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Global Demands of Biofuels
Technologies, Economic Aspects, Market, and Policies

Ram Sarup Singh and Shivani Thakur

Abstract

Currently, the world is confronted with the twin crisis of fuel depletion and global environmental degradation, which resulted in rapid climate change. Indiscriminate extraction and lavish consumption of fossil fuels have led to the reduction of underground carbon resources. Moreover, the price of crude oil keeps on fluctuating and rising on a daily basis. Meanwhile, the scenario war for oil has already been started due to subsequent environmental concerns and political events in the Middle East. Over the globe, scientists have explored several fossil fuel alternatives (biofuels) of bio-origin, which have the potential to quench the ever-increasing thrust of today’s
population. Within few years from now, biofuels will transform from a niche energy source. In the foreseeable future, biofuel policies still require motivation by a plethora of political concerns, which can reduce dependence on fossil fuels and improve the environmental concerns. The shift from traditional fossil fuels to more exotic biofuels would constitute a very revolutionary change. In this chapter, an attempt has been made to collate the information on current biofuel scenario, technologies, economic aspects, market, and policies.

3.1 Introduction

Long back in 1925, Henry Ford stated, “We can get fuel from fruit, from that shrub by the roadside, or from apples, weeds, sawdusts almost everything! There is fuel in every bit of vegetable matter that can be fermented. There is enough alcohol in 1 year’s yield of a hectare of potatoes to drive machinery necessary to cultivate the field for a hundred years, and it remains from someone’s to find out how this fuel can be produced commercially better fuel at a cheaper price than we know now.”

Today, energy security is becoming a serious issue as fossil fuels are non-renewable energy and will deplete eventually in the near future (Masjuki et al. 2013). The increased use of fossil fuels has caused greenhouse gas (GHG) emissions, which have subsequently caused undesirable damage to the environment. The volatility of oil prices along with major concerns about the climate change, oil supply security, and depleting reserves has sparked renewed interest in the production of fuels from renewable resources (Dellmonaco et al. 2010). Then, a big challenge is to find new fields and to implement energy from the projected natural gases and non-conventional sources. As for now, future energy demand is expected to grow at an annual growth rate of 5%-7.9% for the next 20 years. The total biofuel demand is expected to meet approximately 27% of the total transport fuel demand in 2050 (Muller-Langer et al. 2014).

Biofuels are promoted as the best means to meet the prospected increase in energy demand in the coming years. The concept of biofuels was conceived in the 1970s, when the world faced a large-scale oil crisis. Biofuels can assist international development and poverty alleviation, because most people in the developing countries participate in agriculture to increase agricultural income, which strongly improves the overall welfare and also increases food security (Dale and Ong 2014). Biofuels are non-polluting, locally available, sustainable, and reliable fuels that are obtained from renewable sources (Demirbas 2008). Renewable resources are more evenly distributed than fossil and nuclear resources. There are other niche of renewable resources such as biogas, which have been derived by anaerobic treatment of manure and other biomass materials. However, the volumes of biogas used for transportation are relatively very small today (Naik et al. 2010).

The expanding biofuel sector involves both opportunities and threats for development (Bindraban et al. 2009). The increased pressure on arable land currently used for food production can lead to severe food shortages, in particular for the developing world, where already more than 800 million people are suffering from hunger.
and malnutrition (Dragone et al. 2010). So, increasing the production rate of biofuels within available land can be achieved through intensive research in biotechnology, plant agronomy, and use of precision agricultural techniques (Masjuki et al. 2013). An entire branch of biotechnology, referred to as “white biotechnology,” embraces the bioproduction of fuels and chemicals from renewable sources. The major factors that account for the explosive growth in biofuel sector and widespread enthusiasm for the technology are (1) opportunity to reduce dependence on fossil fuels through renewable energy, (2) search for energy security and energy dependence as emerging economies like the United States, (3) as a potential to reduce the net emission of CO$_2$ into the atmosphere and to reduce global warming, (4) to raise commodity prices, to improve income, and, most importantly, to increase rural employment opportunities (FAO 2006). Recent advances in synthetic biology can provide new tools for metabolic engineers to direct their strategies and construct optimal biocatalysts for the sustainable production of biofuels (Dellomonaco et al. 2010). India is the world’s sixth largest consumer of energy. The demand for energy is estimated to grow by eight times by the year 2030 at the present growth rate of 4.8% per annum. Every year, India is losing a substantial amount of foreign exchangers through import of crude fossil fuel, which caters to about 70% of the country’s requirement (Kaushik and Biswas 2010). To date, little research has specifically addressed biofuels in Asian context.

