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The Future Role of Bio-Fuels in the Asia-Pacific Region

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The Future Role of Biofuels in the Asia-Pacific Region[1]

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Abstract: There is growing interest in agriculture as a source of bio-fuels to replace petroleum-based transportation fuels. Ethanol production has more than doubled from 2000 to 2005 but still accounts for less than two percent of the world's transportation petrol supply. The future role of bio-fuels will be determined by continuation of high oil prices, availability of low cost feed stocks and favorable government policy. Possible government strategies include a strong policy commitment to reduce investment risk in the biofuel sector, public support for commercializing second generation biofuel, and accounting for country-specific agricultural and economic realities.

Introduction

In 2006, oil prices surpassed US$75 per barrel and came very close to equaling the record prices of 1980 in real terms. Other energy prices followed suit. For the Asia-Pacific food system, high energy prices have direct costs in outlays for fuel and electricity and indirect impacts, such as the cost of fertilizer needed to produce crops. These raise farm production costs but, more significantly, increase the costs of transporting, processing and marketing food products to the region's 2.7 billion consumers. Unlike previous high-price periods, the current increase in oil prices is having a fundamentally different impact on the food system, creating a more sustained interest in agriculture as a supplier of energy, not just a consumer.

Growth of Biofuels

Biofuels are made from agricultural and other organic materials. Ethanol, the biofuel produced in greatest volume throughout the world, is made primarily from sugar or corn, though a variety of other starch- or sugar-based feedstocks can also be used. Ethanol is primarily used as an additive, mixed with petrol as an octane enhancer in blends up to 10 percent, or as a substitute in larger blended amounts. Ethanol production more than doubled to 46.2 billion liters in 2005 from 17.6 billion liters in 2000 (Figure 1). Global biodiesel production has also grown rapidly in recent years, to 3.9 billion liters in 2005, but is still less than 10 percent of ethanol production. Biodiesel is produced from oil-bearing crops like soybeans and the fruit of the African palm, though it can also be made from animal fats and recycled cooking oil. Blends of 20 percent biodiesel and 80 percent diesel can be used in unmodified diesel engines. Most biodiesel now is produced in Europe.

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[1] This paper draws on Pacific Food System Outlook 2006-07, The Future Role of Biofuels which can be accessed at www.pecc.org/food.

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Second-generation ethanol made from cellulose is in a pilot production phase in some economies and will greatly broaden feedstock availability when it becomes commercially profitable.

Biofuels are not perfect substitutes for fossil fuels. Ethanol has only about 70 percent of the energy content of petrol, and biodiesel 80 percent of the energy content of diesel (von Lampe, 2006). Shipping ethanol generally requires expensive truck or rail transportation since ethanol absorbs water and dissolves impurities encrusted on the inside surfaces of pipelines, potentially contaminating the fuel.

Biofuels and Policy Goals

In the Asia-Pacific region, two economies—the United States and China—account for more than 90 percent of the region's total ethanol production (Figure 2); others have much smaller programs but are planning to expand them. While biodiesel production is miniscule in the region, Malaysia and Indonesia are initiating ambitious programs to develop biodiesel from palm oil, a plentiful and low-cost feedstock in those economies. In economies pursuing biofuel programs, there is much interest in their potential to meet three policy goals:

Reduce dependence on imported oil

Biofuels are viewed as a potential alternative fuel for reducing the region's dependence on oil, particularly imported oil from unstable parts of the world. Region-wide oil production has barely grown in 20 years, yet consumption has grown rapidly in China and other middle-income economies. U.S. oil consumption is at a high level and has also grown rapidly over the past 15 years. Some oil production growth is occurring in Mexico, Canada, and several Southeast Asian and South American economies, but this is offset by production declines in two of the region's biggest producers, the United States and Indonesia.

Reduce green house gas emissions and pollutants

Use of biofuels is viewed as a means to help mitigate serious pollution problems. The region has 40 percent of the world's population, generates 50 percent of global gross domestic product (GDP) and consumes 60 percent of global oil supplies. Rapid economic growth has led to environmental degradation, now a key concern in many Asia-Pacific economies. Eighteen of the 20 most polluted major cities in the world are in the Asia-Pacific region.

