PACIFIC ECONOMIC COOPERATION COUNCIL

PACIFIC FOOD SYSTEM OUTLOOK 2006-2007

THE FUTURE ROLE OF BIOFUELS

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Pacific Food System Outlook 2006-2007
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FOREWORD

The Pacific Food System Outlook's (PFSO) 10th anniversary report examines the current status of and future prospects for biofuels in the region. Current ethanol and biodiesel production in the PECC region is quite modest, even in the United States and China where programs are most advanced. Yet, many economies across the region are developing biofuel programs to reduce dependence on imported petroleum, mitigate harmful emissions, including greenhouse gases, and boost rural economies.

In the energy programs of most nations, biofuels will likely play an expanding but modest role as part of a broad-based portfolio of solutions to high oil prices. In addition to biofuels, that portfolio may include conservation, more efficient energy use, and expanded production of oil, non-conventional fossil fuels, and other alternatives. Biofuels' future role will be even more significant with the commercialization of cellulosic ethanol.

In the May meeting in Singapore, the PFSO team was privileged to have as its guest of honor, Mr. Choo Chiau Beng, Chairman and CEO, Keppel Offshore and Marine and Chairman, Singapore Petroleum Company and Singapore Refining Company. His opening remarks on the future of global energy markets set the stage for our discussions.

We acknowledge the pivotal role of Professor Tan Teck Meng, Chairman, Singapore National Committee for Pacific Economic Cooperation (SINCPEC) in making this year's meeting successful. We also acknowledge the assistance of Mr. Yong Tack Meng, also of SINCPEC.

We are grateful to Associate Professor Pang Yang Hoong, Dean and Vice Provost of Singapore Management University, for her participation in the opening ceremony.

We appreciate the excellent presentations of the leadoff energy panel which included Jason Feer, Vice President and Singapore Bureau Chief, Argus Media Ltd; Hosein Shapouri, Senior Economist, Office of Energy Policy and New Uses, US Department of Agriculture; Gary Blumenthal, President, World Perspective Inc., USA; and Jaime del Río, Fideicomisos Instituidos en Relación con la Agricultura (Trust Funds for Agriculture Development), Bank of Mexico.

We are especially grateful to Betty Ip, Director of Public and Business Affairs, PECC International Secretariat, for her tireless efforts in promoting the PFSO, in making our meeting a success, and in enhancing our part of the PECC web site. We appreciate the critical role of Eduardo Pedrosa, Secretary General, in developing the meeting's energy panel, and the assistance of Daphenie Ho, Zakiah Kassim and Anne Witheford, all of the PECC Secretariat.

We are most grateful to the individual economists representing the participating economies of the PECC region for their contributions and continued support. As in previous years, the financial support of Farm Foundation and USDA's Economic Research Service, as well as support from the country PECC committees has made this unique multinational project a reality. We thank the Singapore Manufacturers' Federation, the Singapore Management University, the Singapore Petroleum Corporation, the Singapore Ministry of Foreign Affairs, and Tecman Holdings Pte, Ltd. for their generous support of our annual meeting.

We appreciate those who helped us with the review of early drafts of the report, including Brad Gilmour, David Kelch, Matt Shane and Hosein Shapouri. Finally, we appreciate the work of Joe Yacinski and Carol Hardy of Yacinksi Design; Mary Thompson of Farm Foundation; and Cheryl Christensen and Neil Conklin of ERS for their important support for this project.

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November 2006

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THE FUTURE ROLE OF BIOFUELS

In 2006, oil prices surpassed US$75 per barrel for the first time in history, and in real terms came very close to equaling the record prices of 1980. Other energy prices followed suit.

For the 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 increase 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.

Prospects for Pacific Rim agriculture to be a supplier of energy are the focus of this report, which is based on two days of discussion at the 10th annual Pacific Food System Outlook meeting in Singapore in May 2006.

Unlike previous high-price periods, the current increase in oil prices is 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. While ethanol production more than doubled to 46.2 billion liters in 2005 from 17.6 billion liters in 2000 (Figure 1), ethanol still accounts for less than two percent of the world's transportation petrol supply.

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.

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.

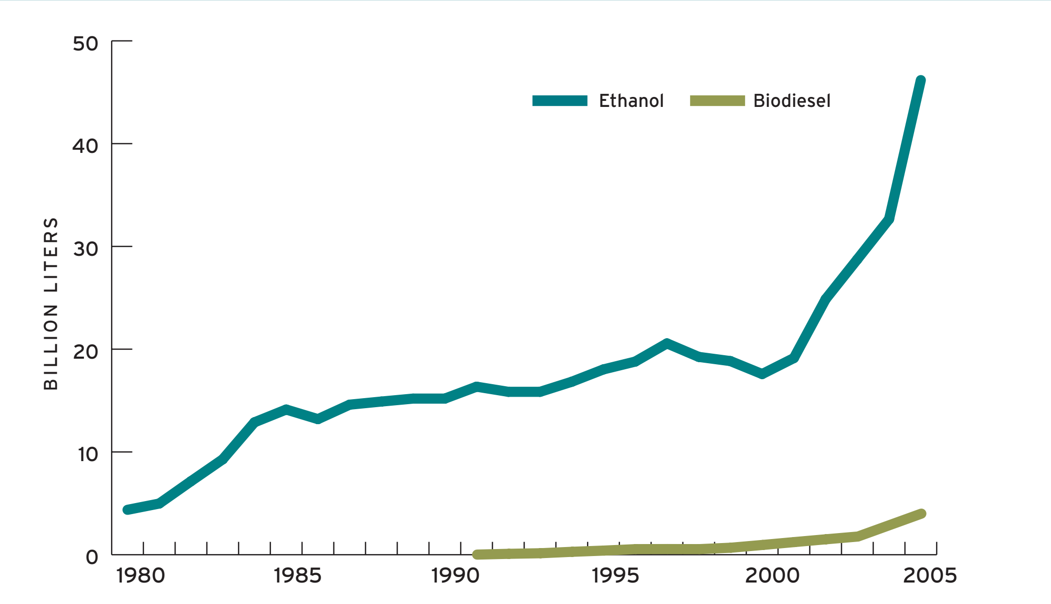
Biofuels are not perfect substitutes for fossil fuels. Ethanol has only about 70 percent of the energy content of petrol, and biodiesel 80 percent of the energy content of diesel (von Lampe, 2006). Shipping ethanol requires expensive truck or rail transportation. Pipelines are not a feasible option as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

Production and use of biofuels are most advanced outside the PECC region. In Brazil, ethanol from sugarcane accounts for about 20 percent of that economy's transportation fuel, with the remaining 80 percent still from oil products.