Transportation and agricultural sectors are the major consumers of fossil fuels and are the biggest contributors to environmental pollution that can be reduced by replacing fossil fuels by renewable fuels of bio-origin (Agarwal 2007). Nevertheless, the use of fossil fuels in transportation sector is growing faster and the trend appears to be moving up dramatically (Masjuki et al. 2013). The efficacy of alternative biofuel policies in achieving energy, environmental, and agricultural policy goal can be assessed using economic cost–benefit analysis (de Gorter and Just 2010). Biofuel policies could be motivated by a plethora of political concerns related to reducing dependence on oil, improving the environment, and increasing the agricultural income (Rajagopal et al. 2007). Policy makers should realize the future crisis to make a short-, medium-, and long-term policy considering all the views, aspects, and alternatives (Masjuki et al. 2013). The main approaches should be (1) tax reduction/exemption for biofuels and (2) biofuel obligations. Unfortunately, the broader picture is not so attractive. A number of concerns are raised by these developments without subsidies, because most of the biofuels have to compete price-wise with petroleum products in most regions of the world (Doornbosch and Steenblik 2007). In order to replace existing fossil fuels and to compete with them, technology development is a prerequisite. In order to enhance the production rate and oil yield, there is no alternative regardless of the advanced technologies.

3.2 End-Use Biofuel Technologies

Since the Arab oil embargo of the 1970s, Brazil has made an incomparable effort in the reduction of its energy dependency by intensifying and extending ethanol production from sugarcane. Today, Brazil is the second largest worldwide ethanol producer.
Renewable fuel standard has mandated biofuel production in the United States, since the establishment of the Energy Policy Act of 2005. Accordingly, 36 billion gallons of biofuels are supposed to be supplied to the market by 2022. Advanced biofuels need to constitute 58.3% of the total mandate (Ziolkowska 2014). The fundamental problem for the advanced biofuel industry is that, despite many attempts, none of them succeeded in identifying a commercially viable way to produce advanced biofuels at a cost-competitive level with petroleum fuels.

Several studies have been undertaken to address this problem and to provide a viable solution. One of the possible solutions is to use two fungal strains (*Thielavia terrestris* and *Myceliophthora thermophila*) because their enzymes are active at high temperatures between 40°C and 75°C (Berka et al. 2011). This will accelerate the biofuel production process and reduce the cost of second-generation biofuels. This will also improve the efficiency of biofuel production in large-scale biorefineries. Moreover, fungi can be exposed to genetic manipulation in order to increase the enzyme efficiency even more than its wild types (Stephanopoulos 2007; Vinuselvi et al. 2011). A similar solution has been given by the scientists from the U.S. Department of Energy (DOE), the BioEnergy Science Center, and the University of California, where they utilized the bacterium *Clostridium cellulolyticum* capable of breaking down the cellulose that enabled the production of isobutanol in a single inexpensive step (Casey 2012). Isobutanol can be burned in car engines with a heat value higher than that of ethanol and similar to gasoline. Thus, the economics of using *C. cellulolyticum* to break down cellulose is very promising in the near future. Furthermore, DOE researchers have found engineered strains of *Escherichia coli* having the ability to break down cellulose and hemicellulose of plant cell walls. In this way, necessary expensive processing steps in conventional systems can be eliminated that could subsequently reduce the final biofuel price and allow a faster commercialization process for the second-generation biofuels (Casey 2011).

### 3.2.1 Spark-Ignition Engines

For the combustion of petroleum, usually spark-ignition engines are used. These are internal combustion engines, where the fuel–air mixture is ignited with the spark. Spark-ignition engines can be either two strokes or four strokes. Generally, spark-ignition engines can also run with bioethanol if 10%–25% ethanol is mixed with gasoline, and no modifications in engines are required. But higher ethanol component blended in petroleum lowers its sustainability for standard car engines due to its certain characteristics. In general, E10 blends do not require engine tuning or vehicle modifications. In many countries, vehicles have been made adaptive by using ethanol-compatible materials in the fuel system and by turning engines for a midrange point, usually at the 22% ethanol level (E22). For using fuels with higher ethanol blends (E20–E100), conventional engines have to be refitted. This is due to characterization of ethanol to dissolve certain rubber and plastics. Larger carburetor
jets have to be installed; moreover, for the temperature below 13°C, cold-starting systems are needed for maximizing the combustion and minimizing non-vaporized ethanol. Depending upon the particular customization requirement, refitting costs may run from few Euros to more than €500. Recently, a number of vehicles are manufactured with engines that can run on any petroleum/bioethanol ratio ≤85%. The sensors of flexible-fuel vehicles (FFVs), that is, E85 FFV, can automatically detect the type of the fuel and adapt engine running. They adjust the air/fuel ratio and the ignition tuning to compensate the different octane levels of fuels in the engines’ cylinders. Dedicated ethanol vehicles are more efficient in using pure ethanol due to better combustion characteristics than FFVs. They retain dual-fuel capacity. Moreover, ethanol, in particular, ensures complete combustion, reducing carbon monoxide emissions (U.S. EPA 2010). Volkswagen, Fait, General Motors, and Ford have all produced dedicated ethanol versions for more than 25 years with full warranty coverage.

3.2.2 Compression-Ignition Engines

Compression-ignition engines are designed for being fueled with diesel. Ethanol is difficult to ignite in a compression-ignition engine. The only option for ethanol ignition is to blend it with an additive to enhance fuel ignition. Other approaches of using ethanol in diesel engines are either to use diesel and ethanol simultaneously by “fumigation” or to convert the diesel engine into a spark-ignition engine.

3.2.3 Fuel Cells

Direct ethanol fuel cell (DEFC) systems hold several advantages, as when bioethanol is fed directly into DEFC and no catalytic reforming is required as such. Moreover, storage of ethanol is much easier than that of hydrogen, and storage of liquid ethanol does not need to be done at high pressure. This will enable vehicles to use a combination of conventional and lower-cost fueling systems (WWI 2006).