Revitalize rural areas

Biofuel production is viewed as a potential contributor to rural economic development by promoting value-adding activity, creating employment opportunities, and generating new markets for agricultural raw materials. Given prospects for rapid urbanization in the region's developing economies in the next 20 years, biofuel production could help retain or even attract new resources to rural areas.

What Will Sustain Biofuels' Future?

The extent to which the region's biofuel programs develop and succeed in the future will depend on the following interrelated and dynamic factors:

High oil prices

Continuing high or rising oil prices will boost the commercial prospects for alternative fuels, while a decline will do the reverse. The current high oil price period differs from the two previous high-price periods. Prices have risen gradually over a span of more than six years rather than spiking sharply and then rapidly declining (Figure 3). Prices are projected to remain relatively high for the next five years according to the US Department of Energy (Shane 2006). These high prices prolong opportunities for efficiency gains, stimulate energy conservation, and generate increased supply from traditional and alternative energy sources, including biofuels. While these adjustments will eventually lower oil prices, most forecasts do not show real oil prices falling below US$40 per barrel.

The current oil market has been affected by supply-side constraints and uncertainties. A high-risk premium for potential supply disruptions, limited production and refining capacity, and environmental concerns limit new production. The market has also been driven by very significant demand-side factors. These include strong world economic growth and rising oil demand from rapidly growing middle-income economies, where consumers are demanding a higher standard of living and are exhibiting big appetites for energy. Rising oil prices have not yet slowed the pace of global income growth, which has actually accelerated since 2001. Almost two-thirds of recent global growth in oil demand has come from China and other middle-income economies, although China's growth clearly is in a class of its own. China's oil consumption now ranks ahead of Japan and is second only to the United States (Feer 2006).

Low-cost feedstocks

The two leading producers of ethanol in the world are the United States and Brazil. Both have plentiful and low-cost supplies of feedstocks. An OECD report found that these two economies were the only ones with viable biofuel programs, given US$39 per barrel oil prices in 2004, the base period for the analysis. Brazil's sugar ethanol sector was economically viable at US$29 per barrel and the US corn ethanol sector without subsidy at US$44. At that time, estimates of biofuel profitability for other OECD economies depended on oil prices between US$65 and US$145 per barrel (von Lampe 2006).

There are other significant inputs required in biofuel production. Energy may account for 20 percent of biofuel operating costs, but feedstocks are by far the most significant cost.

According to a USDA study, feedstock costs can range from 37 percent for sugar cane ethanol in Brazil, to 40 to 50 percent for corn ethanol in the United States, depending on whether produced using a dry or wet milling process. Sugar beets represent 34 percent of the cost of production of sugar-based ethanol in the European Union (EU) (Shapouri et al. 2006).

Biofuel producers face the uncertainty of both volatile input (feedstock and fuel) and output prices. U.S. ethanol producers enjoyed growing margins from a "perfect storm" of rising ethanol prices and stable corn prices starting in 2004 through most of 2006, but markets have recently changed (Swenson, 2006). Oil and ethanol prices have dropped by almost a third and corn prices have risen by more than 50 percent in the last six months. Some estimate that with US$60 oil, U.S. ethanol plants break even paying US$4.00 per bushel for corn under current policies (Elobeid, et al. 2006). With oil prices now approaching $50 per barrel, the break even price is even lower. In the case of sugar ethanol, feedstock prices have tracked fuel prices. The relatively faster growth in corn ethanol margins versus sugar ethanol margins may explain the more rapid expansion in US than in Brazilian ethanol production in recent years (Figure 4).

Biofuel profitability is also enhanced by the sale or productive use of by-products. Dried distillers grain (DDG), a by-product of corn ethanol production, can be used as a protein-rich feed additive in dairy and beef rations and, in more limited amounts, in hog and poultry rations. Bagasse, the fibrous material left over from pressing sugarcane, can be burned to provide heat for distillation and electricity to power machinery, or sold to local utilities.

Second generation biofuels

Much attention, primarily in the United States, Canada and China, is focused on second generation ethanol derived from cellulose. Cellulosic ethanol is made from breaking down into sugar molecules the tough cellular material that gives plants rigidity and structure. That sugar is then converted into ethanol (US Department of Energy 2006).

