from high cost policies (to governments) and towards policies like blending mandates which don't require direct government funding. However, publicly financed support remains significant. A recent report by the Global Subsidies Initiative estimates that public support by the United States, EU and Canada for ethanol and biodiesel alone amounted to approximately $5 billion in 2006.[56] Governments are increasing their spending on R&D, especially related to the accelerated commercialization of second generation biofuels.

Despite the move towards mandatory blending targets in many countries, as mentioned previously, a few governments are moving towards performance focused policies. Rather than mandate an amount of fuel to be consumed, these governments are mandating the amount of GHG reductions required. This strategy to harness market forces is gaining interest in Kyoto signatory countries that are looking for the most cost-effective GHG emission strategies. In addition to the United Kingdom's Renewable Transport Fuel Obligation and the United States' State of California's Low Carbon Fuel Standard (see Text Box), the European Commission (Directorate General for the Environment) is considering a type of fuel quality directive that would require a gradual reduction in GHG emissions from transport fuels each year for the next approximately ten years.

Trends – Sustainability Policy (see Section 2.4 for a detailed overview)

There is a trend away from "across the board" biofuels support and towards recognition that not all biofuels are "green." New schemes are under way to promote sustainability as well as link funding to sustainability. The EU and several EU member states are the only governments that have developed sustainability standards and have attached them to mandatory targets. Brazil has created its "social seal", and has tied it to its blending mandates, but it is not a comprehensive sustainability scheme. Other large (current and future) energy consuming

[56] Steenblick, R, Biofuels – at what cost?, Government support for ethanol and biodiesel in selected OECD countries, September 2007

countries, including the United States, India, and China, are not currently working on sustainability standards and certification schemes.

2.2.5 Institutional Arrangements

The Ministries (or Agencies) charged with the implementation of bioenergy strategies varies across countries. In a few countries, the realization that coordination among relevant Ministries is necessary for successful implementation of bioenergy priorities has led to coordination attempts among the ministries. As bioenergy is for the most part still not commercially competitive, government plays an important role in stimulating growth. However, countries, in particular Canada, the United Kingdom and the United States, are increasingly fostering public-private partnerships to promote innovation and technological progress, and to put in place workable schemes to ensure sustainability.

2.2.6 Duration, Consistency, and Phase Out

Timeframes should be considered carefully when crafting policy. Some policies have clear timeframes written into them. Policies without clear end dates run the risk of becoming embedded. Some policies are designed to phase out as the support they provide becomes unnecessary. Both China and Germany are reducing fiscal incentives for transport biofuel production and are switching to blending mandates.

On the opposite side of things, the consistency of policy support is also a critical consideration. Without a long term support in place, many potential producers may not have the confidence to invest.

2.2.7 Priorities and Policy Combinations

Bioenergy production cannot be optimized for all things, therefore, depending on the priorities of governments, generally policies favour either maximum GHG emissions impacts, or maximum energy security impact, or maximum development impact. Government priorities manifest themselves clearly in the policy tools employed. In all of the G8 +5 Countries a combination of policies are used. The policy situations in each country are significantly complicated by local, state/province policy as well as by international trade and other policy instruments on the regional and global level, which are the topic of the following section.

2.3 Regional Policies

While in the past most policy development to support bioenergy was done on the national level, as production increases and cross-boarder trade becomes more substantial, regional efforts are becoming increasingly common. More emphasis has been put on regional cooperation as producers and politicians realize that harmonized policies are necessary for continued bioenergy market growth.

2.3.1 Bioenergy Technical Standards

National standards for the trade of pellets has been adopted by a number of EU countries such as Sweden, Austria and Germany, with the establishment of region-wide standards currently underway by the European Committee for Standardization (CEN). Pellet standards have established a common size requirement for pellets to facilitate storage and use as feed for automatic burners, as well as established criteria for pellet quality. CEN standards currently classify solid biomass according to composition, allowing it to be traced back along its production chain. Pellet quality has been recognized as an issue of vital importance for pellets meant for domestic use in heating stoves that do not have the advanced cleaning and processing facilities of large-scale biomass plants. CEN also defines a moisture content standard of 10 percent of pellets by weight for domestic uses, in order to maintain uniform energy density and combustion efficiency of the pellets.

2.3.2 Biofuels for Transport Standards

As relatively new fuels in most markets, bioethanol and biodiesel are accompanied by more uncertainties regarding their performance than conventional gasoline and diesel. In the absence of globally accepted quality standards, there is a heightened possibility of sub-par batches of fuels entering the market thereby reducing consumer confidence in biofuels, a factor that is crucial as biofuels make up an increasing share of the transport fuel market. In particular, biodiesel quality can be greatly influenced by the type of feedstock used as input in its production since the saturated fat content of various vegetable oils can differ greatly, affecting the fuel's physical characteristics and performance.

Most standards in place today aim to secure biofuel user confidence regionally and are yet to be integrated internationally. For example, the United States has adopted American Society for Testing and Materials (ASTM) standard D 6751 for biodiesel blends up to 20 percent with conventional diesel that are legally registered by the United States' Environmental Protection Agency and considered safe for use.[57]

In the absence of global criteria some countries have adopted the standards of neighbouring countries and/or trading partners. For example, the ASTM initiated the development of biodiesel standards in 1994 which later became incorporated into the national specifications of Brazil, countries of the EU, Japan, Philippines, South Korea, Australia and South Africa.[58]As the demand for non-fossil biofuels increases, nations are likely to collaborate to adopt, refine and build upon existing biofuel quality standards in order to facilitate, along with the development of international trade policies (see Section 2.5), the globalization of biofuels as a standard commodity.

[57] Worldwatch Institute, *Biofuels for Transport: Global Potential and Implications for Energy and Agriculture* (London: Earthscan, 2007), chapter 9, p150-153
[58] Ibid.

Efforts are indeed underway to move towards harmonized global specifications. The United States and Brazil have agreed to “a roadmap to achieve greater compatibility of biofuels standards and codes” to be completed by the end of 2007. The establishment of uniform standards and codes is a key element of their strategy to expand the biofuels marketplace.[59] This work is being done in collaboration with the industry and standards organizations of the United States (the United States National Institute of Standards and Technology (NIST)), Brazil (the National Institute of Metrology, Standards and Industrial Quality of Brazil (INMETRO), and European Union (The European Committee for Standardization (CEN)) under the International Biofuels Forum (IBF). IBF members include Brazil, the United States, the European Commission, China, India, and South Africa.[60]

2.3.3 Regional Agreements

The Caribbean Basin Initiative (CBI) has had a strong influence over biofuel trade flows, especially in the Western Hemisphere. Apart from the CBI, there are several other regional trade agreements that will most likely impact future biofuel trade between member countries. The Southern Common market (MERCOSUR) was formed in 1991, to allow free trade between member countries with the eventual goal of economic integration within South America. Mercosur as the world's fourth largest trading bloc, after the EU, NAFTA and ASEAN, current members of Mercosur include Argentina, Brazil, Paraguay, Uruguay and Venezuela with Chile, Bolivia, Colombia, Ecuador and Peru as associate members[61]. CAFTA-DR is the second largest free-trade zone in Latin America for U.S. exports that was created by the CBI countries. It has eliminated 80% of export tariffs since its creation in 2004, with the remaining tariffs being scheduled to be phased out over the next 10 years[62]. For further details and explanations of key trade agreements impacting biofuels commerce, see Annex II.

[59] White House. Office of the Spokesman. Washington DC. Media Note. “Memorandum of Understanding Between the United States and Brazil to Advance Cooperation on Biofuels”. March 9, 2007.
[60] Embassy of the United States, Advancing Cooperation on Biofuels: U.S-Brazil Steering Group Meeting, 20 August, 2007, Washington, DC. (available at http://brasilia.usembassy.gov/index.php?action=materia&id=6006&submenu=1&itemmenu=10)
[61] European Commision, European Union in the World-External Relations. The EU’s Relations with Mercosur. Updated, November 2005,; Marcos Sawaya Jank, Geraldine Kutas, Antonio Josino Meirelles Neto, Andre Meloni Nassar, Joaquim Henrique da Cunha Filho, EU-Mercosur Negotiations on Agriculture: Challenges and Perspectives, Institute for International Trade Negotiations (ICONE), ,September 10, 2004, Sao Paolo.
[62] US Department of State, International Information Programs, “Central America Free Trade Agreement – Dominican Republic” . Last updated March 2007, (available at http://usinfo.state.gov/wh/americas/regional_trade/drcafta.html)

2.4 Sustainability Considerations

2.4.1 The Sustainability Challenge – An Overview

Environmentally Sustainable

Bioenergy can provide dramatic environmental gains but also has the potential to cause great harm if not produced in an appropriate way. The sustainability of bioenergy depends largely on how the risks associated with its development – especially pertaining to the land use and climate implications of large-scale feedstock production and potential social inequity- are managed.

The overall lifecycle impacts of bioenergy depend on a number of factors, the most vital of which pertain to land-use changes (particularly sensitive land or land with high conservation value), choice of feedstock and the level of management (including its energy yield per hectare and intensity of fossil input) and the refining process (including the production of co-products and the type of process energy).

Feedstock production is arguably the most important factor in determining the sustainability of bioenergy production. The type of feedstock used and the manner in which it is produced are critical in determining the level of soil erosion and depletion of soil nutrients, use of agro- or forest-chemicals and fertilizers, waste production and management, impact on biodiversity, GHG emission levels, impact on air quality, and the sustainable management of the quantity and quality of surface and ground water. Environmental issues related to *conversion and end use* of bioenergy are predominantly related to GHG emissions, air quality, and water quantity and quality.

One of the greatest threats posed by expanding cultivation is the conversion of natural ecosystems. Increased pressure on forests is also a key concern. Clearing forest areas for agricultural purposes causes the obliteration of species and their natural habitats, and leads to the irreversible loss of species, ecosystem functions and services. It also has a dramatic GHG impact (see next section for more information). Wide-scale destruction of wildlands can additionally affect the hydrologic cycle and impact the climate by reducing regional rainfall and increasing local temperatures.