While biofuels in the PECC region provide less than two percent of transportation fuel, there is much interest in their potential to meet three policy goals:

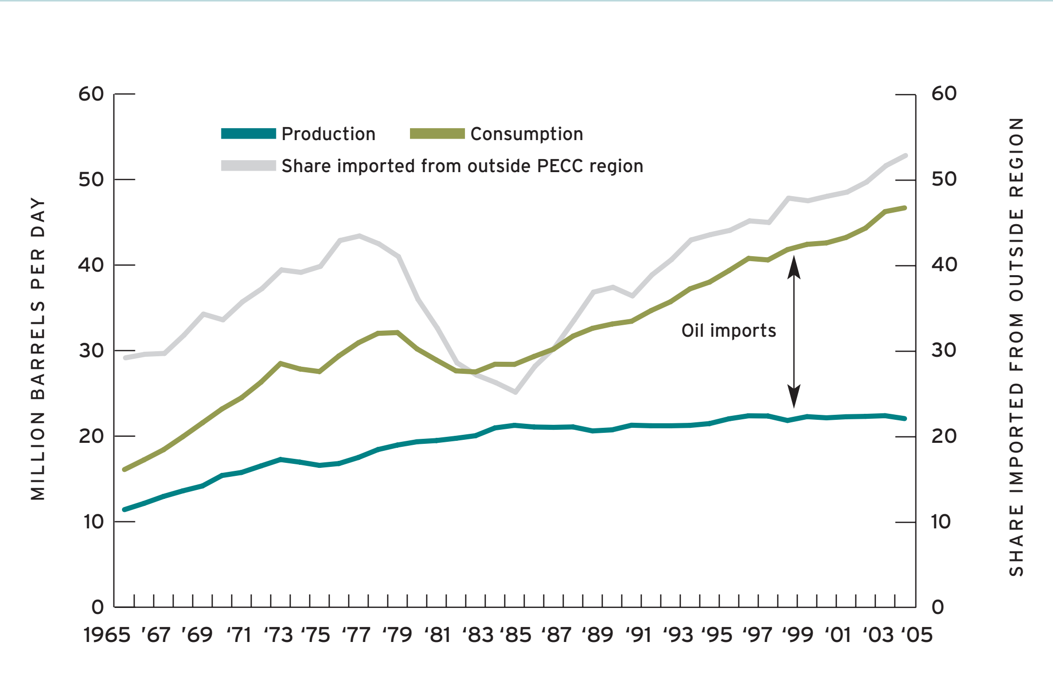
- *Reduce dependence on imported oil:* Biofuels are viewed as a potential alternative fuel for reducing the region's dependence on oil, particularly imported oil from unstable parts of the world. Region-wide oil production has barely grown in 20 years (Figure 2), yet consumption has grown rapidly in China and other middle-income economies. US oil consumption is at a high level and has also grown rapidly in the last 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 pro-

Figure 1 **Global Biofuel Production Doubles Since 2000**



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

Figure 2 **PECC's Growing Dependence on Oil Imports**



Source: BP

ducers, 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 of the PECC economies. Eighteen of the 20 most polluted major cities in the world are in the PECC region.

- *Revitalize rural areas:* Biofuel production is viewed as a tool for 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.

Two PECC economies—the United States and China—account for more than 90 percent of the region's total ethanol production (Figure 3); others have much smaller programs but are planning to expand them. While biodiesel production is miniscule in the PECC region, Malaysia and Indonesia are initiating ambitious programs to develop biodiesel from palm oil, a plentiful and low-cost feedstock in those economies.

Determinants of Biofuels' Future

The extent to which the region's biofuel programs develop and succeed in the future depends 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 increase in oil prices occurred over a span of more than six years. Prices are projected to remain relatively high for the next five years according to the US Department of Energy (Shane 2006). High prices should 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 prices falling below US$40 per barrel.

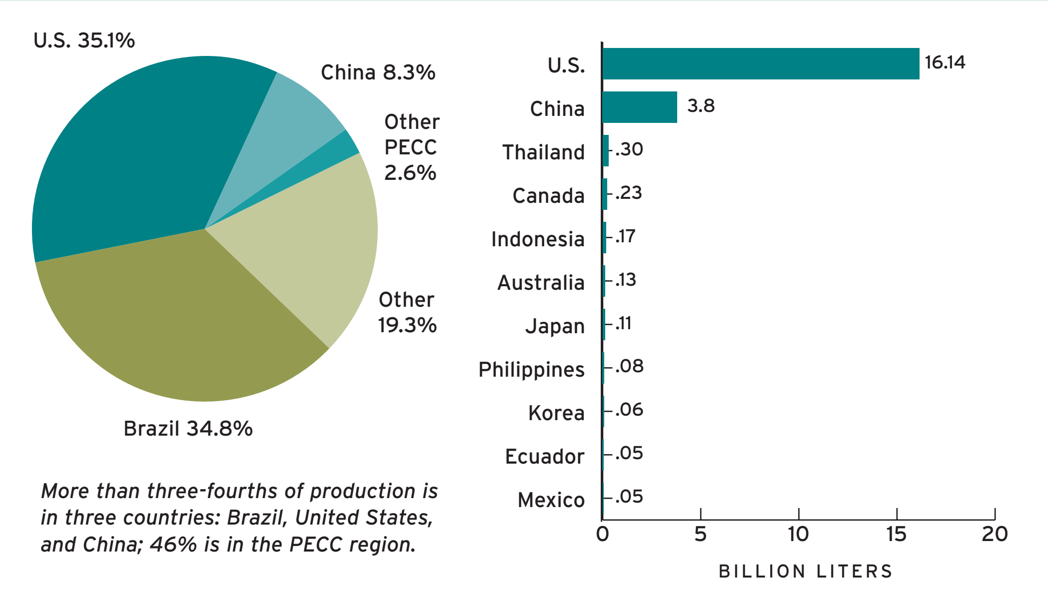
Historically, high oil prices are not sustained for long. The last three major oil price spikes were induced by military conflict—1973, Arab-Israeli war; 1980, Iran-Iraq war; and 1990, Persian Gulf War. In these cases, prices rose very sharply, peaked in a matter of weeks or months, and then gradually declined or stabilized (Figure 4). Each high-priced period was induced by cutbacks in global oil production—4.8 percent in 1974; 13.4 percent in 1980-82; and less than .5 percent in 1991 (Econbrowser.com) and led to significant slowdowns in the world economy.

Following these price spikes, rapid declines in petroleum prices made it difficult to sustain alternative fuels programs and reduced incentives for consumers to curb use of petroleum products. Declining oil prices in the 1980s, for example, made it difficult for Brazil to sustain its program promoting the use of alcohol-burning vehicles. In the United States, declining petrol prices through the 1980s and 1990s contributed to the proliferation of gas-guzzling sports utility vehicles (SUVs) and growing dependence on oil imports.

The current 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 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 (Figure 5). 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 (Figure 6). China's oil consumption now ranks ahead of Japan and is second only to the United States (Feer 2006).