3.2.4 Lipid Biofuels

Biodiesel can cause damages to conventional engines. Because of their solvent properties, fuel supply systems and fuel filters may clog due to breakdown deposits. The appropriate blending ratio of biodiesel with fossil diesel depends on appropriate measures. Typical blends are B5, B20, and B30 with 5%, 20%, and 30% biodiesel concentration, respectively. For older models, rubber and plastic components must be replaced with more resistant materials. The use of lower blends requires no or only minor technological modifications, whereas the use of higher blends, such as B100, needs more efforts in modification of engine and fuel component system.
3.2.5 Compression-Ignition Engines for Pure Plant Oil

Pure plant oil (PPO) cannot be used in diesel engines due to its high viscosity, so the engines should be modified accordingly. When PPO is used in unmodified engines, results can be poor atomization of the fuel in combustion chamber, incomplete combustion, coking of the injectors, and accumulation of soot deposition in the piston crown, rings, and lubricating oil (WWI 2006). Several refitting concepts have been developed, which include either preheating the fuel injection system or using the preequipment with a two-tank system. By using the latter technology, the engine is first started with diesel and is switched off to PPO, when the operating temperature is achieved. Shortly before being turned off, it should be ensured that it does not contain the traces of PPO. PPO should not be used in neither pure form nor mixed with diesel in updated engines, as its combustion properties differ so widely from those of diesel and can cause damage to the injection systems and deposits in the engine may also occur (Paul and Kemnitz 2006).

3.3 Economic Aspects of Biofuels

Interest in biofuels began with oil shocks in the 1970s, but the more rapid developments of biofuel industry in recent years has been primarily driven by mandates, subsidies, climate change concerns, emissions targets, and energy security. Broadly speaking, currently biofuels are more expensive than fossil fuels. From 2004 to 2006, the production of ethanol fuel grew by 26% and biodiesel grew by 172%. In 2004, 3.4 billion gallons of ethanol fuel was produced from 10% of the corn crop. Ethanol demand is expected to more than double in the next 10 years. To meet this demand, new technologies must move out from the laboratories to commercial reality (Bothast 2005). The world ethanol production is about 60% from sugar crop feedstocks. At present, biodiesel accounts for less than 0.2% of the diesel consumed for transport (UN 2006). According to one assessment, biodiesel is about US$0.27 per liter more expensive than regular diesel (Duncan 2003; OECD-FAO 2007). The major economic factor to consider for input costs of biodiesel production is the feedstock, which is about 75%–80% of the total operating cost. On an energy basis, ethanol is currently more expensive than gasoline in all regions of the world except Brazil. Ethanol produced from corns and grains in the United States and Europe, respectively, is more expensive than from sugarcane in Brazil.

Generally, biofuels are more costly than fossil fuels, and consumers will only use them if the cost is compensated by the government or if they are forced to use the biofuels. Currently, biofuels require subsidies, tariffs, fuel mandates, and other government supports for economic viability. Thus, government and consumers are both paying a significant premium to gain the expected benefits of biofuels. A myriad of policies are employed for U.S. biofuels including consumption subsidies, mandated minimum levels of consumption, and production subsidies including feedstock, import barrier, and sustainability standards (Gardner and Tyner 2007).
In Asia, biofuel production requires additional use of land, water, and fertilizers. Additional fertilizers are required to significantly increase the biofuel crop production. In India, where Jatropha plantation has been promoted for biodiesel production, it will require an additional 14.9 mt of organic manure and 2.6 mt of fertilizer per year to meet the production target. Technological advancements are required for the oil extraction, transesterification, and fermentation processes for the production of biodiesel and bioethanol to meet the requirements of biofuels. Moreover, the development of kinetic models that include accurate regulatory network parameters to facilitate the identification of enzymatic bottlenecks in metabolic pathways can be harnessed to achieve production of biofuels (Dellomonaco et al. 2010).

The demand for energy is increasing everyday due to rapid outgrowth of population and urbanization (Demibas 2008). Several countries have already enacted laws that mandate the production of biofuels to meet future demands (Kojima et al. 2007). Total cost of biofuels is composed of the cost of biomass production, biomass transportation, biomass conversion, and labor. Reduction of our demand for petroleum products could also reduce its price and will also generate economic benefits for consumers (Huang et al. 2013). Economic advantages of a biofuel industry would include an increased number of rural manufacturing jobs, an increased income taxes, reduced GHG emissions, and reduction of country’s reliance on crude oil imports.