The impact on soil quality largely varies by the type of feedstock, the intensity of cultivation and the length of crop rotation periods. Heavy use of chemical fertilizers and pesticides are known to cause acidification of soils and surface waters. Intensive farming also causes soil erosion, which is especially a problem in areas with long dry periods followed by heavy rains, steep slopes and unstable soil. Erosion leads to a depletion of soil organic matter and the resulting nutrient runoffs can cause eutrophication in nearby surface waters, affecting other plants and wildlife.

Concerns have also been risen that rapid biofuel growth and mono-cropping practices of preferred varieties will lead to a reduction in agricultural biodiversity with negative repercussions on food security. On the other hand, the use of perennial species such as trees for bioenergy may create more favourable habitats for biodiversity compared to conventional crop production.

By utilizing bioenergy instead of fossil fuels, it is possible to avoid many of the environmental impacts caused by non-renewable energy sources. In addition, sustainable biomass production for liquid biofuels could reduce the negative environmental impacts relative to conventional industrialized agriculture if farming practices aim to maximize total energy yield rather than the oil, starch or sugar contents of crops, diversify biomass input varieties and reduce chemical inputs. In areas where development pressure is a problem, adding value to agricultural or forest lands can help stave off development, maintaining green space and productive lands.

Climate Change

Bioenergy offers significant potentials for emission reductions in electricity, heat and transportation, however there is a wide range in net GHG emissions impacts of different forms of bioenergy. Key factors determining net bioenergy GHG impacts include: land use changes, feedstock type and agricultural practices, type of energy being replaced, manner of conversion and end use. These and other factors must be assessed as part of a full life-cycle accounting of GHG impacts.

Current production and use of biofuels could reduce GHG emissions relative to petroleum-based fuels or could increase them, depending on the pathways chosen for their production. The most critical factor in the GHG balance of bioenergy production is the land-use issue. If virgin forest, for example, is destroyed in order to plant bioenergy crops, the GHG benefits of displacing fossil fuels with the biofuel produced on that land will be negated for decades. Fertilizer use and tillage practice also greatly influence net GHG impacts. Research done by Crutzen et al. indicates that N_2O emissions from fertilizers may be 3-5 times higher than previously thought, translating to much higher GHG emissions.[63]

The climate impact of various forms of bioenergy also depends greatly on their fossil energy balance. Unlike fossil fuels, biomass fuels have the potential to be "carbon-neutral" over their life cycles, emitting only as much carbon as feedstock plants absorbs from the atmosphere as they grow, however this is generally not the case in practice due to GHG emissions produced in the feedstock production, processing, and distribution.

Considerable uncertainty hampers “across the board” estimates of the potential GHG emission reductions from various types of bioenergy. The analysis is complex because of wide variation in the use of by-products, agricultural practices in growing the feedstocks and efficiencies of processes. Reduction potentials must therefore be seen as indicative.

While a range of estimates exist, currently the largest GHG reductions are generally achieved through the use of biomass to heat and electricity. Biomass combustion replacing coal

[63] P. J. Crutzen, A. R. Mosier, K. A. Smith, and W. Winiwarter. N2O release from agro-biofuel production negates global warming reduction by replacing fossil fuels. Atmospheric Chemistry and Physics Discussions, 7, 11191–11205, 2007 (available at www.atmos-chem-phys-discuss.net/7/11191/2007/)

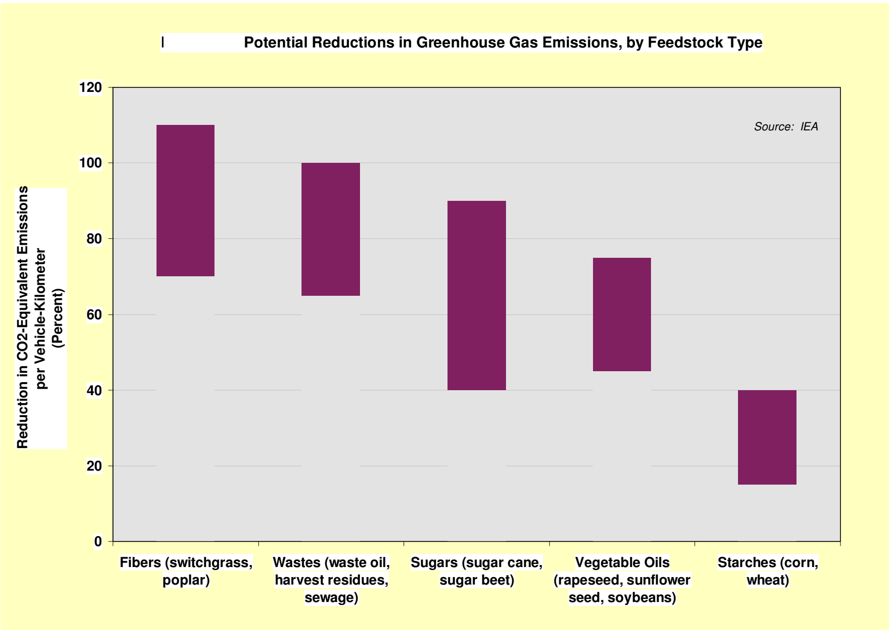
and oil has significant reduction potentials. As mentioned previously, biogas from organic waste not only reduces CO_2 emissions compared to fossil fuels but also avoids methane emissions related to the decomposition of organic wastes.

Electricity and heat from biomass can generate greater savings than transport fuels. Liquid biofuels for transportation are currently a relatively expensive carbon reduction strategy, however advanced biofuels hold significant potential to reduce costs and increase GHG reductions. Second generation biofuels, including cellulosic bioethanol, are expected to produce significant GHG savings – possibly of up to 80 percent. Among the currently used commercial technologies, Brazilian bioethanol produces the largest savings – estimated to be up to 90 percent of GHG emissions compared to fossil fuels. Maize or corn based bioethanol production produces far lower savings, with estimates of average reductions of around 13 percent.[64]

Decision makers aiming to make the biggest climate bang for their buck today will focus, therefore, on biomass for heat and power using the most efficiency conversion methods rather than biofuels for transportation. This equation will certainly change, however, as advanced biofuels (second generation) develop.

Policy makers supporting bioenergy for climate reasons will also have to make a strong effort to prevent carbon emissions from land conversion. The largest climate risk related to bioenergy is the chance that virgin habitats will be burned or otherwise converted to conventional crops, resulting in massive one-time carbon emission.

Figure 2.1 - Potential Reductions in GHG Emissions, by Feedstock Type



[64] Farrell et al, 2006: Bioethanol Can Contribute to Energy and Environmental Goals, Science, Vol. 311. no. 5760, pp. 506 - 508

Socially Sustainable

Along with environmental concerns, social issues are fundamental to the sustainability of bioenergy. Much of the focus has been on the environmental impacts of bioenergy, but the social implications could also be dramatic. What follows is a brief overview of some of the key factors relating to the social sustainability of bioenergy.

Clean, reliable energy provision itself is a critical factor in development and poverty alleviation. The social sustainability of bioenergy expansion will be determined in part by the ability of modern bioenergy markets to extend into poor communities in developing nations, in order to revitalize rural economies, which are often set back due to unreliable energy services. The challenges of traditional bioenergy include indoor air pollution (linked to traditional biomass use for cooking) which counts among the major causes of ill-health and death in developing countries, and the large time commitment needed. Women in least developed countries may spend more than one third of their productive life collecting and transporting wood. Additional help needed from children often prevents them from attending school.

Key social considerations related to modern biofuels industry include: job creation; ownership; access to food; land and water; labour conditions; and rural development generally. Bioenergy is possibly the most labour intensive energy source and there is little doubt that bioenergy development will bring about significant job creation where opportunities will exist in feedstock production, handling and processing; distribution and marketing. New positions would include high-skill science, engineering and business-related employment, medium-level technical jobs and – depending on the scale of production (large scale plantations, or medium and small scale operations) and on the degree of mechanisation – new employment opportunities arise for unskilled workers. Development of bioenergy will have a much more dramatic impact on rural livelihoods when the production involves the participation and ownership of plants by small-scale farmers, their proximity to conversion facilities that are suitable to rural settings and a fair share of the accrued revenue.

Liquid biofuel production from edible crops is booming in a world where an estimated 850 million people worldwide suffer from chronic hunger. Population growth and consumption in rich countries is putting an enormous strain on water, soil and agro-ecosystems; and rich countries continue to subsidize domestic commodity agriculture. The subsequent rise in food prices has caused, and will continue to cause significant debate. On the one-hand, the food-insecure are the people least able to pay more for food and the poorest are migrating to cities or across national borders. On the other hand, the majority of the world's poor still live in agricultural areas. If they can benefit from increased prices for agricultural crops, they will be better off and less likely to move to urban slums.

Ensuring that farmers and producers get a fair share of the profits will be a challenge. Poor households in many developing countries do not have formal title over their land and formal rights over water. As land values increase in biofuel production regions, the poor are more likely to be shoved off of their land. Large scale biofuel plantations can threaten their access to land and water. This also applies to marginal and degraded lands, which some countries, including India, have singled out for bioenergy development. What appears to many to be abandoned land may in fact provide important subsistence functions to the most vulnerable.

Labour conditions in sustainable bioenergy production should be an improvement on existing standards. Labour issues include child and forced labour, working conditions, health and safety, and adequate remuneration.

Economic Sustainability

Economic sustainability is an essential pillar of sustainability. Unlike financial sustainability which demands that financial returns to a particular project or technology are positive, economic sustainability implies that the total costs to society, including financial costs, environmental and social costs, should be outweighed by the benefits. For the private sector to invest in bioenergy without sustained government support, however, the financial returns must be positive.