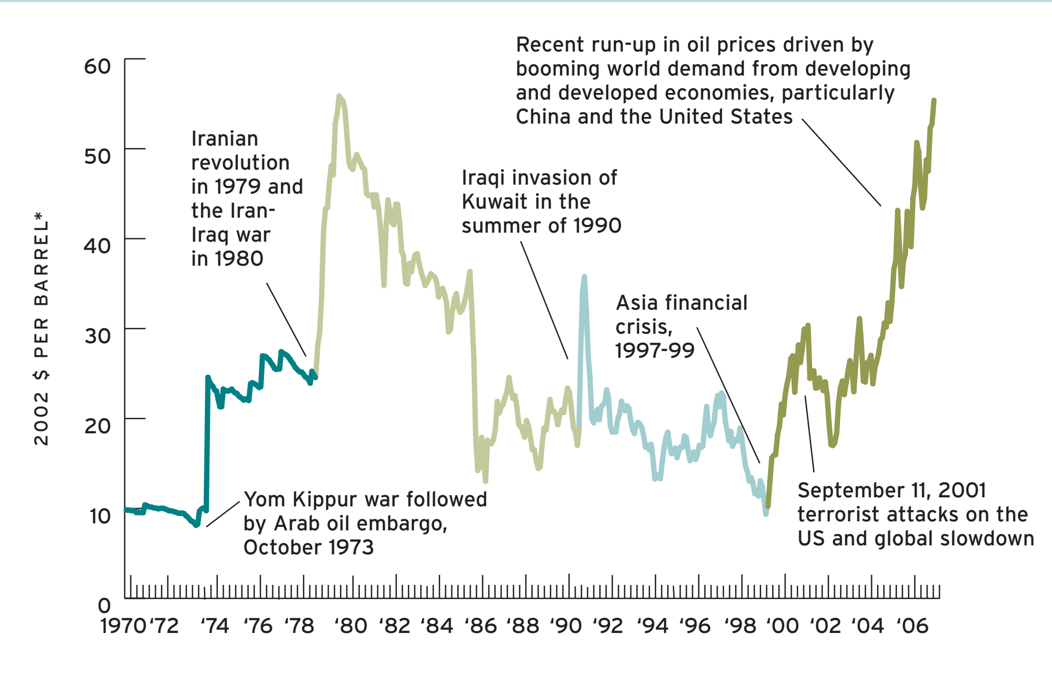
The coexistence of accelerating global economic growth and high oil prices is explained in part by declining energy intensities—that is, lower levels of energy use per dollar of output. In the past 20 years, the United States and Japan have made considerable progress in reducing energy use per dollar of GDP output. Gains are also being made by less developed economies. China's declining energy intensity is "unmatched by any other major modernizing economy" (Smil

Figure 3 PECC Ethanol Production, 2005



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

Figure 4 Current Run-Up in World Oil Prices More Gradual Than Previous High-Price Periods



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

2004) and is now less than half of what it was in 1980, but still three to four times greater than the United States' (Smil 2003). China's progress results from replacing old manufacturing plants and processes with modern ones, and efficiency gains in consumer energy use, including home cooking appliances. With energy intensities higher than in developed economies, developing economies are generally more vulnerable to higher energy prices but become less so with economic development.

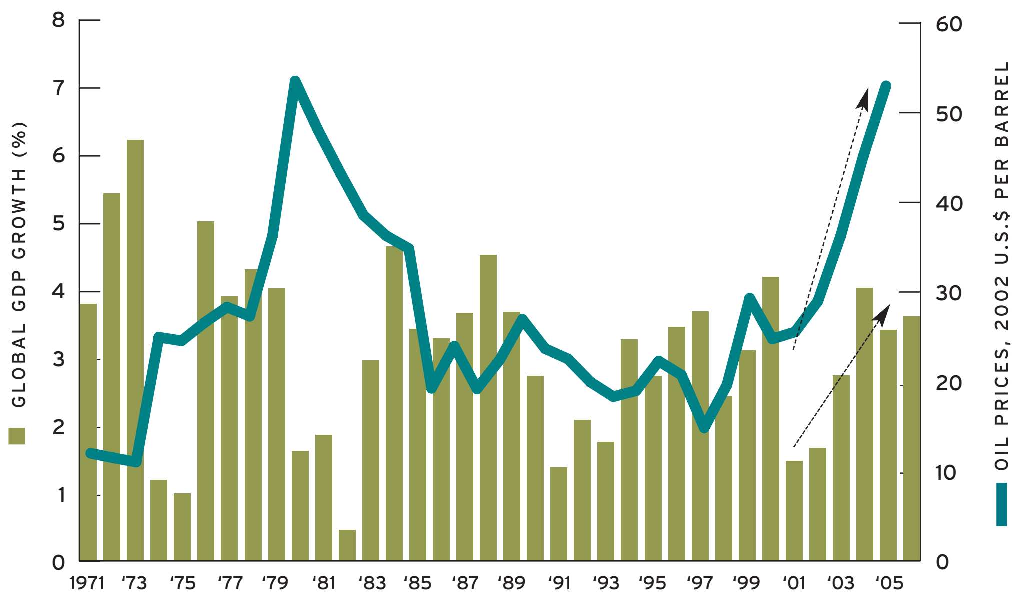
■ *Low-cost feedstocks.* The two leading producers of ethanol in the world are the United States and Brazil. Both have plentiful and low-cost supplies of feedstocks. An OECD report found that these two economies were the only ones with viable or near-viable biofuel programs, given US$39 per barrel oil 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 production inputs 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).

Using net exports as an indicator of low-cost availability in the region, the following commodities may support commercially viable biofuel production beyond modest levels: Australia, grain and sugar; Canada, grain and oilseeds; Indonesia and Malaysia, palm oil; Thailand, sugar and cassava; and the United States, grain and oilseeds (Table 1).

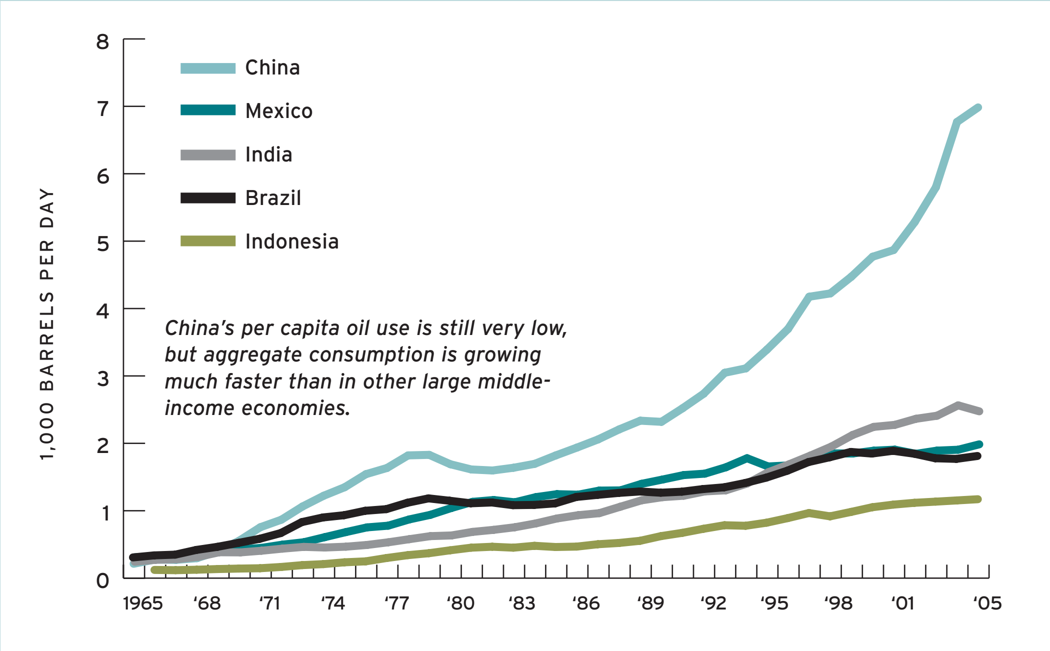
The ratio of biofuel prices to feedstock prices offers an indication of the profitability of biofuel production. The ratio of ethanol to