3.4 Biofuel Policies: World Scenario

Commercially available biofuels are almost entirely produced from food crops like sugarcane, sugar beet, corn, and oil seeds; therefore, policies encouraging biofuel production have repercussions on the markets of goods related with biofuel production (Sorda et al. 2010). A recent report issued by the Joint Research Center of the European Commission in Seville (2010) provides an extensive overview of current policy actions promoted by countries across the world to foster both biofuel production and consumption. The main reasons behind the countries’ decision for green energy production are the will (or the need) to reduce dependence on fossil fuels (energy security), to reduce GHG emissions (climate change mitigation), and to increase demand for certain agricultural products that suffer from production surplus (support to farmer’s income). Each of these three reasons has been criticized. Energy security, for example, could be achieved not only by encouraging biofuel use, but also through other forms of domestically produced renewable energy such as solar and wind power. The contribution of biofuels in reducing GHG emissions has been contested as well. Currently, biofuels are mainly produced from agricultural commodities such as ethanol from corn and biodiesel from rapeseed or palm oil. Farmers can be induced, by higher commodity prices, to put more land under cultivation or to make their production processes more intensive. This may result in an increase of CO₂ emissions from the agriculture sector that can eventually offset the GHG emission reduction obtained from an increase in biofuel consumption. Finally, it is true that an increased demand for food and non-food agricultural products can raise farmer’s income; however, this might come at the expenses of food consumer
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worldwide and the environment. Biofuel policies are making an upward pressure on agricultural prices and can also undermine the environment since they encourage the expansion of agricultural areas at the expenses of rainforests and wilderness (direct and indirect land-use changes). It is important to fully understand the policies issued by the major biofuel producer and consumer countries, because their decisions can have a substantial impact on world markets of both bioenergy and agricultural products.

3.4.1 Brazil

Since the 1970s, Brazil has been at the lead to produce biofuels, in particular ethanol from sugarcane. Because of a combination of climate, soil, and 45 years of sustainable technological research and development, Brazil is currently the lowest-cost producer of sugarcane to date and, consequently, of ethanol for automotive transport. In 2006, there were 320 combined sugar mills and bioethanol distilleries in the country, with a total installed processing capacity in excess of 430 million tons of sugarcane. Including 51 new plants and expansion of those existing, together they could produce up to 30 million tons of sugar and 18 billion liters of ethanol per year (GBEP 2007). The largest plant in Brazil has a production of just below 330 million liters of ethanol per year. There are about 250 separate producers, but most of them are grouped in two associations that make up 70% of the market.

Unlike other countries with substantial biofuel production, Brazil does not offer production subsidies for bioethanol. However, the government has made it mandatory since 1977 for light vehicles to have the E20 blend, with vehicles running also on using up to E25 blends. Brazilian sugarcane ethanol is the only ethanol that is competitive with petroleum, and the E20 mandate causes minimum distortion, because it requires ethanol up to the cost-equivalent level. As a result, Brazil has been hailed as an example of successful biofuel subsidization, and its current mandate is purportedly for environmental rather than economic reasons. However, Brazil’s current ethanol infrastructure is extremely costly to set-up for the government and taxpayers, and it requires decades of taxpayer subsidies, before it became economically viable (Xavier 2007). Though Brazil has a comparative advantage in ethanol production, it still suffers substantial drawbacks through subsidies that serve as an interesting lesson, especially for countries with less cost-effective biofuels such as the United States and European Union (EU) nations.

Although bioethanol is currently not subsidized, the government has given tax breaks to company producers of biodiesel to support domestic production and the research and development of biodiesel. The Brazilian government created the Brazilian Biodiesel Program in 2003 in order to encourage domestic production of biodiesel from SVO and to limit the import of biodiesel. Companies compete for the distribution and sale of produced biodiesel and are evaluated for social sustainability plans. The ministry of agrarian development claimed that 30,000 families are employed in the raw material production of biodiesel, although Brazil has recently come under criticism that projects do not contribute significantly to rural
development and job creation from biodiesel is far lower. By the mid-1980s, more than three-quarters of all cars in Brazil were running on hydrous ethanol. A surge in sugar prices at the end of the 1980s, coupled with lower oil prices, led to a slump in ethanol production as growers diverted their production to the export market and to a loss of public confidence in the security of ethanol supply. By the end of the 1990s, sales of ethanol-fueled cars had almost dried up. Interest in ethanol rebounded in the early 2000s with higher oil prices, and the first flex-fuel cars were introduced.

Rising demand for oxygenates has also driven up ethanol prices, boosting the profitability of ethanol production, and has stimulated investment in new sugarcane plantations and biorefineries. Less than 3 years after they were introduced, Flex-fuel vehicles (FFVs) now make up more than 70% of the vehicles sold in Brazil. Vehicle prices are no higher than for conventional gasoline cars. All refueling stations in Brazil sell near-pure hydrous ethanol (E95) and anhydrous gasohol, and about a quarter also sell a 20% anhydrous ethanol blend (E20). In total, almost two-thirds of the ethanol currently consumed in Brazil is anhydrous. The price of ethanol has risen faster than that of gasoline in the past years, mainly due to high international sugar prices. This has prompted the government to lower the minimum ethanol content in gasoline blends from 25% to 20% in order to prevent an ethanol shortage. Gasoline that does not contain ethanol can no longer be marketed in Brazil.