Economical conversion of cellulose is illusive but has the potential to vastly expand the supply of biomass for alternative energy production. Cellulose is the most widely available biological material in the world, present in such low-value materials as wood chips and wood waste, fast-growing grasses, crop residues like corn stover, and municipal waste (Worldwatch Institute 2006). Furthermore, since ethanol from cellulose is the same as ethanol from grain or sugarcane, it could easily piggyback on the infrastructure now being put in place for ethanol. However, questions remain regarding environmental and logistical costs of harvesting, transporting and storing huge volumes of bulky cellulosic feedstock for processing into ethanol.

Converting cellulose to ethanol is not currently economical and is not likely to be so for another five years by the most optimistic forecasts. Production costs are estimated at US$2.20 per gallon (US$0.58 per liter) in the United States (Wall Street Journal, June 29, 2006). This is still significantly more than corn ethanol at US$1.10 per gallon (US$0.29 per liter) (Collins 2006) but could go much lower in the long run.

According to one study, the United States could produce a sustainable supply of more than one billion tons of biomass, which could yield 60 billion gallons (227 billion liters) of fuel ethanol (160 billion liters on a petrol-equivalent basis). That would be about one-third of the transportation fuel now used annually in the United States, and 15 times current US ethanol output (US Department of Energy and US Department of Agriculture 2005).

A public research role will continue to be essential, given the uncertainties about finding enzymes and processes to make cellulosic ethanol economically viable. A recent comprehensive "roadmap" by the US Department of Energy calls for coordination of public and private research efforts to further reduce costs of enzymes and increase the supply of biomass with crop varieties bred for higher yields per hectare (US Department of Energy 2006). Research is also focused on finding or developing varieties that grow well on marginal lands, have drought and pest resistance, are inexpensive to harvest, and are more easily converted to ethanol.

Government policy

Almost nowhere are energy markets free of government intervention. Biofuels are no exception. Strong policy support is a common feature in major biofuel- producing economies—Brazil (See appendix), the United States, and the EU. The governments of these and most Asia-Pacific economies use a variety of policy tools to encourage development and commercialization of biofuels (von Lampe, 2006). These tools include mandated blending requirements, production and use subsidies and, in the United States and elsewhere, replacing the oil-based methyl tertiary butyl ether (MTBE), an octane enhancer, with ethanol to reduce negative environmental risks. Policy is essential in promoting the development of infrastructure to deliver biofuels as widely as possible throughout the market and to promote the manufacture or retro-fitting of vehicles that can use them. It is important in supporting research and development of second-generation ethanol. Policy can also have a role in meeting environmental objectives by increasing the cost of fossil fuel use by taxing CO_2 or by requiring carbon capture and sequestration.

Competitive Fossil Fuel Alternatives

Oil overtook coal as the world's most important source of energy in the 1960s (Smil 2003), supporting the rapidly expanding use of the internal combustion engine. Most energy experts contend oil reserves will last for more than 40 years at current rates of production (Aspen Institute 2006) and that non-conventional fossil fuels could "…extend the hydrocarbon era into the second half of the 21st century" (Smil 2003). World oil output is forecasted to rise by 15 million barrels per day by 2015, a significant increase in light of current concerns about shortages (The Economist, April 20, 2006).

High oil prices have drawn attention not just to biofuels but to other fossil fuel alternatives. Large investments are being made in developing more difficult-to-access conventional oil resources located in remote areas or deeper waters, and in non-conventional sources such as tar sands, heavy crude oil and synthetic fuels. Many of these fossil fuel alternatives have lower costs of production than biofuels (Figure 5). Canada's oil sands, for example, can produce oil for US$25-30 per barrel.

Another alternative is converting coal to oil. This is of particular interest to economies with abundant coal resources, such as China and the United States. This technology dates back to the 1920s but has been used to the greatest extent by South Africa's Sasol Ltd., a partially state-owned energy company, for the last 30 years. Sasol is exporting the technology to China. With Sasol's assistance, China's largest coal producer has started to build its first coal-to-oil facility. Royal Dutch Shell Group has proposed building two plants in Shanxi Province, China, costing US$6-8 billion. Oil prices of US$30-35 per barrel may be sufficient to make coal to oil profitable despite the high investment costs (Wall Street Journal, August 16, 2006).

Environmental Tradeoffs

A key interest in developing or expanding production and use of biofuels is the environmental benefits, including the potential to reduce emissions, such as greenhouse gases (GHG). An estimated 25 percent of man-made global carbon dioxide (CO_2) emissions, the principal GHG, come from road transport which has grown rapidly over the past 40 years and is projected to continue to increase. This is especially true in developing parts of the Asia-Pacific region where economic growth, middle-class expansion and urbanization will be rapid in the next 20 years.