Key factors determining the viability of bioenergy production include:

- policy/regulatory/tax frameworks
- prices of alternative/competing energy sources (coal electric, wind, oil, etc.)
- feedstock costs and availability
- co-product markets
- consumer demand
- infrastructure compatibility
- labour costs
- capital/financing costs
- technological advances/breakthroughs.

Bioenergy without subsidies are currently not competitive with their (also subsidezed) fossil fuel counterparts, with the exception of Brazilian sugarcane ethanol (see Table 2.4 and Table 2.5 below), wood based heating in Northern Europe, and importantly industrial applications based on residues from production processes, for instance in sugar factories and timber mills. It should be noted that a comprehensive accounting of subsidies for fossil fuels so as to be able to make a fair comparison among fuels is beyond the scope of this study. While carbon credits might be influential in the future, currently the carbon market does not have a large influence over the economics of bioenergy production.

Table 2.4 - Fuel Ethanol Costs and Prices of Gasoline, 2004 (Euros per energy-equivalent liter)

	Ethanol	Gasoline (w/tax)	Gasoline (w/o tax)
United States	0.36(corn)	0.45	0.32
Europe	0.70(wheat)	1.09	0.34
Brazil	0.27(sugar cane)	0.69	0.33

Adapted from: Worldwatch Institute (2006). Biofuels for Transportation, Washington, DC.

Note: Bioethanol prices are adjusted for the difference in energy content per litre of ethanol (0.67 the energy of gasoline)

Table 2.5 - Biodiesel Costs and Prices of Diesel, 2004 (Euros per energy-equivalent liter)

	Biodiesel	Diesel (w/tax)	Diesel (w/o tax)
United States	0.50(soy)	0.47	0.31
Europe	0.56(rape)	1 .06	0.33
Brazil	0.52(soy)	0.40	0.32

Adapted from: Worldwatch Institute (2006). Biofuels for Transportation, Washington, DC.

Note: Biofuel prices are adjusted for the difference in energy content per litre of biodiesel (0.9 the energy of diesel)

2.4.2 Addressing Sustainability Issues

The majority of the work currently being done around the world to comprehensively address the complex sustainability questions surrounding biofuels development is being driven with voluntary initiatives. However it is clear that sustainability performance standards backed by the power of law will be necessary to prevent negative impacts.

The leading strategy at the international level, and in many cases at the national level, is to create sustainability standards that can then be applied by various actors (government, industry, independent organization, etc.) using some form of certification scheme or other mechanism for ensuring compliance. There is currently no international set of sustainability standards or sustainability assurance mechanisms for biofuels. There are, however, several international efforts underway, as well as national and sub-national initiatives at different levels of development.

A number of sustainability schemes exist for related products (i.e. forestry and traditional agricultural products). There are significant differences in breadth and comprehensiveness, for instance, some systems are crop specific and others cover biomass broadly. Some cover only feedstock production and others look at the entire production chain.

The creation of sustainability assurance schemes for biofuels is inherently complicated, in part because the range of crops and other materials that could serve as biofuel feedstock is very wide and will become even wider when next generation biofuels production is commercialized. This is in addition to the enormous range production contexts which include local and regional growing conditions and agro-ecosystems, agricultural production methods, and policy and cultural contexts.

This section will outline key international, voluntary efforts as well as leading national and sub-national efforts.

Mandatory – International Level

There are no international legally binding sustainability regulations for biofuels, but some related international law will be applicable – climate change commitments, endangered species treaties, and trade agreements for example. One option would be to integrate sustainable biofuel standards into existing international systems like the International Standards Organization

(ISO). Another option would be the creation of a multilateral environmental agreement (MEA) for biofuels. However because of the nature of such agreements the standards are unlikely to be rigorous, the process to create an MEA is very long, and full implementation by signatories often happens slowly if at all.

In lieu of a global sustainability system, some regional governance bodies and national governments are integrating sustainability requirements into national policies. In January 2007 the European Commission created a binding 10 percent target for the share of biofuels in gasoline and diesel in each EU Member State by 2020, to be accompanied by the introduction of a sustainability scheme for biofuels. This scheme is currently under development.

Mandatory – National Level

A number of aspects of sustainability are addressed under national environmental and human welfare laws – water and air pollution regulations and minimum wage requirements for example. However, the broader sustainability issues that the rapid growth of bioenergy raises which span landscapes and economic sectors – competition with food production, land allocation conflicts, fair income and ownership distribution, net GHG emissions of production operations, for example - are generally not captured by specific national environmental, agriculture, and other laws (many of which were enacted without taking bioenergy into account).

In the new context that the rapid increase of bioenergy production creates, some governments did not wait for international or regional institutions to take the lead.

Key National Efforts: In the United Kingdom, a sustainability standards development process has been connected to their Renewable Transport Fuel Obligation (RTFO) which will come into effect in 2008 and will require that 5 percent of all fuel sold in the United Kingdom comes from a renewable source by 2010. No sustainability requirement is tied to the renewable transport fuel obligation at this time, however, biofuel producers will have to report on the GHG balance, and environmental impact of their biofuels.

"Reporting is seen as a 'stepping-stone' towards a mandatory assurance scheme that rewards biofuels based upon their carbon intensity and seeks to penalise feedstock produced unsustainably. This first step is necessary due to the limited initial availability of data; the need to demonstrate the robustness of the criteria and methodology; and to reduce the risk of challenge under trade rules."[65]

This information will be used to develop sustainability standards, which should be imposed on any extension of the RTFO. The Low Carbon Vehicle Partnership has been asked to lead the development of carbon and sustainability standards through a multi-stakeholder process. Starting in 2010, the government will reward biofuels under the RTFO based on the amount of carbon the fuel saves. This will be subject to compatibility with EU and WTO requirements and future consultation on the environmental and economic impacts. Starting in

[65] LCVehicle summary doc) (available at http://www.lowcvp.org.uk/cutting-carbon/biofuels.asp)

April 2011, the government will reward biofuels only if they meet appropriate sustainability standards.[66]

In 2006 the Netherlands started a process to develop sustainability criteria for biomass used for energy. The development of these criteria and indicators to measure compliance has been ongoing, and groundwork is being laid for the creation of pilot projects to field test these criteria and indicators for the eventual development of monitoring and certification systems.[67] The government is currently in the process of incorporating sustainability indicators into Dutch policy, however, due to WTO restrictions, it is not possible to implement sustainability criteria as minimum standards in formal rules and regulations.[68] Instead, companies will be obliged to report on the sustainability criteria. This reporting obligation is under development, and GHG calculation methodologies are being refined for use in this process.[69]

The German Government recently changed its liquid biofuels support laws. They are phasing out their tax exemptions for liquid biofuels (except for advanced liquid biofuels) and are phasing in liquid biofuels blending quotas with mandatory sustainability requirements as per their Biofuels Quota Law. These standards are currently under development and will relate principally to sustainable production of feedstocks (especially from agriculture), natural habitat protection, and minimum GHG reductions. These German government sustainability requirements should be released in a Biofuel Sustainability Ordinance (BSO) in the fall of 2007. The BSO will include "a detailed scheme for the approval of certification systems, the accreditation of certifying bodies, and the validation of certificates."[70]

Sub-National Efforts

A number of state, city, and local level initiatives exist, but generally are still under development. In the United States, for example, biofuel sustainability regulations are being developed in California, Minnesota, Oregon and Washington.

The City of Portland, Oregon in the United States, has passed a Renewable Fuels Standard with procurement options being assessed on a point system. While there are not comprehensive sustainability requirement, the law delineates 'preferred' and 'acceptable' feedstocks and the evaluation criteria include distance travelled of the raw feedstock, intermediaries, and finished biofuel.[71]

Voluntary – International Level

Some form of international regulation would be preferable to regional or national systems because this would allow acceptance of these standards under international trade law. One of

[66] Ibid.
[67] Kampman, Bettina, Frans Rooijers, and Jasper Faber. "A Strategy on Climate-Neutral Fuels". CE Delft. Holland. July 2006
[68] Lammers, Ella. SenterNovem. Email to Suzanne Hunt. August 23, 2007
[69] Energy Transition Task Force. "Criteria for Sustainable Biomass Production: Final Report of the Project Group 'Sustainable Production of Biomass'" July 2006. Holland
[70] Fritsche 2007
[71] City of Portland, Oregon Request for Proposals for Biodiesel and Ultra Low-Sulfur Diesel Motor Fuels. Solicitation No. 106848.)

the key barriers today to the development of sustainability standards for biofuels is the concern that they will create an additional barrier to trade and will be used by some countries to protect their domestic industries (See Sections 1.2.3 and 2.5 for more on Trade). As mentioned previously, most existing initiatives, and initiatives in progress, are voluntary systems. Brief descriptions of key international initiatives are below.[72]

The Global Bioenergy Partnership (GBEP) is engaged in ensuring the sustainable production of bioenergy. In the light of the 2005 G8 Gleneagles Plan of Action and of the 2007 G8 Heiligendamm Summit Declaration, this Report is a basis to advance work in this area.[73]

The United Nations Environment Programme (UNEP) is currently in the process of defining sustainability criteria for biofuels. They acknowledge that this initial set of criteria will need to be further developed and suggest that concrete targets be set, and tools be developed to help implement them. UNEP is working in close cooperation with partners in governments, industry and civil society, including the Roundtable of Sustainable Biofuels, and will provide the link between the technical findings of this group and the GBEP and other intergovernmental processes. [74]

FAO is implementing an ambitious project on “Bioenergy and Food Security” that is developing an analytical framework for the assessment of food security impacts of expanded bioenergy systems based on food crops and second generation bioenergy systems. UNEP, the Food and Agriculture Organization of the United Nations (FAO) and the United Nations Industrial Development Organization (UNIDO) are preparing a Global Environment Facility (GEF) project that will provide guidance to countries on the environmental and socioeconomic conditions that support sustainable production, conversion and use of liquid biofuels.[75]