3.4.2 Argentina

Argentina started to subsidize biofuels in 2007 mainly to diversify the energy supply, to reduce the environmental impact, and to promote the rural development. The program focuses on conventional biofuels, since Argentina already has a large biodiesel industry based on soybean oil and a rapidly increasing ethanol industry based on sugarcane and grains. Starting from January 2010, gasoline and diesel sold in Argentina must contain 5% of biofuel. Prices for ethanol and biodiesel sold into the domestic market are established by the law. Biofuel producers do not enjoy tax incentives if they sell their products abroad. Conversely, producers who sell in the domestic market can ask for the reimbursement of the value-added tax (VAT). In addition, the government assures that all biofuel produced will be purchased for the 15-year period. However, the incentives are not guaranteed (they are renewed annually) and prices are set by the government. Argentinean biodiesel is produced from soybean, and major plants are located in the Rosario area. Argentina is still a small player in the world biofuel market, but its production is growing rapidly. Ethanol production is much more limited and is linked to the sugar industry. Biofuel produced in Argentina, despite the domestic incentives, is almost entirely exported because it enjoys more favorable export tariffs (15% effective levy) than the raw materials (soybean and soybean oil) form which it is produced. However, the new, stricter EU standards for biofuels (minimum of 35% reduction in GHG emissions) might represent a constraint for Argentinean exports in the coming years. The fact that Spain banned imports of biodiesel from extra-EU countries might negatively affect the Argentinean biodiesel industry in the coming years.
3.4.3 United States

Subsidies in the United States range from US$5.5 billion to US$7.3 billion annually and support the exponentially growing production of corn ethanol. Driven by subsidies, U.S. ethanol production has grown from 16.2 billion liters in 2005 to an estimated 24.5 billion liters in 2007. Given the current subsidies and support, production of biofuels is expected to grow over the next several years. The figure will reach 36 billion US gallons of renewable fuel used by 2022. Ethanol production in 2006 represented about 3.5% of motor vehicle gasoline supplies in the country. Most ethanol is used in low-percentage gasoline blends, but sales of high-percentage blends are rising. About 6 million FFVs are now running on E85 (a blend of 85% ethanol and 15% gasoline). The United States has a long history of tax reductions for biofuels, and it exempted gasohol (E10) in 1978 from the US$0.04/gal fuel-excise tax. This was replaced by an income tax credit in 2004. However, many U.S. states still retain fuel-excise tax reductions on pure biofuels and blends, with a value of about US$0.20/gal. These tax reductions are complemented by biofuel mandates that further support biofuel consumption. Energy Policy Act 2005 established a mandate that requires renewable resources account for at least 4.2% of transport fuel distributed to U.S. motorists. U.S. subsidies, like those of other OECD countries, boost supply at every step of the production process. Investors in biofuels also benefit from tax credits and grants from local, state, and federal governments, a trend called “subsidy stacking.” Municipal governments can offer free land and utility; the state offers tax credits for investment and economic development grants; and the federal agency provides support through environmental, agricultural, and regional development program. Energy Policy Act 2005 expanded grants for capital inputs, authorizing an average of US$250 million over 2 years in grants for cellulosic ethanol plants, as well as loans for ethanol production from cellulosic biomass or municipal solid waste. Municipalities and states have offered further support through similar grants and investment incentives. See the Global Subsidies Initiative (2007) report for more details.

The production capacity of the U.S. ethanol industry is rising sharply as new plants have been built or are under construction. By the end of 2007, over 126 ethanol plants were in operation and another 100 were under construction. Most of them are dry mills, which produce ethanol as the primary output; wet mills are designed to produce a range of products alongside ethanol, including maize oil, syrup, and animal feed. Production capacity in the industry is expected to exceed a staggering 36 billion liters (10 billion gallons) by 2008, but even this addition will not be sufficient to meet all new demands. The U.S. ethanol demand is outstripping the supply, with about 2.3 billion liters imported in 2006, mostly from Brazil. As a result, there are calls for import tariffs to be removed to prevent domestic ethanol prices from rising further, which would push up gasoline prices at the pump, and for fuel standards to be eased. The price of ethanol has risen sharply in recent years in absolute terms and relative to gasoline.

Ironically, despite significant support, the U.S. biofuel policy appears to have little net impact on the nation’s oil use. This is because the amount of fuel displaced by ethanol is more than offset by increased gasoline consumption due to less energy stringent vehicle efficiency standards permitted by a loophole in legislation promoting flex-fuel vehicles (Childs et al. 2007). While ethanol’s share in the overall gasoline market is
relatively small, its importance to the corn market is comparatively large. About 14% of corn use went to ethanol production in the 2005–2006 crop year. Carryover stocks of corn represented about 17.5% of use at the end of 2006, but expanded use of corn to produce ethanol in the 2006–2007 crop year will leave the ending stocks-to-use ratio at 7.5% (USDA 2006). With continued strong ethanol expansion, the USDA’s 2007 long-term projections indicate that more than 30% of the corn crop will be used to produce ethanol by 2009–2010, remaining near that share in subsequent years. The United States also produces a small volume of biodiesel, mainly from soybeans; output totaled 220 kilotonne of oil equivalent (ktoe) in 2005, which is less than half of 1% of that of ethanol, although production capacity is growing rapidly. Support for biodiesel is much more recent. Minnesota was the first state to introduce a requirement that diesel must contain at least 2% biodiesel in 2005. A federal excise tax credit of 1 cent per gallon of crop-based biodiesel for each percentage point share in the fuel blend was introduced in January 2005. Soybean producers also receive hefty subsidies from the federal government.