Both biofuels and petrol give off CO_2 when burned. Biofuels are theoretically carbon neutral, releasing CO_2 recently absorbed from the atmosphere by the crops used to produce the biofuel. Petrol and other fossil fuels add to the CO_2 supply in the atmosphere by giving off CO_2 absorbed and trapped in plant material millions of years ago.
The advantage of biofuels is less clear in a "life-cycle" analysis that examines not just combustion, but the production and processing of the feedstock into fuel. Most studies indicate that the net energy balance of biofuels is positive (Farrell et al. 2006), but there is considerable variability. Net balances are small for corn ethanol and more significant for biodiesel from soybeans, ethanol from sugarcane, and ethanol from cellulose (Hill et al. 2006). The variability arises from differences in the feedstocks used, the cultural practices employed to produce them, and the kinds of inputs used in processing. A high net balance for a biofuel's "life cycle" indicates a relatively less-polluting impact on the environment.

Biofuel production may have other environmental consequences, including heavy water use and toxic and odorific emissions from individual plants. Another important consideration is potential land requirements if biofuels become a more mainstream fuel. While average crop and biofuel yields are improving, biofuel production is still a very land-intensive energy source. According to the OECD, the EU would have to convert 70 percent of its agricultural land area to meet 10 percent of its fuel needs; the United States 30 percent; Canada 36 percent; and Brazil 3 percent (von Lampe 2006).

Technological advances and efficiency gains—higher biomass yields per hectare and more liters of biofuel per ton of biomass—will steadily reduce the economic cost and environmental impacts of biofuel production. In Brazil, for example, the ethanol yield per hectare of sugarcane production has tripled to 6,000 liters since 1975. The integration of ethanol and livestock production could increase efficiency and reduce the environmental impact by using the methane from cow manure to power the distillery and using the by-products in wet form to supplement feed requirements for dairy or beef animals. In this scenario, the estimated energy balance for corn ethanol would improve significantly (Howie 2006).

Biofuel production will likely be most profitable and environmentally benign in tropical areas where per-hectare biomass yields are higher, and fossil fuel inputs and other input costs are lower. For example, Brazil uses bagasse, which is a by-product from sugar production, to power ethanol distilleries while in the United States natural gas and coal are used (Worldwatch Institute 2006). Nevertheless, there are still concerns in economies like Indonesia about expanding palm oil production encroaching on fragile rainforest areas. There are also potential ethical concerns about the diversion of crops, land and other resources in very large quantities for the production of fuel instead of food.

Rural Impacts

Biofuel plants will boost local employment and economic activity. Construction will have temporary benefits, while operation will have more sustained economic impacts. One study estimates that an average-sized plant in the United States (150-190 million liters per year) generates one job for every three to four million liters of production (Swenson 2006).

Introducing biofuel production leads to tradeoffs in the local economy. Increased demand for a biofuel feedstock will raise its price, making it more expensive for competing users. This is seen most clearly with sugar. Brazil is the world's largest sugar producer, with twenty percent of production and almost forty percent of exports. More than half of that nation's sugar crop now goes to ethanol production, so sugar prices are highly correlated with the price of petrol and affect the cost of sugar for human consumption.

US corn prices have risen sharply in recent months because of the rapid expansion in ethanol production. The share of U.S. corn used in ethanol production was about twenty percent in 2006 and will likely rise to thirty percent by 2008. Higher corn prices raise feed costs for livestock producers. At the same time, dried distillers grain, a protein-rich by-product of ethanol production, lowers protein meal costs for dairy and beef feeding. However, according to one study, the savings would not be enough to offset the impact of higher corn prices on feed costs (Marshall and Greenhalgh 2006). Biofuel production also tends to restructure the agricultural economy in terms of the types of crops produced, the intensity of resource use (fertilizer, water), and the nature of local storage and transportation services.

Implications for Asia-Pacific Government Strategies

Relatively high oil prices will continue to sustain a keen regional interest in alternative fuels, including biofuels. Biofuels will likely play an expanding but modest role in the energy mix of almost every country in the region but will represent only one element of a broad-based portfolio of policy responses to high oil prices. Other policy elements include promotion of energy conservation, development and promotion of more efficient uses of energy, and expanded production of oil and non-conventional fossil fuels. Biofuels' future role may become more significant with the commercialization of cellulosic ethanol.