The Roundtable on Sustainable Biofuels (RSB) is the key international multi-stakeholder initiative to develop sustainability standards for biofuels. The Roundtable is being lead and funded by the Swiss EPFL (École Polytechnique Fédérale de Lausanne) Energy Center. Their first draft principles for sustainable biofuels production are available for review.[76] [77] Examples of draft principles are: “Biomass production should not lead to the destruction or damaging of areas of high biodiversity,” and “biomass production should not degrade or damage soils.”[78]

IEA Task 40 is an international working group headed under the Bioenergy Agreement of the International Energy Agency formed to deal with International trade of biomass and bioenergy, its implications and prospects. One of their key priorities is the development of a sustainable biomass supply and thus they work on certification, standardization and terminology

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[72] For a more comprehensive list of certification and standards initiatives that relate both directly and indirectly to bioenergy, see Lewandowski and Faaij 2006 or the UNEP 2007 biofuels working papers.
[73] Global Bioenergy Partnership (GBEP), last updated 28 August 2007, (available at http://www.globalbioenergy.org/)
[74] UNEP working papers 2007 (available at www.unep.org)
[75] Food and Agriculture Organization (FAO) U.S., Bioenergy and Food Security Project - (available at http://www.fao.org/nr/ben/befs/)
[76] Anyone can comment on these draft principles by going to www.bioenergywiki.net.
[77] Frie, Christoph, Edgard Gnansounou, and Hans Puettgen. White Paper: Sustainable Biofuels Program: The Need for Biofuel Certification/Labeling École Polytechnique Fédérale de Lausanne, November 2006
[78] Bioenergy Wiki, Roundtable on Sustainable Biofuels (RSB) Comments Process, Last updated 29 Auguest, 2007 (available at http://www.bioenergywiki.net/index.php/RSB_comments_process#Original_and_Current_Edits_of_ Principles)

for sustainable biomass trade and provide important information and analysis for ongoing sustainability assurance efforts.[79]

Related International Certification Schemes

Related systems, namely forestry and agricultural certification systems are being used as models, and/or other aspects of the systems are being adapted for broader biomass certification systems. Some of the most prominent are:

The Sustainable Agriculture Standard from the Sustainable Agriculture Network led by the Rainforest Action Network "covers the management of farms of all different sizes and includes aspects relating to agricultural, social, legal, labour and environmental issues, in addition to sections on community relations and occupational health and safety."[80] One of the ten principles is "Wildlife Protection". The associated criterion is "The farmer must keep an inventory of the wild animals held in captivity on the farm and implement policies and procedures to regulate and reduce their tenancy. Endangered or threatened species must not be held in captivity." Two of the criteria associated with this criterion are: "The farm is able to demonstrate a reduction over time in the number of animals held in captivity; no additional animals on the farm are put into captivity," and "the animals' owners have the respective permits required by national laws."[81]

The Forest Stewardship Council (FSC) was formed to promote environmentally appropriate, socially beneficial and economically viable management of the world's forests. FSC certifies forest land and forest products (e.g. wood, paper, wooden value-added products, non-timber forest products, buildings). It also accredits independent third party organizations who can then certify forest managers and forest product producers to FSC standards.[82] An example of one of their ten principles is "The legal and customary rights of indigenous peoples to own, use and manage their lands, territories, and resources shall be recognized and respected." Two of the associated criteria are, "Indigenous peoples shall control forest management on their lands and territories unless they delegate control with free and informed consent to other agencies," and, "Forest management shall not threaten or diminish, either directly or indirectly, the resources or tenure rights of indigenous peoples."

The International Federation of Organic Agricultural Movements (IFOAM) is the global umbrella organization for the organic movement that unites more than 750 member organizations in 108 countries. IFOAM's mission is "leading, uniting and assisting the organic movement in its full diversity." "IFOAM provides a market guarantee for integrity of organic claims" and, "unites the organic world through a common system of standards, verification and market identity. It fosters equivalence among participating IFOAM accredited certifiers, paving

[79] International Energy Agency (IEA) Task 40, Sustainable International Bioenergy Trade (available at www.fairbiotrade.org)
[80] Rainforest Alliance, Sustainable Agriculture Standard, Sustainable Agriculture Network, 2005 (available at http://www.rainforest-alliance.org/programs/agriculture/certified-crops/documents/standards_2005.pdf)
[81] Sustainable Agriculture Standard. Sustainable Agriculture Network. November 2005. (available at www.rainforest-alliance.org)
[82] Forest Stewardship Council (FSC), last updated 6 September, 2007 (available at http://www.fsc.org/en/)

the way for more orderly and reliable trade whilst acknowledging consumer trust in the organic 'brand'".[83]

Fairtrade Label Organization (FLO) International was created to improve the position of the poor and disadvantaged producers in the developing world, by setting the Fairtrade standards, and by creating a framework that enables trade to take place at conditions respecting their interest. Members of FLO International encourage industry and consumers to support fairer trade and to purchase FLO certified products.[84]

Feedstock Specific Initiatives

The Roundtable on Sustainable Palm Oil was launched by the World Wildlife Fund (WWF) in cooperation with palm industry stakeholders to research and develop definitions and criteria for the sustainable production and use of palm oil and to facilitate the development and implementation of best practices.[85] An example of one of their Principles is, "Use of appropriate best practices by growers and millers" and several of the associated criteria are, "Operating procedures are appropriately documented and consistently implemented and monitored," "practices maintain soil fertility at, or where possible improve soil fertility to, a level that ensures optimal and sustained yield," and "Practices maintain the quality and availability of surface and ground water."[86]

The Better Sugarcane Initiative (BSI) "is a collaboration of progressive sugarcane retailers, investors, traders, producers and NGOs" who are working together to develop baselines and internationally-applicable measures to define sustainable sugar cane production. "The end result of BSI will be a set of performance-based measures and baselines, which can be used by companies and investors across the globe as sourcing and investment screens and by producers to enhance the long-term sustainability of production."[87]

The Roundtable for Responsible Soy (RTRS) was only created in 2005 and is moving more slowly than the other commodity initiatives, however it has a similar strategy and objective: "the goal of the RTRS is to set up a multi-stakeholder and participatory process that promotes economically viable, socially equitable and environmentally sustainable production, processing and trading of soy".[88]

Voluntary – National and Sub-National Level

The Social Fuel Stamp was created as part of Brazil's National Program of Biodiesel Production and Use. It attempts to encourage socially sustainable biofuels production by providing tax incentives for biodiesel producers to purchase feedstocks from small family farms in poorer regions of the country. To receive the stamp, producers must agree to: "purchase minimum

[83] International Federation for Organic Agriculture Movements (IFOAM), last updated 29 August, 2007 (available at http://www.ifoam.org/)
[84] Fairtrade Labelling Organizaitons International (FLO), last updated 25 July, 2007 (available at http://www.fairtrade.net/)
[85] Roundtable on Sustainable Palm Oil (RSPO), last updated 14 September 2007 (available at http://www.rspo.org/)
[86] RSPO Principles and Criteria for Sustainable Palm Oil Production. Public release version. 17 October 2005.
[87] Better Sugarcane Initiative (BSI) (available at http://www.bettersugarcane.org/)
[88] Roundtable on Responsible Soy (RTRS) (available at http://www.responsiblesoy.org/)

percentages of raw materials from family farmers, 10 percent from regions North and Mid-West; 30 percent from the South and Southeast and 50 percent from the Northeast and the Semi-Arid Region; and they must "enter into contracts with family farmers establishing deadlines and conditions of delivery of the raw material and the respective prices, and to provide them with technical assistance." Participating companies may benefit from a partial or total reduction of federal taxes.[89] [90] While this seal is not mandatory, it is now required by the government for fuel to be counted towards national blending mandates.

The Institute for Agriculture and Trade Policy (IATP), an international non-governmental organization based in the United States, is working to develop sustainable standards for biomass production and harvesting as an Associate Member of the ISEAL Alliance. Draft global principles that address social and environmental aspects have been developed with Friends of the Earth and are available for comment and review at *www.sustainablebiomass.org*. Based on the feedback received, final principles will be developed and will inform how and to what extent IATP moves forward with the development of criteria and a certification system for sustainable biomass standards. Initial research and field work with farmers is now being undertaken, with a focus on perennial grasses and agricultural crop residues. IATP is also participating in the Minnesota state-based efforts to develop criteria for sustainable production of native perennial grass feedstocks.[91]

The Sustainable Biodiesel Alliance (SBA) is a non-profit organization founded by biodiesel advocates Annie Nelson and Daryl Hannah and members of the sustainable biodiesel community. The SBA was created to promote sustainable biodiesel practices and to develop a certification and labeling system for biodiesel in the United States. They are working in tandem with the Roundtable on Sustainable Biofuels on sustainability standards and a certification system. They are also developing sustainability guidelines for companies to use right away while full certification schemes are still under development.[92]

The Private Sector

A number of companies, especially in Europe, consider “sustainability” a key driver in bioenergy development. A few companies are developing their own ‘sustainable procurement policies’. The Essent corporation in Europe for example, developed the Essent Green Gold audit and certification system to guarantee the sustainable sourcing of biomass. However, the majority of companies concerned about sourcing or selling sustainable biofuels are engaging in the multi-stakeholder processes (which are viewed as much more legitimate by consumers). BP, Dupont and other large corporate players are engaged in the international Roundtable for Sustainable Biofuels. This process is expected to take at least a year or more to develop standards that could be applied, so at the urging of a number of companies in the United States, the

[89] Tax reductions/exemptions are defined by the national biodiesel tax legislation.
[90] Brazilian Government. “Biodiesel: The New Fuel from Brazil” National Program of Biodiesel Production and Use (PNPB). (available at http://www.biodiesel.gov.br/docs/Folder_biodiesel_ingles_paginado)
[91] Kleinschmit, Jim. Personal Communication with Suzanne Hunt. August 2007
[92] Sustainable Biodiesel Alliance, www.fuelresponsibly.org

Sustainable Biodiesel Alliance is developing basic sustainability guidelines for companies to use in the meantime (as mentioned above). Businesses are interested in seeing that strategies to ensure sustainability are transparent, consistent over time and create a level playing field among market participants. There are indications that there is some support in the private sector for broad sustainability criteria, but also concern about the burden of detailed reporting requirements. In addition, companies that want to participate in sustainability standards development are becoming increasingly concerned with what the proliferation of standards development initiatives and what they perceive as a fragmentation of standards development initiatives. They want clarity and guidance as to how best to engage and in which processes.