3.4.4 Canada

Almost 70% of Canadian ethanol is produced from corn, while the remaining 30% from wheat. Biodiesel is from animal fats like tallow grease, yellow grease (used oil from deep fryers), and canola (rapeseed oil). Similar to the United States, Canada also mandates the blending of regular gasoline with ethanol. The Environmental Protection Act Bill C-33 established that gasoline must contain 5% of renewable fuel in 2010—similarly, addition of 2% renewable content in diesel and heating oil by 2012. It has been estimated that, in order to meet these targets, at least 1.9 billion liters of ethanol should be produced at current gasoline sale trends. To achieve the diesel and heating oil target, an additional 520 million liters of ethanol must be either produced or imported (Sorda et al. 2010). Federal mandates are not the only policy in place to support ethanol production. Ethanol manufacturers have been enjoying a CAN$0.10/L incentive rate since April 2008, thanks to the ecoENERGY for Biofuels Program. Starting from January 2011, however, the incentive rate started to decline by CAN$0.01 per year until it will reach CAN$0.04 in 2015 and 2016. A similar incentive exists also for biodiesel producers. In this case, the incentive rate is CAN$0.20, also declining in the next few years, until it reaches CAN$0.06 in 2016. Several found schemes are also in place to expand biofuel production through an increase of production capacity (new infrastructure). Similar to what happens in the United States, also in Canada, local government (provinces) integrates federal measures with their own policies. Finally, trade protection is much lower than that of the United States and the EU. Renewable fuels from NAFTA countries can be imported duty-free, while there is an import tariff of CAN$0.05/L on Brazilian ethanol.

3.4.5 European Union

Over recent years, the EU has significantly increased its consumption of biofuels. According to the first estimates for 2006, biofuel consumption in the EU grew
from just below 3 million tonnes of oil equivalent (Mtoe) in 2005 to approximately 6
Mtoe in 2006, growth of 86.5%, and reaching a 1.9% share of fuels used in transport
(EurObserv’ER 2007). Biodiesel predominates, representing 71.6% of the energy con-
tent of biofuels dedicated to transport, significantly ahead of bioethanol (16.3%) and
the other biofuels (12.1%, i.e., 629,809 tons oil equivalent [toe] of vegetable oil and
13,940 toe of biogas) (EurObserv’ER 2007). Consumption of biodiesel increased by
71.4% between 2005 and 2006, compared with 57.5% growth for bioethanol. Data for
2005 show that the total area used for energy crop production was around 2.8 million
hectares, representing about 3% of the total EU-25 arable land (EC 2006). Biodiesel
and ethanol are mainly used blended with diesel and gasoline, respectively, in low
proportions, but high-proportion blends (e.g., ethanol used for FFVs) and pure forms
are also available in some countries, such as Sweden. Most of the ethanol is processed
into ethyl tertiary butyl ether (ETBE) that is used as an additive to gasoline. Biodiesel
is produced primarily from rapeseed. In 2004, an estimated 4.1 million tons of rape-
seed was used, equal to slightly more than 20% of EU-25 oilseed production. Germany
is the main producer, followed by France, Italy, and the Czech Republic. Since, EU is
by far the world’s largest producer of biodiesel, there is no significant external trade.
Import duties on biodiesel and vegetable oils are between 0% and 5% (EC 2006). EU
production of bioethanol is estimated to have used around 1.2 million tons of cereals
and 1 million tons of sugar beet from 2004’s raw materials. This represents 0.4% of
the total EU-25 cereals and 0.8% of sugar beet production. Apart from France, where
three-quarters of bioethanol is obtained from sugar beet, the majority of EU plants
process grains mainly maize, wheat, and barley. The leading EU producers are Spain,
Germany, and Sweden. In Europe, biofuels have been championed as an energy source
that can provide new incomes for farmers both domestically and abroad, increase
security of energy supply, and reduce GHG emissions from transport. EU currently
does not have a community-wide excise tax on transport fuels, and member states can
grant tax preferences according to their individual needs. However, there are coordin-
ated efforts to increase the use of biofuels to meet a proposed mandate to fill 10% of
transportation energy needs with biofuels by 2020. At the European Council summit
on March 8–9, 2007, the EU’s member states formally endorsed the 10% biofuel target
but made it clear that such a goal must be subject to sustainable biofuel production and
that the so-called second-generation biofuels become commercially viable (EC 2007).
This conditionality is linked to increasing concerns about the sustainability of the first-
generation biofuels currently available (e.g., biodiesel, bioethanol), which are made
from agricultural crops. In early 2008, the European Commission proposed a manda-
tory sustainability certification scheme for both imported and domestically produced
biofuels, requiring at least a 35% reduction in GHG emissions compared with fossil
fuels. While Europe lags behind the United States and Brazil in ethanol production, it
has provided support to its growing biodiesel industry. Energy crops in EU member
states are heavily subsidized, and farmers are compensated for setting aside land. Set-
aside land makes up about 10% of the total EU farmland, and it is used 95% of the time
to grow energy crops. Energy crops further qualify for set-aside payments and energy
crop aid, and they are excluded from production quotas. Nine member states have
further set mandatory blending requirements, and the majority couple the mandate
with fuel-excise tax exemptions. While information on capital investment support is difficult, given individual member programs, available data show that state aid to industry may account for up to 60% of initial investment, with governments regularly providing grants that account for 15%–40% of capital infrastructure investment.