Promoting biofuel development is a relatively low-risk strategy for diversifying energy sources in economies with low-cost feedstocks. Expanding production and use of first-generation biofuels like sugar and corn ethanol or palm diesel may help the lay the groundwork for cellulosic ethanol. Biofuels do not require complete overhaul of existing infrastructure channels. In contrast, hydrogen fuel cell technology requires radically different energy distribution systems.

Environmental impacts of biofuels must be weighed. Biofuels may reduce harmful emissions, including GHG, relative to fossil fuels, but there is considerable variability depending on the feedstock used and the production methods and inputs used to produce those feedstocks. The resource-intensive nature of biofuel production generates land and water use impacts.

Biofuels may have more impact on local and regional economies than on energy markets. Biofuel production has the potential to generate new jobs, raise commodity prices and boost farm incomes. But policy makers must be mindful of economic tradeoffs, such as higher feed prices in the case of corn ethanol, or higher sugar prices in the case of sugar ethanol. Consideration must also be given to impacts on the intensity of land use and the structure of transportation, storage and local service sectors. In some remote or isolated areas, biofuels could help meet local energy needs and reduce dependence on fossil fuels from distant sources.

Policy commitments

As countries in the region assess options relative to biofuels, several approaches may need to be pursued. A critical factor in successful implementation of biofuels programs is a strong policy commitment to sustain development through periods of high feedstock prices and/or low oil prices.

There are several policy tools Asia-Pacific economies might consider:

- Tax incentives to biofuel producers and mandated blending targets to reduce investment risk from input and output price fluctuations
- Preferential taxes for consumers to encourage use of biofuels and purchase of biofuel-using vehicles, and for fuel distributors to offer biofuels at petrol/diesel stations
- Support public- and private-sector research to lower the cost of second-generation biofuel production by raising feedstock yields per area and biofuel yields per ton of feedstock.

Economy-specific strategies

The most desirable combination of government policy and private-sector actions to support expanded use of biofuels will be tailored to the specific economy. Key issues will be the unique energy and agricultural market conditions of each economy, as well as the public's commitment to such plans.

Indonesia, Malaysia and Thailand are similar to Brazil in terms of agricultural resources, labor costs and energy use. All are surplus producers of potential feedstocks for biofuel production. Indonesia and Malaysia, the world's leading exporters of palm oil, are initiating ambitious biofuels programs for domestic use and export. Thailand is a surplus producer of grain, sugar and cassava, and is ready to mandate a ten percent blend of ethanol in petrol by the end of 2006. These economies, like Brazil, have low-to-medium per capita incomes and limited energy needs. Here, policy structures similar to those of Brazil may be appropriate.

China's growing interest in biofuels, including cellulosic ethanol, is driven by rapid growth in domestic energy consumption and rising dependence on imported oil. China is also exploring non-conventional fossil fuels like coal-to-liquid, and nuclear energy.
In the richly endowed agricultural economies of North America and Oceania, biofuel developments are most advanced in the United States. Both Mexico and Canada have major fossil fuel resources and are net exporters of oil. Australia, a net importer of oil but a net exporter of other energy resources, faces drought-induced variability in biomass supplies.

In East Asia, limited biomass supplies constrain the potential scope of biofuel programs, which currently focus on niche uses like powering public vehicles. Japan and Korea are developing ties with surplus biomass economies—Brazil and Indonesia—as import sources for ethanol and biodiesel.

Appendix: Lessons from Brazil

The largest biofuel program in the world is in Brazil. More than half of the nation's sugarcane crop is processed into ethanol, which now accounts for about 20 percent of total motor vehicle fuel use. Brazil is currently expanding into biodiesel, capitalizing on plentiful supplies of oil-bearing crops, primarily soybeans, with a target of five percent blend with petroleum-based diesel by 2013.

A long-term policy commitment sustained Brazil's ethanol program through decades of volatile petroleum and sugar prices. The government has spent billions of dollars since the 1970s to support sugarcane producers, develop distilleries, develop a distribution infrastructure and promote production of pure-ethanol-burning and later flex-fuel vehicles (able to run on petrol or an ethanol-petrol blend that is up to 85 percent ethanol). Advocates contend that while the costs were high, the program saved the economy far more in foreign exchange from reduced petroleum imports (Sandalow 2006).