The Multilateral Development Banks

The MDBs may play a more active role in developing and applying sustainability assurances in the future. They recently created an MDB biofuels working group. Of the MDBs the IDB is most engaged in biofuels, although they are just beginning to engage in efforts to address sustainability assurances for biofuels.

2.4.3 Key Findings

No international sustainability assurance system exists for biofuels or bioenergy more broadly. As described above, several international processes to create such a system are underway, however, even these do not deal with all concerns due to the potential for impact shifting. This occurs when feedstock from existing fields/plantations is used for biofuels that was originally used for other applications which leads to unsustainably produced feedstocks being used, or to new plantations/fields being created, to supply these other applications. The fungibility of feedstocks, land, and other inputs for feed, fuel, and food is leading some to call for a universal framework for sustainability requirements.

Enforcement is critical to the functioning of any of these schemes. While a discussion of enforcement strategies is beyond the scope of this summary, it must be acknowledged as central. The capacity of countries to enforce protections, or even to enact them in the first place, is highly variable. In many developing countries, where much of the investment interest is focused, the pressure to reduce regulations and oversight in order to attract foreign investment is an additional challenge. These factors point to the need for international assurance systems.

Ultimately sustainability requirements will need to be agreed upon internationally, applied locally, and applied to all biomass regardless of end use if leakage effects or impact shifting is to be avoided.

2.5 Trade Considerations

Historically, biomass and biofuel trade flows have been limited, as most of the production has been for domestic consumption. However, in the coming years, international trade in biofuels and feedstocks is expected to escalate rapidly to satisfy increasing worldwide demand. Worries about high fossil fuels prices, energy security concerns and climate change mitigation efforts are indeed expected to feature highly in the international agenda in the years to come. This will likely translate into the increasing use of blending targets. Considering that several countries will not be in a position to produce enough biofuels to satisfy their demand and that some countries and regions are endowed with conditions which allow them to produce biofuels and feedstock competitively, an international market for those products will likely emerge.

2.5.1 Significance of Policy Intervention for Trade Patterns/Development

Given the increasingly important place that bioenergy occupies in international energy markets, policies that liberalize or constrict trade of bio-based energy products are likely to greatly impact future production and consumption patterns. These policies are greatly influenced by regional trade agreements that individual countries are part of (see below and Annex II), domestic policies on the use of bio-based energy (Annex I), and regional or individual country standards for bioenergy products. Among solid biomass, biogas and liquid biofuels, the development of domestic liquid fuel stocks and international liquid fuel markets has generated most interest given the impending concerns regarding transport fuel security.

2.5.2 Trade Bodies and Agreements

There are a number of multilateral, regional and national policy instruments that currently have an impact on international trade of biomass and biofuels and will become increasing important as trade expands. The WTO provisions that may be relevant for biofuels will become more high profile in the years to come (see below and Annex II). In addition to the WTO, several regional and bilateral trade agreements, mostly involving the United States and the EU, currently regulate biofuels trade. As an example among these, the United States-Caribbean Basin Initiative (CBI) allows for some duty-free trade for ethanol. More specifically, if produced from at least 50 percent local (CBI) feedstocks, ethanol may be imported duty-free into the United States market. If the local feedstock content is lower, limitations apply on quantity of duty-free ethanol. Nevertheless, up to 7 percent of the United States market may be supplied duty-free by CBI ethanol containing no local feedstocks. In this case, hydrous ethanol produced in other countries (mainly Brazil), can be shipped to a dehydration plant in a CBI country for reprocessing. After the ethanol is dehydrated, it is imported duty free into the United States. Until recently imports of dehydrated (anhydrous) ethanol under the CBI were far below the 7 percent cap (approximately 3 percent in 2005), though the situation is changing as agribusinesses are increasingly investing in ethanol plants in Central America and the Caribbean[93]

The WTO does not currently have a trade regime specific to biofuels: International trade in biofuels falls, therefore, under the rules of the General Agreement on Tariffs and Trade (GATT 1994), which covers trade in all goods, as well as under the rules of other relevant WTO Agreements, such as the Agreement on Technical Barriers to Trade, the Agreement on the Application of Sanitary and Phytosanitary measures, the Agreement on Subsidies, etc. Agricultural products are subject to the GATT and to the general rules of the WTO insofar as the Agreement on Agriculture does not contain derogating provisions. While many Panel and Appellate Body decisions have ensured the effective integration of agriculture in the general WTO discipline, specific provisions of the Agreement allow certain aspects of these exemptions to persist. The ongoing WTO negotiations will decide whether and to what extent agriculture should continue to be allowed to enjoy a status that derogates from the WTO.

The Agreement on Agriculture covers products from chapter 1 to chapter 24 of the Harmonized System, with the exception of fish and fish products and the addition of a number of specific products, such as hides and skins, silk, wool, cotton, flax, modified starches, etc. The discipline of the Agreement on Agriculture is based on the three pillars, namely market access, domestic subsidies and export subsidies. One of the main features of the Agreement on Agriculture is that it allows Members to pay subsidies in derogation from the Agreement on Subsidies.[94]

Defining a product as an agricultural or an industrial product has, therefore, important implications, since the multilaterally agreed rules applying to these two categories of products are different; WTO members enjoying a large margin of manoeuvre as far as agricultural products are at stake and much less as far as industrial products are at stake.

Paragraph 31 (iii) of 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.” Negotiations on environmental goods have been carried out by the Committee on Trade and Environment Special Session (CTE-SS) and by the Negotiating Group on Non-Agriculture Market Access (NAMA). Negotiations on environmental services have been conducted within the Special Sessions of the Council for Trade in Services. According to some WTO members, renewable energy products - which could include bioethanol and biodiesel and related products, such as parts and components of biodiesel and bioethanol plants and "flexi fuel" engines and vehicles - could be classified as environmental goods. Many disagreements among countries on the identification of environmental goods, on the scope and approach to take to liberalize trade in such products, and on mechanisms for regularly updating the product list to account for constantly moving targets, have hampered any conclusive result.

[93] For a discussion of which different trade agreements impact the biofuels market, see Annex II.
[94] The Agreement classifies these support measures in two major groups: domestic support measures (blue and yellow boxes) and general support exempt from reduction commitments (green box) on the one hand, and export subsidies on the other hand.

2.5.3 Policy Instruments that Impact on Trade

Tariffs

In order to protect domestic agriculture and biofuel industries, tariffs may be imposed by some nations on both raw materials and final products. The trend so far has been to apply significant import duties on ethanol, the finished product, as well as on biofuel feedstock. In general, tariff escalation exercised by some nations favours the production of raw materials in the exporting countries and the production of the final products in the importing countries. Considering that the industrial processing is the phase where much of the value is added, tariff escalation makes it more difficult for countries producing raw materials to process and manufacture value-added products for export.

For the market of finished biomass products and raw materials, several international trade policy barriers exist presently. Most agricultural residues that contain traces of starch are classified as animal fodder and are thus subject to EU import levies. For example, rice residues that comprise of 0-35 percent starch are levied at 44 €/tonne.[95]

Countries with large markets (the United States, Japan and the EU) present a major constraint to exporters since they are completely or partially inaccessible due to trade barriers. The United States applies MFN duties of 2.5 percent for imports from most-favoured nations (MFN) as defined by the WTO and a 20 percent duty is applied for other importers. Ad valorem duties in Japan for biomass amounts to 27 percent (MFN) influencing the competitiveness of foreign imports. General transport tariffs have also increased significantly in the past few years impacting biomass trade. Wood pellets incurred a total cost of 7-7.5€/GJ in the Netherlands in 2004, with 1.75 €/GJ being for transport tariffs. Table 2.6 provides an up to date overview of tariffs on biofuels in major OECD bioenergy markets:

[95] Junginger, M., M. de Wit and A. Faaij, 2006, IEA Bioenergy task 40 – Country report for the Netherlands – update 2006, Copernicus Institute – Department of Science, Technology and Society, Utrecht, the Netherlands, p. 28. as cited in Martin Junginger (main editor), André Faaij, Peter-Paul Schouwenberg, Chris Arthers, Douglas Bradley, Gustavo Best, Jussi Heinimö, Bo Hektor, Patrick Horstink, Angela Grassi, Kees Kwant, Øyvind Leistad, Erik Ling, Malgorzata Peksa, Tapio Ranta, Frank Rosillo-Calle, Yves Ryckmans, Martijn Wagener, Arnaldo Walter, Jeremy Woods, November 2006, Sustainable International Bioenergy and Trade: Securing Supply and Demand.