3.4.6 India

India’s biofuel production efforts are centered on second-generation biodiesel made from Jatropha. While mandatory blends are currently E5, there are discussions to raise the standard to E10 and eventually E20 blends as biodiesel from Jatropha becomes more cost effective. Individual states in India have adopted various policies to support the growing of Jatropha and research into biofuel production. The state of Andhra Pradesh formed a public–private partnership with the firm Reliance Industries, giving the firm 200 ac of land for Jatropha cultivation for biodiesel use. Similarly, the states of Karnataka, Chhattisgarh, and Rajasthan are promoting the planting of Jatropha saplings. In particular, Chhattisgarh will become self-reliant on energy by 2015, using biodiesel and selling Jatropha seeds for profit. In addition to encouraging Jatropha planting, the state of Tamil Nadu has abolished the purchase tax on Jatropha in order to promote its distribution and use.

3.4.7 China

China’s policies focus especially on ethanol since the country is a net importer of vegetable oil. In 2002, the government launched the Ethanol Promotion Program in order to reduce corn excessive stocks. In 2004, the National Development and Reform Commission (NDRC) initiated the State Scheme of Extensive Pilot Projects on Bioethanol Gasoline for Automobiles with which the government controlled both production and distribution of ethanol. In 2006, some pilot projects implemented in 5 provinces and 27 cities reached the 10% blending target. Later on in the same year, the NDRC proposed to set a 6.6 billion liter target for 2010, but the proposal was rejected by the State Council because of high food prices. In 2007, the NDRC launched the Medium- and Long-Term Development Plan for Renewable Energy, which establishes that renewable energy’s share of total primary energy consumption must rise to 10% by 2010 and to 15% by 2020. Of course, biofuels will play a key role to reach these targets. Ethanol production is projected to reach 2 million tons by 2010 and 10 million tons by 2020. Biodiesel consumption targets were also established to be 200,000 tons by 2010 and 2 million tons by 2020. The government is fully committed in meeting these objectives without affecting food prices. To do so, it does not allow factories to employ corn in ethanol production but instead encourages the employment of crops such as cassava, sorghum, and sweet potatoes. These restrictions, however, reduce the potential of Chinese production, which is nevertheless forecasted to reach 1.7 million tons in 2009.

The government also controls ethanol price, which is maintained at a level that would make production not economically feasible without external financial assistance.
In 2007, producers were granted a US$200/ton subsidy, which was replaced in 2008 by payments based on the evaluation of individual plant’s performance. Additionally, ethanol producers do not have to pay the 5% consumption tax and the 17% VAT. Intermediate inputs like grains and fertilizers were also granted financial assistance. Similar to what happens in both the United States and the EU, also in China, research on second-generation biofuels is supported. The subsidy is about US$438/ha for Jatropha plantations and US$394 for Cassava. No direct subsidies are given for biodiesel. Biofuel production in China is directed by the state through the state-owned industry. Production and demand are stringently planned and controlled. The Chinese government has recognized the importance of using sustainable energy, and the NDRC is directing increased production of biofuels, with a target to produce 2 million tons of biodiesel by 2020. China has a large variety of feedstock options for biodiesel production as well, with promise in Jatropha, Rapeseed, and Soybean. The State Forestry Administration recently allocated 7000 ha in Hebei province for biodiesel production. Hebei is one of seven regions that will be used as biofuel demonstration forests. In 2007, the NDRC signed a memorandum of understanding with the U.S. Departments of Energy and Agriculture to facilitate further development of biofuels and facilitate transfer of scientific and technical knowledge on feedstocks and biofuel production. Although widespread mandates have not yet been established in China, there are mandatory E10 blends in five provinces, that is, Heilongjiang, Jilin, Liaoning, Anhui, and Henan.

3.4.8 Australia

Australia started subsidizing the biofuel sector in 2001 and set a non-binding target of 350 million liters to be reached by 2010. In 2006, two Australian states set two even more stricter targets: New South Wales a 10% binding share of ethanol in gasoline by 2011 and Queensland a 5% one. Australia’s biofuel production in 2007 was 83 million liter for ethanol and 77 million for biodiesel. The statistical data from U.S. EIA, 2015, were related to Asia–Oceania biofuel production pattern during 2000–2012. Despite these small figures, biofuels are highly subsidized if compared to other industries. The most important policy is the tax rebate, which has been established to offset the fuel-excise duty of A$0.38143 per liter for both ethanol and biodiesel until 2011. In July 2011, the tax rebate for ethanol was abolished even though the excise was lowered to A$0.125. The Energy Grant–Cleaner Fuel, however, kept guaranteeing an alternative subsidy for ethanol: A$0.1/L decreasing by A$0.025/year until 2015. Biodiesel underwent a similar treatment when the excise duty dropped to A$0.191/L in 2011 and the Energy Grant–Cleaner Fuel program introduced a A$0.153/L subsidy, also decreasing until 2015, when it will be eliminated.