In the mid to late 1990s, Brazil eliminated direct subsidies and price-setting for ethanol. It pursued a less-intrusive approach with two main elements—a blending requirement now about 20 percent and tax incentives favoring ethanol use and the purchase of ethanol-using or flex-fuel vehicles (USDA 2006). Flex-fuel vehicles have become very popular, accounting for more than 70 percent of Brazil's current automobile production. With ethanol widely available at virtually all of Brazil's 32,000 gas stations, consumers have great flexibility in choosing the ethanol-petrol blend that best suits their needs on the basis of relative ethanol/petrol prices and other criteria (Lula 2006).

Brazil's biofuel program is a transitional model relevant to Asia-Pacific economies with abundant low-cost agricultural feedstocks but with relatively low fuel demand. Approximately 20 percent of current fuel use in Brazil is ethanol, not because ethanol supply is so great, but because overall fuel demand is quite limited. Brazil is a middle-income economy with per capita energy consumption only 15 percent that of the United States and Canada. Sustaining a 20 percent ethanol fuel share as Brazil transitions to higher levels of income and energy consumption may be difficult given current technology and resource constraints. Current ethanol production levels are not much higher than those in the late 1990s. Production of domestic off- and on-shore petroleum resources has grown more rapidly during this time than ethanol and is more responsible for Brazil's progress toward energy independence.

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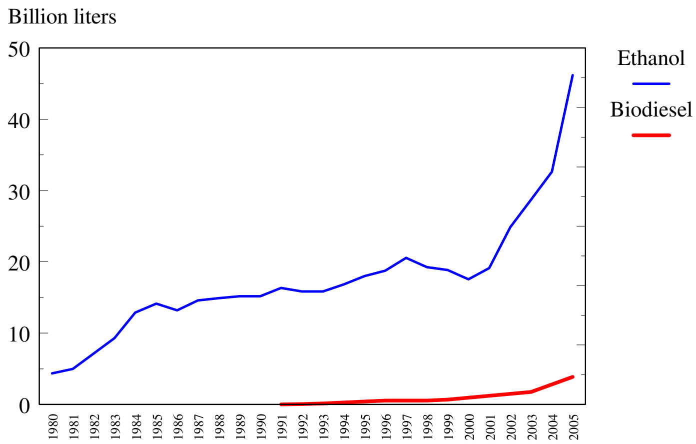
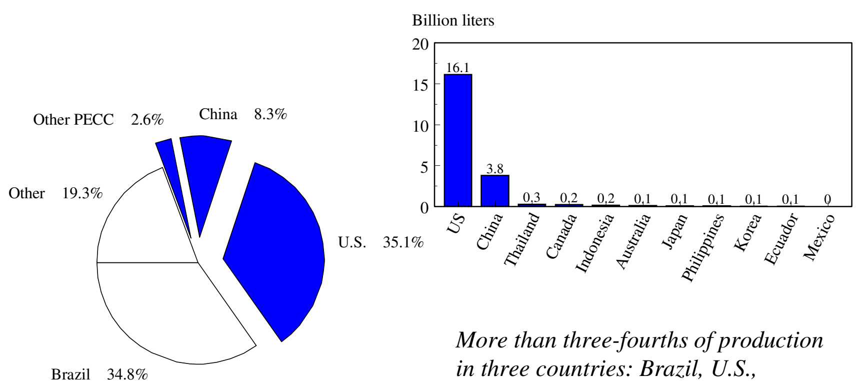
Fig. 1–Biofuel Production Doubles Since 2000



Sources: Earth Policy Institute, http://www.earth-policy.org/Updates/2005/Update49_data.htm#table1