Table 2.6 - Applied tariffs on undernatured ethyl alcohol (HS 2207.10) in several representative countries, as of 1 January 2007

Country	Applied MFN tariff (local currency or ad valorem rate)	At pre-tariff unit value of $ 0.50/litre		Exceptions (in addition to other WTO member economies with which country has a free-trade agreement) or notes
		Ad valorem equivalent (percent)	Specific-rate equivalent (US$/litre)	
Australia	5% + AU$ 0.38143/litre	51%	0.34	USA, New Zeland
Brazil	0%	0%	0.00	Lowered from 20% in March 2006
Canada	CA$ 0.0492/litre	9%	0.047	FTA partners
European Union	€ 19.2/Hl (hectolitre)	52%	0.26	EFTA countries, developing countries in GSP
Switzerland	CHF 35 per 100 kg	46%	0.232	EU, developing countries in GSP
United States	2.5% + $ 0.51/gallon	28%	0.138	FTA partners, CBI countries

Source: Steenblick, R, Biofuels – at what cost?, Government support for ethanol and biodiesel in selected OECD countries, September 2007

Quotas

Import quotas, such as those employed by the EU, regulate sugar imports through a complex system of duty free tariff quotas for sugar from different exporters. As mentioned above, duty-free under CBI is linked to a quota system. Duty-free ethanol imports under quotas have also played a role during the negotiations of the United States-Central America Free Trade Agreement (CAFTA). However, CAFTA did not introduce major changes. It does not increase overall preferential access to the United States ethanol market but it does establish country-specific shares for El Salvador and Costa Rica within the existing CBI quota. The other CAFTA countries retain existing CBI benefits on ethanol.

Other Barriers to Trade

Other barriers to trade can take the form of technical regulations or sustainability requirements. In order to enter multiple markets, biofuel exporters may incur extra costs to adjust their products to different technical requirements and to prove compliance with such requirements. In a similar way, sustainability certification for feedstock and fuels may act as trade barriers.

There is currently no specific customs classification for bioethanol for biofuel production in the harmonized system commodity description and coding system (HS). Ethanol is traded under the code 22 07 that includes denaturated (HS 22 07 20) and undenaturated (HS 22 07 10) alcohol, both of which can be used for fuel production. Biodiesel has recently been reclassified by the World Customs Organization under the HS code 3824 90 – an industrial code which includes a large spectrum of chemical products and preparations of the chemical or allied industries (including those consisting of mixtures of natural products) not elsewhere specified or included.

In collecting and analyzing data on trade flows in biofuels and tariff regimes thereon, some basic difficulties are encountered: first, the lack of proper HS codes for distinct biofuels; second, the multiple potential uses of feedstocks, which makes it difficult to track the percentage of agriculture production devoted to biofuel manufacturing as opposed to feed and food consumption or other industrial uses. However, break-downs of final uses of feedstocks are carried out by some countries at the national or regional grouping levels.

The situation is complicated further by the vast array of products – from different feedstocks to different final products - that make up global trade in bioenergy. As bioenergy trade becomes increasingly more important with accelerating global demand, custom classification issues will need to be streamlined to facilitate international trade and identify clearly the rules which apply to each biofuel.

Domestic markets in several countries are not only protected by tariff and non-tariff barriers, but as well by subsidies and other incentives provided by national sub-nation and local authorities. Incentives include exemption from or reduction of fuel-excise taxes, grants for the construction of plants, subsidies for the production of feedstocks and other kinds of tax holidays.

Additionally, the risk of contamination from pathogens or pests contained in imported biomass has been limiting factor restricting biomass trade. For example, untreated round woodchips with bark, from outside the EU are in most cases not allowed or subject to very strict inspection before being imported. Agricultural residues that qualify as both fodder and biomass may not be imported if they don't meet certain fodder quality criteria.

2.5.4 Key Findings

International trade in biofuels and related feedstocks could provide win-win opportunities: for several developed countries imports are a necessary precondition for meeting the self-imposed blending targets; for several developing countries producing and exporting biofuels may provide new business opportunities and end-markets for their agricultural products. For small and medium-sized developing countries, export markets may be necessary to initiate their industries. Several developing countries – with land to devote to biomass production, a favourable climate to grow them, and low-cost farm labour – are well placed to become efficient producers. Nevertheless, biofuels face tariffs and non-tariff measures. This can offset lower production costs in producing countries, represent significant barriers to international trade, and have negative repercussions on investments in the sector. A more liberal trade regime would greatly contribute to the achievement of the economic, energy, environmental and social goals that countries are pursuing.[96]

[96] The emerging biofuels market: Regulatory, trade and development implications, UNCTAD/DITC/TED/2006/4, New York and Geneva, 2006.

2.6 Bioenergy Consumption in G8 +5 Countries

This section provides an overview of current status/trends of different bioenergy consumption in G8 +5 Countries. Additional and more detailed information on production, consumption and trade of bioenergy is presented, on a country basis, in the Annex I. This aggregated overview is based on the statistics on renewables produced by IEA (IEA 2007), which maintains the most complete and consistent information system on energy matters. In spite of IEA efforts, however, biofuels statistics should be taken with caution because biofuels are either largely informal or of very recent development, all factors that affect the completeness and reliability of recorded data (ref. Annex III on bioenergy data).

In most countries, for instance, the use of wood traded as fuelwood and charcoal through informal markets is not properly reflected in existing statistics. The experience gained by FAO field projects shows that in most cases the actual fuelwood consumption is considerably higher than that mentioned in the national statistics.

Nevertheless, these statistics are considered accurate enough for an understanding of the status of bioenergy in G8 +5 Countries and its contribution to the national energy mix.

2.6.1 Biofuel Contributions to National Energy Consumption

Table 2.7 shows the quantitative biofuels' Total Primary Energy Supply, which represents the amount available within the countries for internal use.[97] China with its 9000 PJ/yr is the largest user of biomass as a source of energy followed by countries such as India (6000 PJ/yr), USA 2300 PJ/yr, and Brazil (2000 PJ/yr) while the bioenergy contribution in countries such as Canada, France and Germany is around 450 PJ/yr.

In Figure 2.2 and Figure 2.3 the consumption trends can be appreciated. It can be noted that they increase at a quite high pace over time especially in countries such as Brazil, Germany, Italy and United Kingdom while in other countries like France, Japan, India and Mexico remain stabilized. Russia is the only one country in which its consumption is decreasing.

[97]Total Primary Energy Supply (TPES) is made of production + imports – exports –international bunkers ± stock change (IEA 2007).

Table 2.7 - Total Primary Energy Supply (TPES) from biofuels (PJ)

	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	2554	2607	2531	2601	2507	2551	2285	2256	2474	2633	2697
G8 Countries	4097	4144	4086	4160	4156	4186	3900	3904	4198	4460	4666
Brazil	1728	1706	1719	1756	1838	1794	1823	1951	2110	2277	2801
China	8610	8656	8703	8750	8906	8973	9053	9127	9202	9277	9360
India	5862	5918	5978	6039	6144	6230	6313	6389	6464	6539	6620
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	17006	17095	17233	17392	17741	17859	18064	18345	18662	18977	19693

Figure 2.2

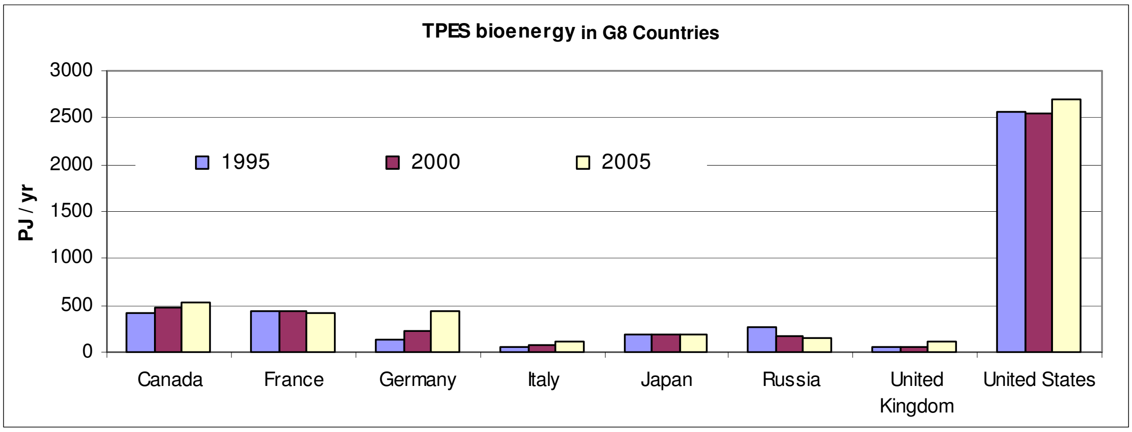


Figure 2.3

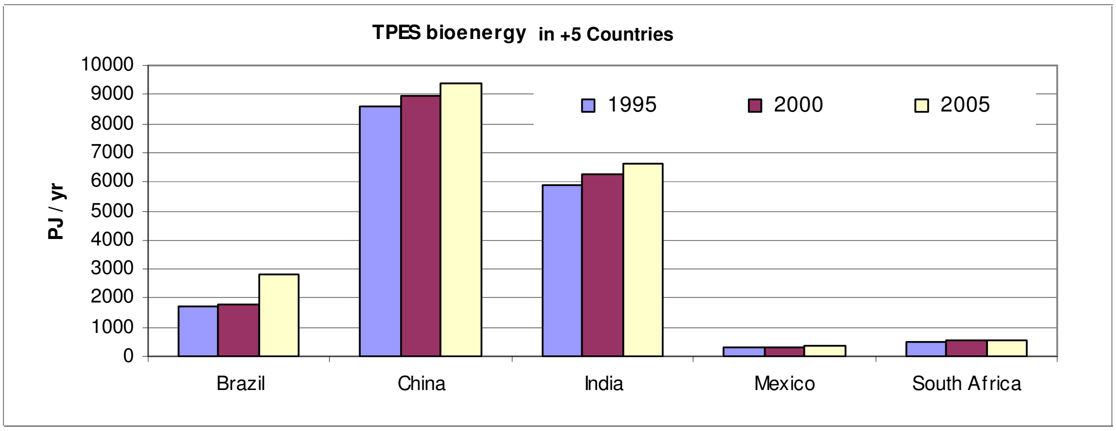


Table 2.8 shows the share of bioenergy to the national energy mix from 1995 to 2005. Its contribution to TPES reaches almost 30 percent in the case of Brazil and India but in countries such as United Kingdom and Russia is a meagre 1 percent. In countries such as Canada, France, Germany and USA varies between 3 and 4 percent.