3.4.9 Thailand

Thailand’s biofuel policy incentivizes both biodiesel through mandatory blending and ethanol consumption through tax exemptions, which allow ethanol blends to
be cheaper than regular gasoline. Ethanol is produced from sugarcane and molasses, but tapioca-based production is expanding. Gasoline blended with ethanol is called “gasohol,” which has contributed to a significant decrease of standard gasoline and currently accounts for nearly 50% of total gasoline consumption. Gasohol is exempted from the excise tax and this allows ethanol blends to be 10%–15% cheaper than regular gasoline. The government is active in further promoting biofuel production, especially through the diffusion of E20 and E85 blends as well as of flex-fuel vehicles. E20 and E85 blends will be substantially cheaper than regular gasoline (−20% and −50%, respectively), thanks to excise duty exemptions and additional state subsidy from the State Oil Fund. Biodiesel with 2% methyl ester content has completely replaced regular diesel in the whole country in 2008. A B5 blend should start to be enforced in 2011. Additionally, the government set up the Committee on Biofuel Development and Promotion in order to increase domestic palm oil production, the main biodiesel feedstock, of which currently Thailand is a net importer (Sorda, Banse and Kemfert 2010).

3.4.10 Malaysia

Malaysia is one of the greatest palm oil producers in the world, and this gives the country a big competitive advantage in biodiesel production. The government first intervened in 2005 with the National Biofuel Policy that introduced a 5% biodiesel blending (B5) mandate, which has been implemented recently. At the moment, biofuel production in Malaysia is not economically viable yet, mainly because of high palm oil prices, which makes palm oil producers (that are also biofuel manufactures) more convenient to directly sell palm oil instead of further processing it. The Malaysian biodiesel sector is suffering from competition from neighboring Indonesia. As a result, Malaysian exports have substantially decreased in the recent years (USDA 2012). Malaysia produces two types of biodiesel, that is, envodiesel and palm methyl esters (PME) biodiesel. The latter is the result of the blending of regular diesel with raw palm oil and is used only domestically, despite car manufacturers discourage its use. The former is exported and represents the largest share of total biodiesel production (75%). In 2007, Malaysia exported slightly less than 100,000 tons of PME biodiesel. Producers can be eligible for financial support through two aid schemes, that is, the pioneer status and the incentive tax allowance. The first provides a 70% tax reduction on the statutory income obtained from biodiesel production for 5 years. The second is for the companies with high investment costs in equipment and machinery, where allowances spent for fixed assets can be detracted from taxable income for a 5-year period. Trade restriction measures are not present. Exports of processed palm oil or biodiesel are duty-free, while crude palm oil exports are taxed.

3.4.11 Indonesia

In 2008, the Indonesian government established mandatory levels of biofuel consumption. Biofuel must reach 2.5% of total energy consumption by 2010 and 20% by
2025. The ethanol component of gasoline was of 3% by 2010 and increase to 15% by 2025. Later on these targets were reformulated and raised to 10% of biofuel share by 2010. Indonesian Ministry of Energy and Mineral Resources and Parliament come to an agreement to provide biofuel subsidies at 3000 rupiah per liter for biodiesel and 3500 rupiah per liter of ethanol in 2013. Moreover, Indonesia coal and mineral mining companies are required to consume 2% of biofuels in their total fuel consumption starting from July 2012. Biofuel blending policies, however, have been hampered by high feedstock prices. In 2006, Pertamina, the state-owned oil and fuel distribution company and only biofuel supplier, started selling a gasoline blended with 5% biodiesel (B5); however, in 2009, it was forced to reduce the blend to 1% due to higher palm oil prices. Pertamina, starting from February 2012, started blending conventional diesel with 7.5% biodiesel. New production facilities are under construction for both biodiesel and ethanol. In 2010, biodiesel production capacity was more than 4 million tons/year. Ethanol capacity was much lower, but the new facilities under construction will make it possible to reach higher outputs. In 2011, almost 90% of Indonesian biodiesel production was exported. Most of biodiesel goes to the EU. In 2011, 39% of total EU biodiesel imports came from Indonesia. The government provides fuel subsidies for almost 15 billion dollars, which are used to allow the selling of ethanol and biofuel blends at the same price of standard gasoline. Of course, this implies heavy losses for Pertamina, which account for about 40 million dollars/year.

3.5 Conclusions

Because of the strong and growing demand of crude oil and stricter emission standards, the demand for alternative fuels is increasing. Biofuels are the right solution as an alternative to petroleum fuels to bridge the gap. Biofuels are steadily gaining recognition as an important part of agricultural and energy sectors. Within a couple of years, biofuels have transformed from a niche energy source. All the countries hope that biofuels will provide a win–win strategy that can simultaneously promote energy security and economic developmental protection. Production of biofuels is still expensive; moreover, the fuel quality is not yet constant and conversion technologies of certain biofuels are still immature.

There is an urgent need to review existing biofuel policies in an international context in order to protect the poor and to promote rural and agricultural development while ensuring environmental sustainability. Undoubtedly, the multidisciplinary research efforts that combine new molecular approaches for strain development and process integration in the framework of process engineering will allow expansion and commercial implementation of innovative technologies to exploit the vast resources. There is lack of knowledge on biofuels in general public. Public acceptance for biofuels will be the last challenge to be addressed once all the systems are in place. Since public is the major user of fossil fuel in transportation sector, lack of public support for new transportation fuels can eventually lead to catastrophic failure.
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