Figure 5 **Unlike Previous High Price Periods, Global GDP and Oil Prices Have Risen Together Since 2001**



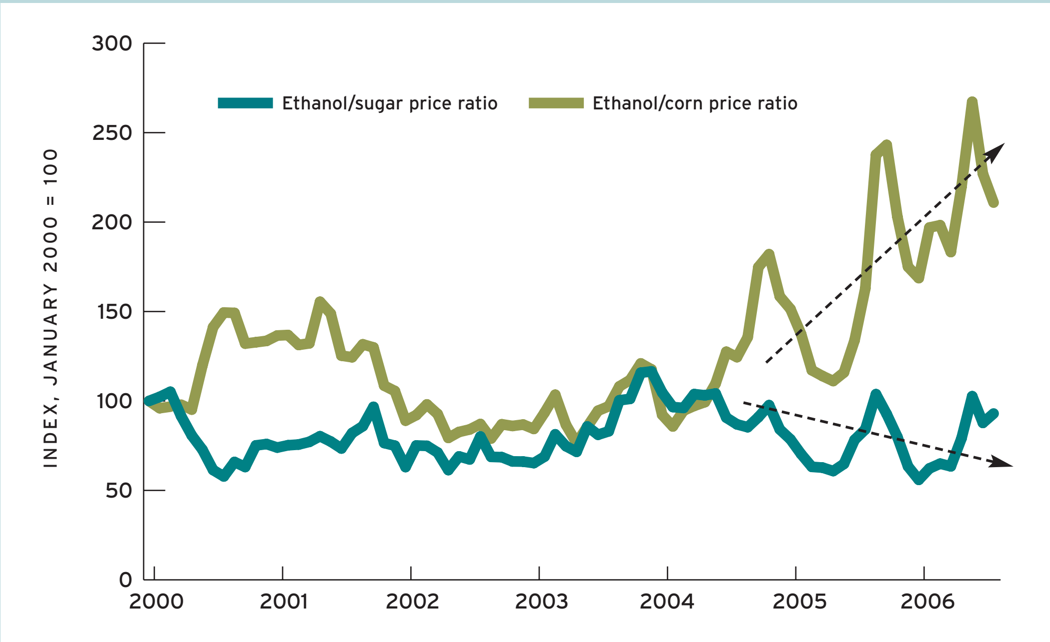
Source: U.S. Federal Reserve of St. Louis, and World Bank, World Development Indicators. Growth rates based on GDP in 2000 US dollars.

Figure 6 China's Growth in Oil Use Fastest Among Middle-Income Economies



Source: BP

Figure 7 A "Perfect Storm"* of Rising Ethanol Prices and Stable Corn Prices



Source: Ethanol rack prices from Shapouri; sugar price is sugar-11, world spot cash price; and corn is No. 2 yellow, Central Illinois, USA.
*Dave Swenson. "Input-Outrageous: The Economic Impacts of Modern Biofuels Production."
Department of Economics, Iowa State University. June 2006.

Table 1 Availability of Crops for Biofuel Production Based on Net

Economy	Grain	Oilseeds	Vegetable oil	Sugar	Cassava
	Net exports (million tons)				
Australia	19.0	1.3	-0.1	3.3	–
Canada	12.2	3.6	0.3	-1.2	–
Chile	-1.6	-0.2	-0.1	-0.2	–
China	2.5	-19.3	-5.5	-1.3	-10.6
Colombia	-3.6	-0.5	-0.1	1.1	–
Ecuador	-0.8	0.1	–	0.1	–
Hong Kong, China	-0.6	–	–	-0.2	–
Indonesia	-7.0	-1.2	8.3	-1.2	0.2
Japan	-25.8	-7.5	-0.7	-1.5	-0.6
Korea	-12.8	-1.7	-0.5	-1.3	-0.8
Malaysia	-5.5	-1.0	11.6	-0.9	-0.5
Mexico	-12.9	-5.5	-0.7	-0.1	–
New Zealand	-0.4	–	-0.1	-0.3	–
Peru	-2.5	-0.1	-0.3	-0.1	–
Philippines	-3.9	-0.4	1.0	0.1	-0.2
Singapore	-0.6	-0.1	-0.2	-0.3	-0.2
Chinese Taipei	-6.6	-2.4	-0.2	-0.9	-0.4
Thailand	8.1	-1.1	0.1	4.8	14.9
United States	78.7	28.8	-0.1	-1.4	-0.3
Vietnam	2.6	0.1	–	–	1.4
Brazil	-3.20	17.5	2.2	14.5	-0.1

Trade numbers are averages for 2002-04; a positive number = net exports; – = negligible, less than 50,000 tons
Source: Food and Agriculture Organization; World Bank, World Development Indicators, 2006.

corn prices, for example, rose sharply after 2004 as oil and ethanol prices rose, but corn prices remained relatively stable (Figure 7). This contrasts with sugar ethanol and biodiesel from vegetable oil, where feedstock prices rose along with fuel prices. World sugar prices in 2006 were at a quarter-century high because of the strengthening linkages between sugar and energy markets, among other factors (del Río 2006). 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 8).

Biofuel producers must be concerned about the uncertainty of both feedstock and output prices. Futures markets are increasingly being used in the United States to hedge against future corn price increases and ethanol price declines. Some estimate that with US$70 oil, U.S. ethanol plants can pay as much as US$6.00 per bushel for corn under current policies and still break even (*Wall Street Journal*, July 26, 2006).

An economic variable affecting the profitability of biofuels is the price of by-products, each of which has its own market (Shapouri et al. 2006). 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. Carbon dioxide, usually released into the atmosphere, is captured by some ethanol plants and

Exports

Net exports of food and ag prods	Energy consumption per capita 2003	Arable land per capita 2003	GDP per capita 2004
Billion US$	United States = 100		
13.5	72	400	76
4.2	105	240	79
2.3	21	20	27
-8.0	14	18	15
1.3	8	8	18
1.3	9	22	10
-4.6	31	–	78
2.9	10	17	9
-35.7	52	5	74
-7.9	55	5	52
4.5	30	12	26
-3.6	20	40	25
6.7	55	62	59
-0.3	6	23	14
-1.0	7	12	12
-1.3	68	–	71
-4.6	51	7	55
6.7	18	37	20
7.8	100	100	100
1.0	7	13	7
18.1	14	55	21

sold for use in the food and beverage sector. 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. The sale or productive use of each of these by-products adds to a plant's profitability.