The bioenergy share in India, China and Mexico is decreasing (see Figure 2.4 and Figure 2.5). It is most likely that the reduction of biofuels share be the result of the increased utilization of kerosene and LPG by the household sector.

On the contrary, the biofuel contribution is increasing in the G8 Countries especially Germany, Italy and United Kingdom where their annual consumption grew at a rate of 4-6 percent during the last few years, especially in Germany and United Kingdom.

Table 2.8 - Total Primary Energy Supply (TPES) from biofuel (% of all-fuels' TPES)

	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	25.0	23.9	23.7	24.1	23.1	23.3	24.3	26.0	26.5	29.8
China	19.6	19.0	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	11.0	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

Figure 2.4 – Percent of biofuel to all fuels TPES – G8 Countries

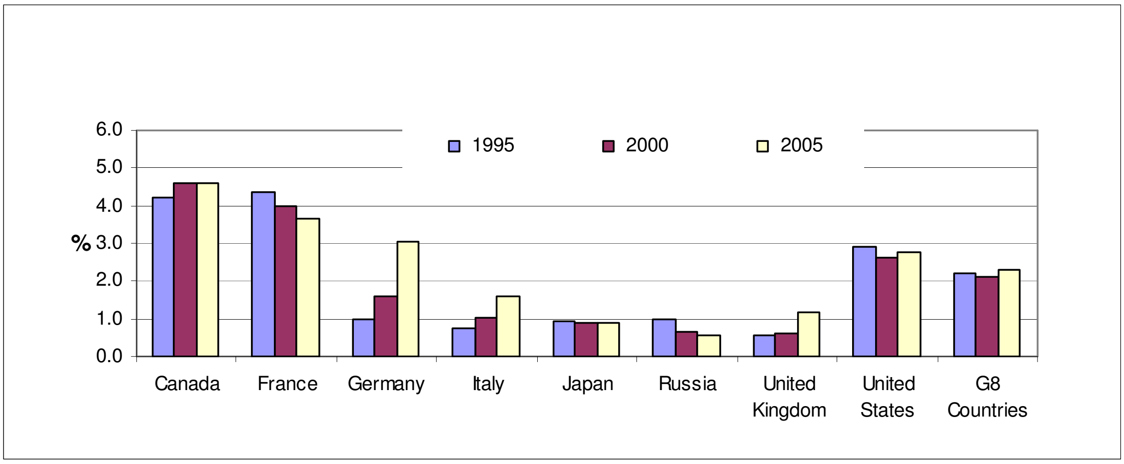
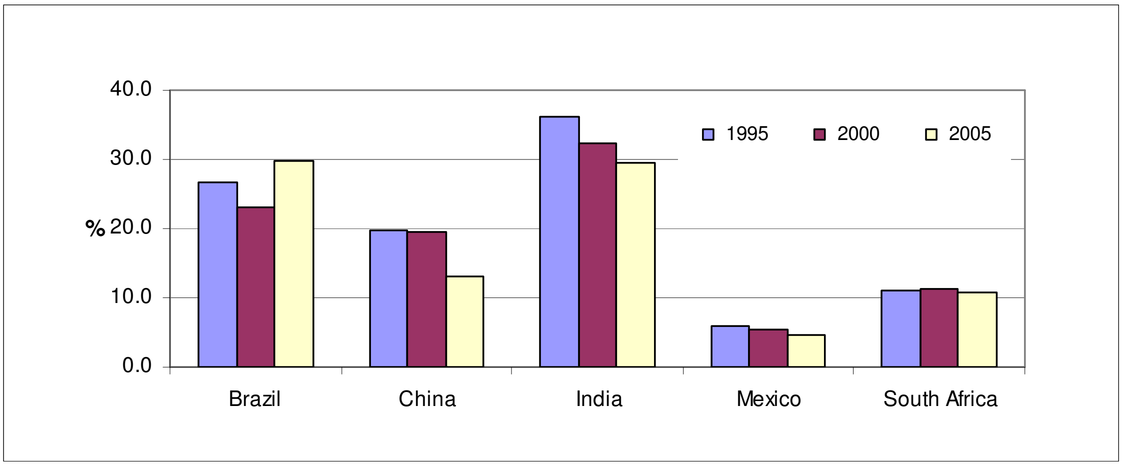


Figure 2.5 – Percent of biofuel to all fuels TPES – +5 Countries



Consumption of Biofuel by Sectors (end-users)

The analysis of main end-users of bioenergy also deserves attention. The Table 2.9 shows the aggregated biofuel consumption in all G8 +5 Countries which reaches more than 24000 PJ/yr for the year 2005 and they have been growing at a 4-5 percent annually since 2003, at a faster rate than in previous years.

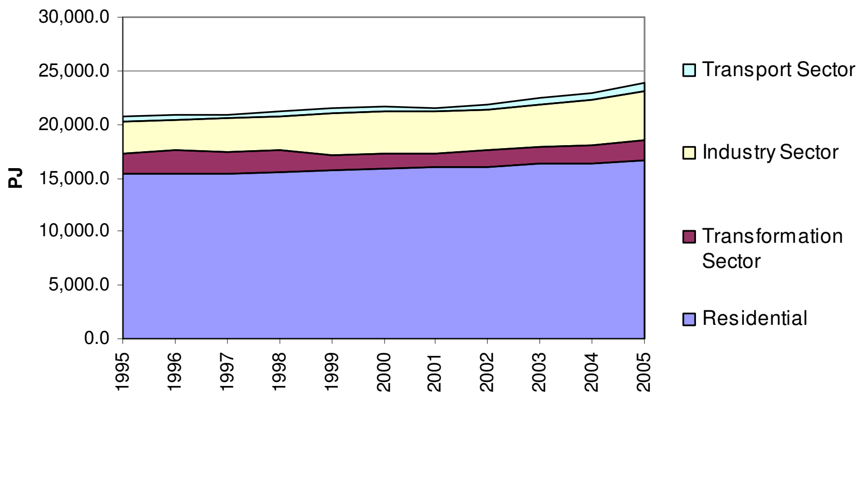
The Figure 2.6 also confirms that, overall, the main end user of bioenergy is the residential sector, with a share ranging between 72.6 percent in 1995 and 68.4 percent in 2005 (see also Figure 2.7) followed by industries with 19 percent and transportation biofuels (biodiesel and bioethanol) with only 3 percent.

Table 2.9 - Aggregated G8 +5 Countries biofuel consumption by fuel category and sector of use

G8+5 total Values in PJ		1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
All biofuels	Domestic Supply	21,111.8	21,246.5	21,324.4	21,557.4	21,900.7	22,048.9	21,968.3	22,251.7	22,859.6	23,440.8	24,363.6
	Transformation Sect	2,021.1	2,085.3	2,090.1	2,046.1	1,326.0	1,363.9	1,393.7	1,567.1	1,615.0	1,731.9	1,919.3
	Industry Sector	2,931.4	2,904.2	3,032.8	3,155.6	4,002.8	3,989.2	3,832.1	3,799.7	3,973.4	4,200.8	4,525.1
	Transport Sector	410.9	395.0	408.4	416.2	422.7	420.0	396.8	465.5	521.5	630.2	748.1
	Residential	15,333.2	15,456.4	15,396.0	15,550.8	15,717.5	15,847.5	15,944.9	16,004.8	16,282.8	16,406.9	16,656.7
Solid Biom	Domestic Supply	20,539.0	20,683.2	20,739.8	20,950.6	21,203.5	21,325.4	21,228.7	21,396.9	21,923.9	22,348.8	23,112.2
	Transformation Sect	1,949.4	2,005.3	1,997.2	1,946.5	1,216.1	1,228.6	1,237.6	1,390.6	1,424.6	1,523.1	1,680.1
	Industry Sector	2,903.3	2,877.9	3,008.4	3,128.9	3,912.9	3,898.3	3,729.3	3,683.5	3,877.4	4,096.8	4,421.3
	Transport Sector											
	Residential	15,301.5	15,423.2	15,361.9	15,516.0	15,675.6	15,799.9	15,880.4	15,926.3	16,186.1	16,290.0	16,515.6
Gas from E	Domestic Supply	112.2	122.4	136.3	145.1	227.9	253.9	301.8	355.2	368.0	408.9	458.1
	Transformation Sect	71.7	80.1	92.9	99.6	109.8	135.3	156.0	173.8	187.4	205.7	226.5
	Industry Sector	4.4	4.8	4.8	5.8	69.7	63.6	76.7	97.8	75.3	76.1	81.9
	Transport Sector											
	Residential	31.7	33.2	34.0	34.8	41.9	47.6	64.5	78.5	96.8	116.9	141.2
Biogasoline	Domestic Supply	187.2	172.2	213.4	237.8	259.6	259.4	266.0	330.0	398.5	459.6	512.4
	Transformation Sect											
	Industry Sector											
	Transport Sector	184.8	169.0	211.7	234.2	253.4	264.2	277.5	335.0	393.5	456.3	514.2
	Residential											
Biodiesels(	Domestic Supply	7.1	10.3	12.9	12.3	14.2	21.8	25.6	34.4	45.9	67.1	109.5
	Transformation Sect											
	Industry Sector											
	Transport Sector	7.1	10.5	13.8	12.0	14.1	21.8	25.6	34.9	45.2	67.4	109.4
	Residential											
Other Liqui	Domestic Supply	266.3	258.4	222.1	211.5	195.6	188.4	146.1	135.2	123.2	156.5	171.4
	Transformation Sect							0.2	2.8	3.0	3.1	12.7
	Industry Sector	23.7	21.5	19.6	20.8	20.2	27.2	26.1	18.4	20.7	27.9	21.9
	Transport Sector	219.0	215.4	182.9	169.9	155.2	133.9	93.7	95.6	82.8	106.5	124.5
	Residential											

The contribution of biogasoline (mainly bioethanol) is still relatively small but its demand is rapidly growing (from 187 to 512 PJ between 1995 and 2005) at the annual rate of 17 percent. On the other hand, the consumption of biodiesel in 2005 is also marginal when compared to solid biomass with only a contribution of 110 PJ/yr. It should be also noted that the consumption of biodiesel grows very rapidly.