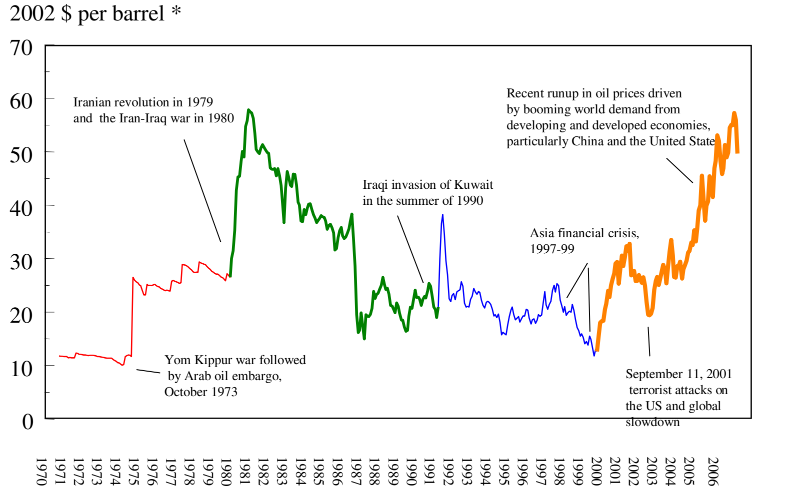
Fig. 2—Asia-Pacific Ethanol Production, 2005



More than three-fourths of production in three countries: Brazil, U.S., and China. 46% in PECC region.

Source: Renewable Fuels Association, http://www.ethanolrfa.org/industry/statistics/#C

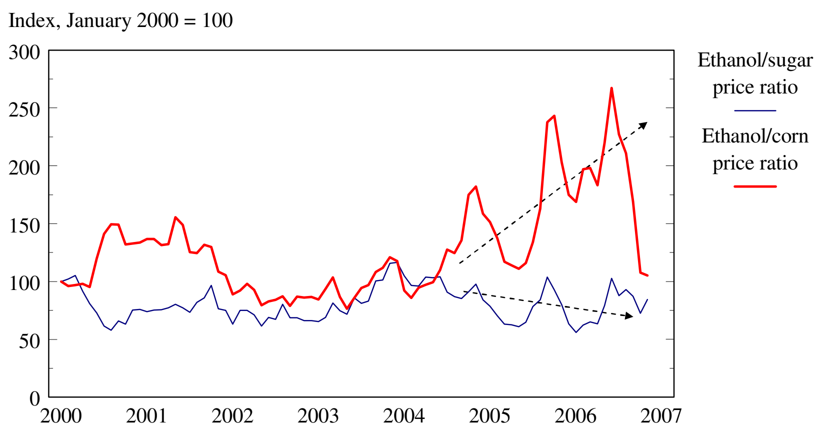
Fig. 3—Gradual Run Up in World Oil Prices



Source: Federal Reserve of St. Louis.

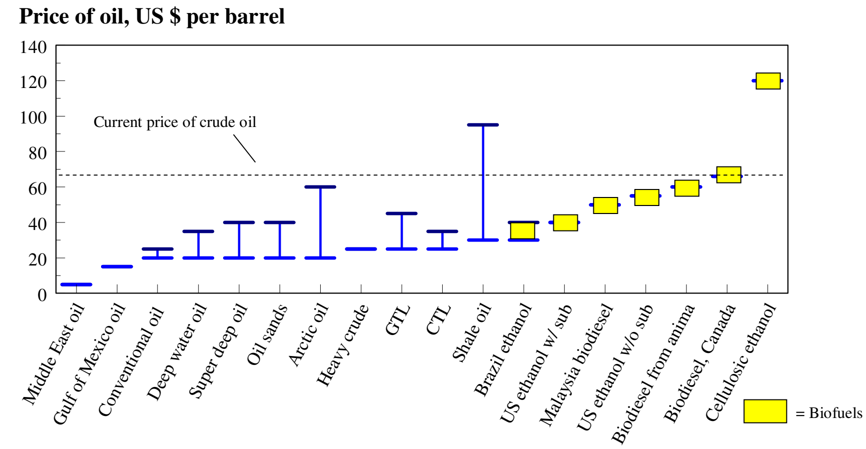
*--Deflated West Texas Intermediate Crude using Producer Price Index for all commodities, U.S. Department of Labor, Bureau of Labor Statistics, not seasonally adjusted, Index 2002=100

Fig. 4—U.S. Ethanol and Corn Prices



Source: Ethanol rack prices from Shapouri; sugar price is sugar-11, world spot cash price; and corn is No. 2 yellow, Central Ill.

Fig. 5—Prices of Oil, Biofuels and Alternatives



Sources: Penm and Kinsella; Doornbosch and Upton; Aspen Institute; The Economist; Charlebois; and Financial Times.