■ *Other biofuel options.* DuPont and British Petroleum recently announced plans to develop and market biobutanol. Unlike ethanol, biobutanol has the same energy density as petrol, can use existing pipeline infrastructure, and can be used in cars with practically no modification. A bacterium converts the starch into a mixture of acetone and butanol, which differs in chemical structure from ethanol in being a four-carbon versus a two-carbon alcohol (Forbes.com. A Competitor for Ethanol?).

Even more attention, primarily in the United States, Canada and China, is focused on cellulosic ethanol, a so-called second-generation biofuel. 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 into ethanol has great promise. 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). These sources could be produced as by-products (corn stover) or on marginal lands and not in direct competition with agricultural crops. Since all ethanol is the same, cellulosic ethanol could piggyback on the infrastructure now being put in place for ethanol. However, questions remain about what impacts harvesting grasses, trees and crop residues would have on erodibility and fertility of land resources. There are also questions regarding logistical and environmental 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, "costing as little as US$0.60 a gallon (US$.16 per liter) to produce and selling for less than US$2.00 gallon (US$0.53 per liter) at the pump" (Gillis 2006). Genetic engineering and biotechnology have reduced the cost of cellulase, a key family of enzymes for breaking down cellulose into sugar, from about US$5.00 (US $1.32) to about US$0.50 per gallon (US$.13 per liter) of ethanol (Aspen Institute 2006).

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.

■ *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. Even at high prices, consumers around the world are reluctant to shift to other energy sources because of petrol's and diesel's high energy density, ease of storage and transport, and low production costs (Smil 2003). 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).

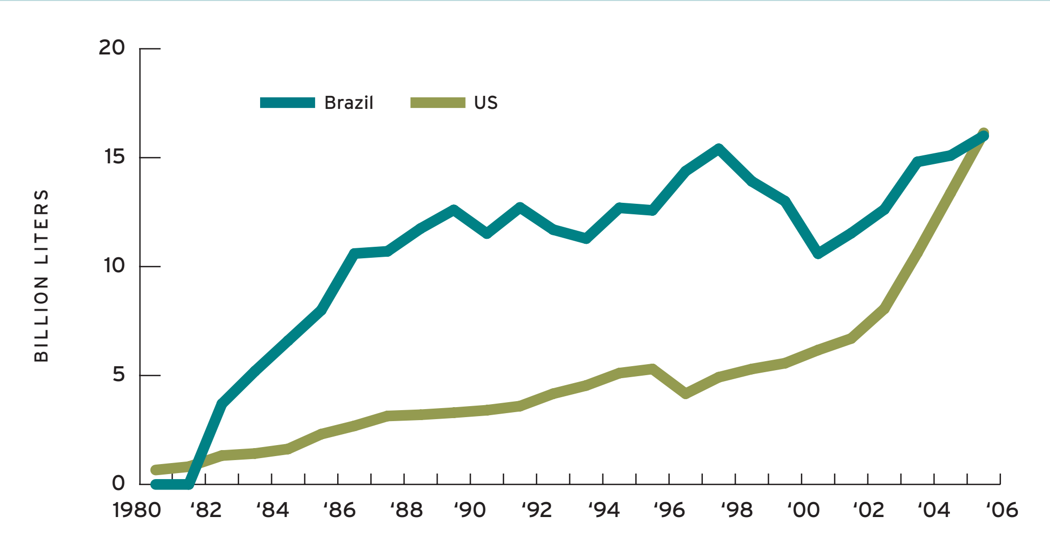
High oil prices have drawn attention to biofuels, as well as to other energy alternatives. Large investments are being made in developing more difficult-to-access conventional oil resources located in remote areas or deeper waters, and in non-conventional sources such as tar sands, heavy crude oil and synthetic fuels. Many of these fossil fuel alternatives have lower costs of production than biofuels (Figure 9). Canada's oil sands, for example, can produce oil for US$25-30 per barrel. Huge investments in technology and infrastructure are required to exploit these resources (Choo Chiau Beng 2006). More than C$100 billion in projects are planned or under construction in Alberta's oil sands region, where reserves are estimated at 150 to 300 billion barrels of oil (Urstadt 2006). This compares with Saudi Arabia's conventional oil reserves of 260 billion barrels.

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, but the process faces a double uncertainty: fluctuating oil and coal prices (*Wall Street Journal*, August 16, 2006).

This focus on processing/transforming resources like tar sands or coal to oil underscores the growing investment required in the production of alternative fuels. Energy companies are changing their orientation from mining and exploration to technology-intensive processing and manufacturing. New technologies are also increasing output from old oil reservoirs using steam-injection, deeper drilling (more than 5,000 meters), and directional drilling that increases drilling productivity.

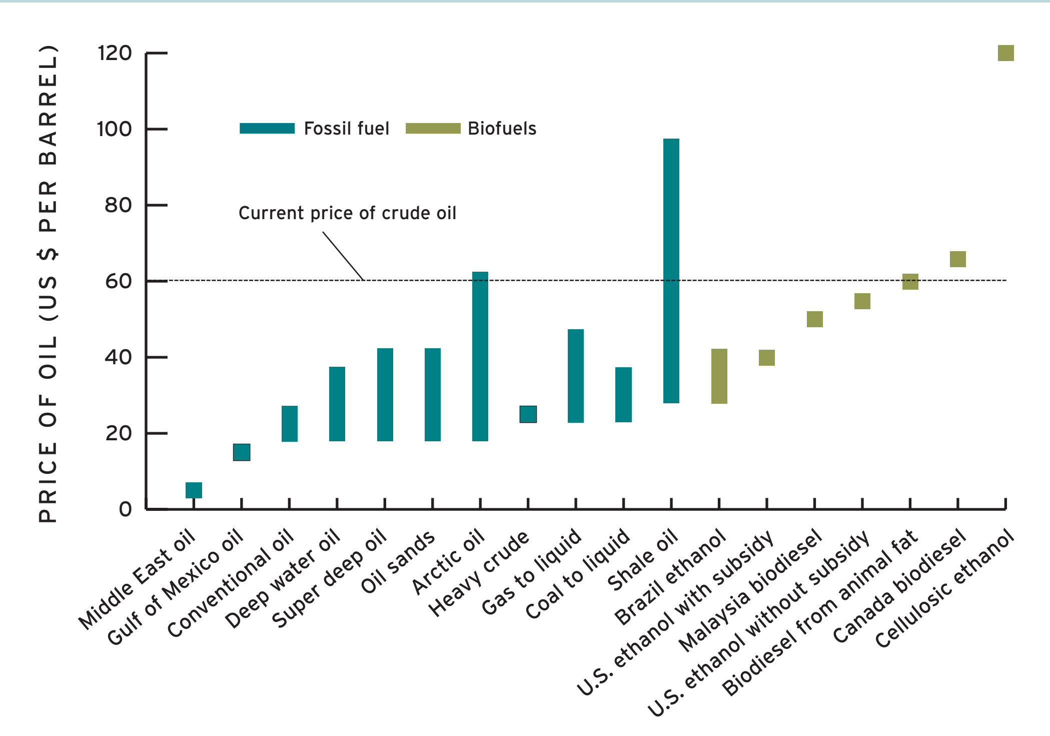
■ *The role of government policy.* Almost nowhere are energy markets free of government intervention. Biofuels are no exception. Strong policy support is a common feature in major biofuel-producing economies—Brazil (Box), the United States, and the EU. The governments of these and most PECC economies (Appendix) use a variety of policy tools to encourage development and commercialization of biofuels (von Lampe, 2006). These tools include mandated