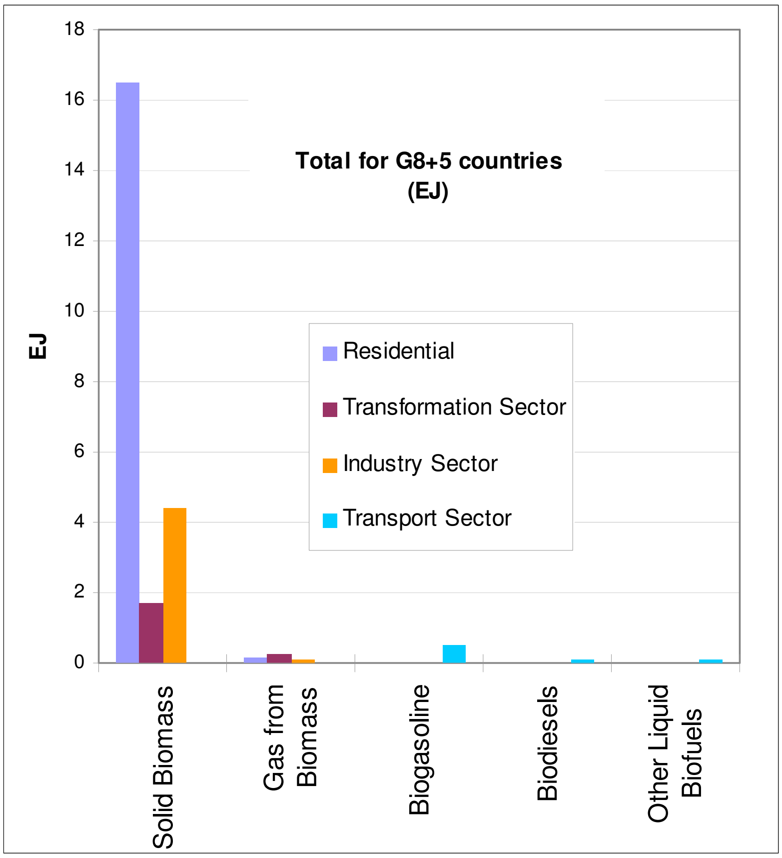
Figure 2.6 - Biofuel consumption in G8 +5 Countries (all biofuel categories)



From the Table 2.9 and the Figure 2.7 it may be noted that 95 percent of the total biomass used for energy is derived from solid biomass and the rest (5 percent) are constituted by liquid and gaseous biofuels.

The same table indicates that solid biomass is making the major contribution to national energy mix.

Figure 2.7 - Biofuel consumption in 2005 in G8 +5 Countries by biofuel type and sector of use



2.7 Main Conclusions

Together, the G8 +5 Countries account for about 55 percent of the world's population, 70+ percent of global GDP, and about 72% of world energy related and industry CO_2 emissions (excluding deforestation) (16.1t CO_2 eq per capita on average versus 4.2 t/cap for non Annex 1 countries – according to the IPCC).[98] Therefore, the G8 +5 Countries must take the lead in transforming energy and transport sectors to low carbon systems that are sustainable in the long term. The G8 +5 Countries must play a leadership role and collaborate effectively if these new industries are to reach their fuel potential while avoiding environmental and social pitfalls.

[98] Sims, Ralph. Email Communication to Suzanne Hunt. October 5, 2007.

R,D&D is an area where coordination among nations is urgently needed, especially for accelerating the commercialization of second generation biofuels for transportation.

Government policies play a determinant role in the financial attractiveness of biofuels, and, in turn, a correct and complete information is essential for the formulation of sound policies.

The information provided in this section, complemented with the information provided for individual countries in Annex I, shows as completely and consistently as possible the status and the trends of bioenergy use in G8 +5 Countries, which is characterized by the following key issues:

- Bioenergy is an important source of energy in all the G8 +5 Countries. However, their contribution at national level varies considerably from country to country.
- Most of the bioenergy consumed in G8 +5 Countries is produced locally.
- Most of the bioenergy (81 percent) have been used in countries such as Brazil, China, India, South Africa and Mexico where the contribution of solid biomass (mainly fuelwood and charcoal) constitute the largest share.
- Most of the bioenergy (more than 70 percent) is used by the residential sector followed by the industrial sector for the production of heat and electricity, for which it represents a cost effective option at current fossil fuel prices.
- The consumption of solid biomass by the industrial sector has considerably raised in the last decade in G8 Countries. Most likely this trend will continue due to several technical, economic and environmental advantages
- The contribution of solid biomass for bioelectricity production (by the industrial sector) is also very important with a great contribution from black liquor of pulp and paper plants especially in G8 Countries
- The use of first generation liquid biofuels as engine fuels is still marginal, but rapidly growing in the last few years of the analysis. However, they have also generated many concerns of experts and civil society. Perhaps, the second-generation technologies will be able to give higher contributions, depending on technological breakthroughs
- Still, solid biomass (woody biomass from forests, farm lands and wood industries, other solid biomass from agro-industries and agricultural by-products) provides the largest share of bioenergy and is likely to remain so for many years to come.
- Bioenergy statistics are essential for, among other things, understanding the dynamics of bioenergy systems; evaluating the role played by different types of biofuels in the energy sector and supply sources; assessing the share of biomass used (directly and indirectly) for energy purposes; assessing the role of biofuel in GHG inventories; and formulating sound bioenergy policies.
- Current statistics are not fully representing the real contribution of bioenergy, especially concerning informal sectors, and are not up-to-date enough to reflect specific biofuels supply/demand dynamics. Thus, they are not fully adequate to the tasks mentioned above

and a stronger coordinated effort to produce reliable and timely information is urgently needed.

2.7.1 International Harmonization

A joint FAO-IEA energy definition task force should be created to propose universal terminology, reporting methodologies, etc. related to bioenergy to facilitate information gathering, sharing, and analysis. UN-Energy should be involved as a forum for launching the results internationally. A database could be developed for bioenergy where all of the various sources can be combined and compared so that user can have access to all of this information. FAO's Interactive-Wood Energy Statistics (i-WESTAT) could be used as a model or could be expanded to include all bioenergy.

2.7.2 Interministerial Mechanisms

The harmonization and the integration of policies across government agencies is necessary. Governments should seek effective mechanisms to integrate the respective priorities in their bioenergy policies. Sector of particular interest are: energy, agriculture, trade and industry.

2.7.3 Sustainable Bioenergy Development

Bioenergy has a key role to play in the future global energy system: however, if not developed sustainably, rapid bioenergy development could exacerbate challenges rather than help solve them. A concerted effort to identify, develop, and disseminate best management practices is needed. There is very little effort going on at the federal government level regarding bioenergy best practices in the G8 +5 Countries.

Policies are driving growth but not necessarily sustainable growth. Government policies are causing rapid growth in bioenergy production. However without any sustainability performance requirements attached to these policies, unintended consequences are arising.

Sustainability assurance strategies have a key role to play in promoting good management of natural resources and improvement of rural livelihoods. The private sector has stressed that a harmonization of incentive structures at an international level would improve the business climate in bioenergy markets.[99]

As mentioned previously, the WTO legal context restricts mandatory (legally binding) social sustainability standards, especially for working conditions. Therefore, "other" policies (such as bilateral agreements between exporters and importers) are needed, and "alignment policies" such as best practice, project-finance related standards. The G8 Countries are the key donors in bi- and multilateral, development assistance and play a dominant role in defining project investments in lower income countries. Coordination of standards for such investments

[99] GBEP Dialogue between Private Sector, GBEP and WEC Italy, March 7, 2007

is needed. These sustainability assurances would not be subject to WTO rules that create a barrier to sustainability standards utilization in other contexts.

Labelling and certification of biofuels and related feedstocks may eventually be instrumental to ensure that widespread biofuel production and use will indeed be conducive to environmental improvements. Certification and labelling remain, however, a rather complex issue. Efforts should ensure that the development of sustainability criteria and certification systems contribute to reaching environmental objectives without creating unnecessary barriers to international trade, especially to exports from developing countries. Emphasis could be placed on best practices, guidelines and a better use of existing knowledge related to land and water resources associated by capacity building in countries that could be significant exporters of biofuels. Such an approach could also contribute to poverty alleviation and less carbon intensive production systems.

Some important countries (e.g. United States, India, China) could make important contributions to sustainability standards and certification schemes. A focus on collaboration with these countries would expand the reach and influence of sustainability standards.

2.7.4 Climate Change

Climate change is a key driver behind bioenergy development in Europe and a number of other countries. In order to maximize GHG emission reductions and minimize costs, bioenergy support policies are increasingly focusing on biogas and CHP. Bioenergy policies focused on maximizing GHG emissions reductions should focus on emissions impacts rather than bioenergy quantity targets as is being done in the United Kingdom and the United States state of California.

2.7.5 Trade

Reducing and eliminating trade barriers and phasing out trade-distorting subsidies would contribute to establishing a level playing field for the bioenergy sector and should be considered a key objective. Investors in prospective biofuels export facilities need to be assured that markets will be open and they will be able to exploit economies of scale.

Support policies that phase out over time have been used successfully in some countries to ensure that government supports do not become an entrenched, inefficient use of government support.

Domestic and regional policies can positively affect bioenergy trade flows. For example, the EU has passed several biofuels support policies over the past few years including a biofuels directive in 2007, building upon former legislation EC 2003/30, which requires a 10% biofuels penetration level for transport fuel in all EU countries by 2020 effectively guaranteeing a market. It is widely acknowledged that most EU countries will have to import some fuel to achieve this target thus the policy is stimulating trade. Already production is ramping up in Asian, African and Eastern European countries to trade to and within the EU.