Figure 8 Ethanol Production Expanding More Rapidly in United States Than Brazil



Source: Earth Policy Institute:http://www.earth-policy.org/Updates/2005/Update49_data.htm#table1 and Renewable Fuels Association, http://www.ethanolrfa.org/industry/statistics/#E

Figure 9 High Oil Prices Make Biofuels and Other Alternatives Competitive



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

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 now is expanding into biodiesel, capitalizing on plentiful supplies of oil-bearing crops, primarily soybeans, with a target of 5 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. Initiated in the 1970s after the Arab oil embargo, when petroleum prices were high and sugar prices low, the policy program was designed to promote the nation's energy independence and to create an alternative and value-added market for sugar producers. The government has spent billions of dollars 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. Today more than 70 percent of Brazil's current automobile production has flexible-fuel capability, up from 30 percent in 2004. With ethanol widely available at Brazil's 32,000 gas stations, Brazilian 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 PECC 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 (Figure 10). 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. Brazil already is having difficulty raising the ethanol share, having lowered the mandated level from 25 to 20 percent of transportation fuel use this year. Current 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 (Figure 11).

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.

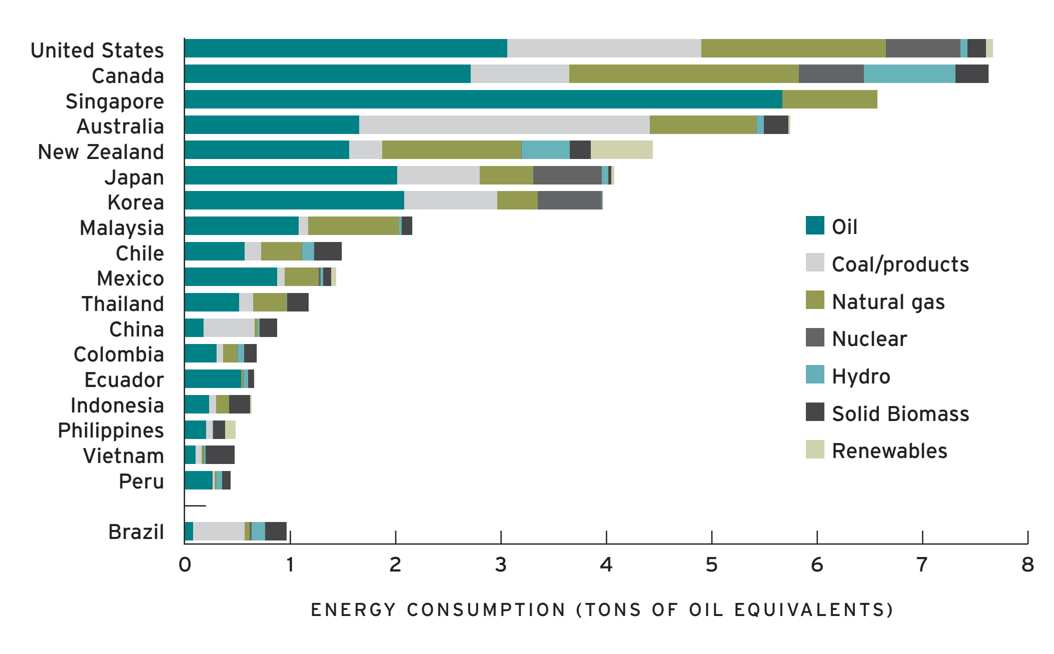
Environmental Tradeoffs

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, comes from road transport. Road transport has grown rapidly over the past 40 years and is projected to continue to increase. This is especially true in developing parts of the PECC 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.

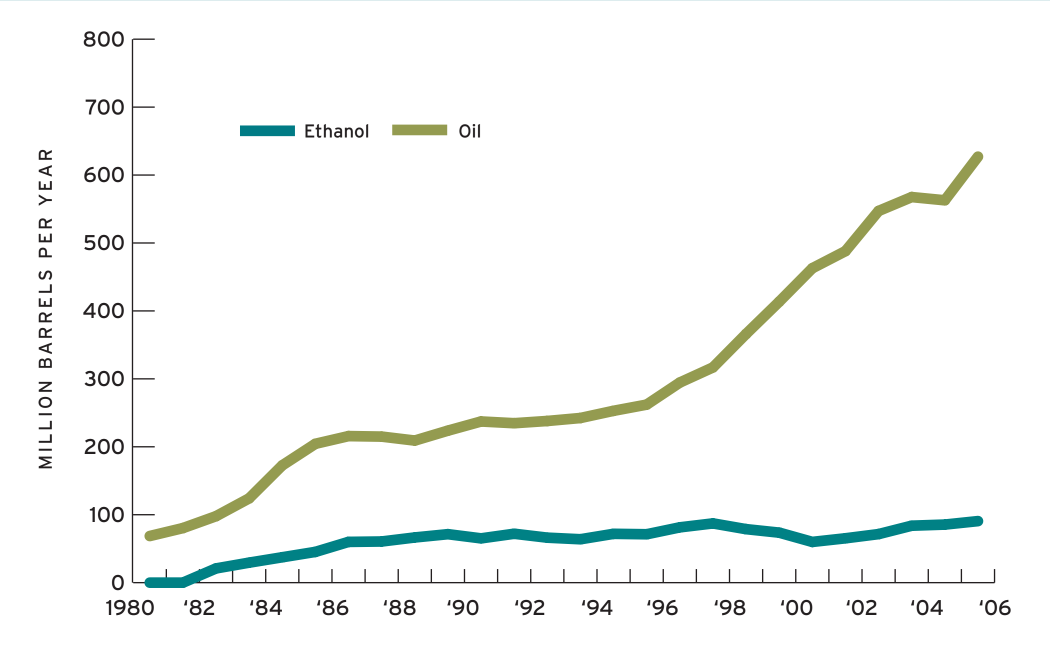
The advantage of biofuels is less clear in a "life-cycle" analysis that examines not just combustion, but the production and processing of the feedstock into fuel. Most studies indicate that the net

Figure 10 Per Capita Annual Energy Consumption Varies Across the Region



Source: World Resources Institute, http://earthtrends.wri.org/pdf_library/data_tables/ene2_2005.pdf

Figure 11 Expanding Oil Production in Brazil More Responsible for Fuel Self-sufficiency Than Ethanol



Source: BP

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.

The biofuel with the lowest net energy balance—corn ethanol—reduces GHG the least of all the biofuels when compared to petrol. It also has other potential environmental consequences. For example, the cultivation of corn in the United States uses more fertilizer and pesticides than soybeans, leading to greater potential for runoff and groundwater contamination. In general, agriculture is the biggest source of another GHG, nitrous oxide (N_2O), which is released by naturally-occurring bacteria stimulated by the cultivation of soil and from the application of nitrogen and animal waste fertilizers.

Biofuel production may have other environmental consequences, including heavy water use and toxic and odorific emissions by 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). According to the University of Minnesota, if all US corn and soybean acreage were devoted to ethanol and biodiesel production, it would offset only 12 percent and 6 percent of petrol and diesel consumption for transportation fuel, respectively, and only 2.4 percent and 2.9 percent, respectively, on a net energy basis, adjusting for the fossil fuel requirements for producing the biofuels (Hill et al. 2006).

Use of so much land to meet a relatively small share of transportation fuel demand is improbable. The resource commitment would be much less in a lower-income economy because of lower fuel demand. But 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.

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 its 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 in the PECC region will likely play an expanding but modest role in most every economy, but only as one element of a broad-based portfolio of energy policies. Biofuels' future role may become more significant with the commercialization of cellulosic ethanol.

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).

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 (20 percent of production and almost 40 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 been relatively stable in recent years. Were it not for large carryover stocks, prices would have been higher from the rapid expansion in ethanol production. The share of US corn used in ethanol production is rising quickly and is expected to nearly equal the 20-percent share of corn exported in 2006. Corn prices tend to be US$0.05 higher per bushel in areas near ethanol processing plants. 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 PECC Government Strategies

Relatively high oil prices will continue to sustain a keen regional interest in alternative fuels, including biofuels. Biofuel production will likely play an expanding but modest role in most every country, but only as one element of a broad-based portfolio of energy policies. 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 advance the timeline for cellulosic ethanol by lowering up-front risks and costs.

Biofuels do not require complete overhaul of existing infrastructure channels. With little or no engine modifications, biofuels can be used in existing petrol and diesel engines in blends of up to 10 percent in the case of ethanol and 20 percent for biodiesel. For higher blends, engines require some relatively low-cost modifications. 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.

As countries in the region assess policy options relative to biofuels, here are strategies to consider:

- *Policy commitments:* A critical factor in successful implementation of biofuels programs is strong policy commitments to sustain development through periods of high feedstock prices and/or low oil prices. Policy tools PECC economies might consider include:
  - 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 bio-

fuel-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 10 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.

■ *Share technology:* APEC's Open Food System initiative established the principle of cultivating a "food technology culture" to diffuse developments in food production, storage, shipping, packaging and processing across the region. The same concept should apply to biofuel technologies. Improved access to these technologies could result in broader application, spur growth in biofuel production and help lower energy costs.

Biofuels have much potential, but the rewards depend on the natural resources and economics of each economy and the commitment of policy makers and citizens to implement needed strategies.

ABBREVIATIONS USED IN THE PACIFIC FOOD SYSTEM OUTLOOK

APEC– Asia Pacific Economic Cooperation forum
EU– European Community
CO_2– Carbon Dioxide
GHG– Greenhouse gas
GTL– Gas-to-liquid
GDP– Gross Domestic Product
MTBE– Methyl tertiary butyl ether
MFN– Most Favored Nation
N_2O– Nitrous Oxide
OECD– Organization of Economic Cooperation and Development
PECC– Pacific Economic Cooperation Council
RFS– Renewable fuel standard
USDA– US Department of Agriculture

APPENDIX: BIOFUEL BRIEFS

Australia

ETHANOL FEEDSTOCK: grain, molasses
NUMBER OF PLANTS: 3 existing; 7 planned or under construction
BIODIESEL FEEDSTOCK: mainly used cooking oil or tallow
NUMBER OF PLANTS: 6 existing (including 4 that have just come on line in recent months); 5 planned or under construction
PRODUCTION: ethanol production capacity 75.2 million liters in 2005/06; biodiesel production capacity 179.9 million liters in 2005/06

In December 2005, the government announced a Biofuels Action Plan for achieving the target of 350 million liters of biofuel production by 2010. Based on individual company action plans, biofuel production in 2010 could be in the range 403–532 million liters (1-2 percent of fuel consumption). The excise tax paid by biofuel producers on ethanol and biodiesel is currently fully refunded to producers under a system of production grants. From 2011 to 2015 the excise tax effectively payable on ethanol and biodiesel will be raised in five equal annual steps. Under the Biofuels Capital Grants Program, A$37.6 million had been made available to encourage investment in new ethanol and biodiesel capacity. The import tax on imported ethanol will be reduced in 2011 in line with taxation on domestically produced ethanol. More than 400 service stations now sell ethanol or biodiesel blends. Under the Renewable Energy Development Initiative, A$100 million has been made available for new technologies, including ones applied to biofuels.

State governments are encouraging the use of biodiesel in trains and buses in South Australia and the use of ethanol in government vehicles in New South Wales.

Canada

ETHANOL FEEDSTOCK: corn, wheat, barley
NUMBER OF PLANTS: 7; 3 under construction
PRODUCTION: current production approximately 200 million liters
CONSUMPTION: 316 liters

Biodiesel production in Canada is in a pilot phase. There are three plants, but they are not fully commercialized yet. Production in 2004 was estimated at 6 million liters. There are plans to develop additional plant capacity in the next couple of years.

In May 2006, the government announced a Renewable Fuels Strategy, which includes a 5 percent biofuels use target by 2010 (approximately 3 billion liters). Full details of the strategy are expected in the fall of 2006. The Strategy is part of the government's plans to reduce greenhouse gas emissions. Tariff barriers on ethanol are limited: none with the United States under NAFTA and only C$0.0492 /liter with MFN countries and Brazil. Many provinces exempt renewable fuels from road taxes. The federal government provides a fuel excise tax exemption of C$0.10/liter for ethanol, and C$0.4/liter for biodiesel (OECD). Saskatchewan, Manitoba and Ontario have passed legislation requiring ethanol use when supply becomes available. The federal government is providing capital assistance through the Ethanol Expansion Program (EEP). Saskatchewan has mandated a 7.5 percent blend by October 2006. Ontario has mandated a 5 percent blend by January 2007.

China

ETHANOL FEEDSTOCK: corn (78 percent), wheat (22 percent); potential feedstock: cassava, sweet potatoes, and rice
NUMBER OF PLANTS: 4; 3 under construction
PRODUCTION: 3.8 billion liters (2005); 1.13 billion liters for fuel ethanol, the rest for the beverage/chemical sectors
BIODIESEL FEEDSTOCK: waste palm and other vegetable oils and animal fats
PRODUCTION: Very limited because of scarce oil-bearing feedstocks

China is the third-largest ethanol producer in the world, after the United States and Brazil. It is in the midst of a $5 billion, 10-year program to expand ethanol production as part of a broader effort to raise the energy share of renewables (biofuels, nuclear, hydroelectric and solar power) from 7 percent to 16 percent by 2020 to meet growing energy demands and environmental challenges. Currently, there are mandates in five provinces for 10 percent ethanol and 90 percent petrol blends (E10) to create a new market for surplus grain in major corn-producing areas and to displace oil imports. The government plans to expand E10 use in nine cities in Hubei, seven in Shandong, five in Jiangsu, and six in Hebei. Ethanol producers depend on government subsidies to make production profitable. China's Resources Alcohol Corp. will set up a pilot demonstration facility in Zhaodong, Heilongjiang province, where an ethanol facility already exists, to produce cellulosic ethanol from wheat straw, grasses and other organic material.

Colombia

ETHANOL FEEDSTOCK: sugarcane
NUMBER OF PLANTS: Unknown

Starting in 2006, the government is mandating the use of 10 percent ethanol in fuel in cities with populations of more than 500,000. The government is also requiring the cultivation of an additional 150,000 hectares of sugarcane and nine new ethanol plants to produce the necessary 985 million liters per year.

Indonesia

BIODIESEL FEEDSTOCK: palm oil, castor, coconut, *Jatropha curcas*, and cotton seed
NUMBER OF PLANTS: 6
PRODUCTION: 3.5 million liters
ETHANOL FEEDSTOCK: cassava, sugarcane, corn, *Manihot esculenta*, sweet potato, sago
NUMBER OF PLANTS: 10
PRODUCTION: 200 million liters, so far not fuel grade

Indonesia is the world's second-largest palm oil producer and the only OPEC country that is a net importer of oil. Petrol use is heavily subsidized. The government recently announced a $22 billion, five-year program to diversify energy sources, alleviate the rising cost of petroleum product subsidies, and mitigate environmental pollution problems. Plans have been announced to invest $1.1 billion in expanding palm oil production and in developing 8 to 11 biodiesel plants, targeting up to 10 percent biofuel content of diesel by 2010. Government has a similar target for ethanol use in petrol. State-owned petroleum company, Pertamina, currently is marketing a 5 percent biodiesel product at a few outlets in Jakarta.

Japan

ETHANOL FEEDSTOCK: sugarcane (Okinawa)
NUMBER OF PLANTS: 6 ethanol plants, 4 synthesis ethanol
PRODUCTION: 294 million liters, mainly non-fuel uses
IMPORTS: 509 million liters
BIODIESEL FEEDSTOCK: Used vegetable oil
NUMBER OF PLANTS: 3

Japan's government has promoted low-level ethanol blends in preparation for a possible blending mandate, with the long-term intention of replacing 20 percent of the nation's oil demand with biofuels or gas-to-liquid (GTL) fuels by 2030. It is also promoting the development of ethanol processing in six prefectures. In June 2006, Japan's Environment Ministry announced intentions to require that biofuels account for 10 percent of all transportation fuels by 2030 (not supported yet by other ministries). Since feedstock supplies are limited in Japan, the government will promote close ties with Brazil as a source of ethanol imports. Japan is promoting production of biodiesel from used vegetable oil to be blended with diesel for use by public buses, official cars, and municipal garbage trucks.

Korea

BIODIESEL FEEDSTOCK: imported soy oil (85 percent), used frying oil (15 percent)
NUMBER OF PLANTS: 8
PRODUCTION: 340 million liters

The government is pursuing energy policies aimed at increasing the use of new and renewable energy sources to reduce greenhouse gas emissions, a serious problem in Seoul and other urban areas. As of the end of 2005, new and renewable energy sources accounted for only 2.2 percent of the nation's total energy consumption. The goal is to achieve 5 percent by 2011. Starting in July 2006, diesel fuel users will be able to buy diesel blended with a small amounts of biodiesel (0.5 percent) from a limited number of petrol stations. After further testing, the government plans to target B20 by 2008. Currently, B20 is only being produced for use in trucks and buses. After consumer complaints, the government required lowering of the biodiesel share in diesel fuel to less than 5 percent for private vehicles. In response to growing interest in ethanol, the Korean government is conducting feasibility studies and discussing joint ventures with Indonesia.

Malaysia

BIODIESEL FEEDSTOCK: palm oil
NUMBER OF PLANTS: 3; 10 plants under construction. Government has granted licenses for 32 biodiesel plants, with potential annual capacity of 3.3 billion liters
PRODUCTION: 200 million liters now; 1.7 billion liters in 2007

The National Biofuel Policy, announced in August 2005, will spur the Malaysia biofuel industry. The policy calls for rapid growth of the biofuels sector, using a four-prong strategy: production of a target biofuel blend of 5 percent processed palm oil and 95 percent diesel (B5), use of B5 by public vehicles, development of a quality standard, and promotion of exports. As a product encouraged under the Promotion of Investments Act of 1986, biodiesel projects are eligible for tax exemption on at least 70 percent of the income derived from production for five years, with more revenue eligible under certain provisions. Palm-based biodiesel became a viable fuel option when crude oil surpassed US$50 per barrel.

Mexico

ETHANOL FEEDSTOCK: corn, sugarcane
PRODUCTION: 45 million liters; to achieve 10 percent fuel blend target outlined in pending legislation for three largest cities would require 640 million liters
BIODIESEL FEEDSTOCK: soyoil, avocado, coconut, sunflower
PRODUCTION: 6 million liters

There are no specific biofuels promotion programs in effect; pending legislation, if enacted, would encourage the use of biofuels as part of a broader program to promote renewable energy sources and to phase in the use of ethanol in petrol, with no specific target blend ratio. The cities of Jalisco and Mexico City are collaborating on a project to convert several beverage alcohol production facilities to fuel production, using sugarcane as the feedstock. By expanding use of fuel ethanol, policy makers aim to reduce pollution in Mexico City and Guadalajara.

New Zealand

ETHANOL FEEDSTOCK: whey (lactose) from casein
PRODUCTION: 16-20 million liters
BIODIESEL FEEDSTOCK: tallow
PRODUCTION: voluntary target of 65 million liters for 2012.

The National Energy Efficiency and Conservation Strategy has established targets to increase the share of energy from renewables by 2012. In August 2003, the Environmental Risk Management Authority (ERMA) approved the use of petrol-ethanol blends not to exceed 10 percent ethanol. This is an important step towards meeting the 7 percent of the renewable energy target expected to come from transport fuels.

Peru

ETHANOL FEEDSTOCK: sugarcane

In 2002, Peru announced a plan to build 20 distilleries and an ethanol pipeline from the interior to the port of Bayovar. Up to 245,000 hectares of sugarcane will be planted in forest areas now used for coca leaf production. The government hopes to export 1.1 billion liters of ethanol by 2010. A 2005 law promotes use of ethanol as 5 percent to 10 percent additive in petrol.

Philippines

BIODIESEL FEEDSTOCK: coconut
NUMBER OF PLANTS: 3

PRODUCTION: 110 million liter capacity
ETHANOL FEEDSTOCK: sugarcane
NUMBER OF PLANTS: plans for 10 in two years
PRODUCTION: 360 million liters in two years

Current biofuel production is very limited. Government is subsidizing the use of biodiesel for public transportation and a 1 percent blend in government vehicles. Legislation is pending to require 5 percent to 10 percent biofuel blend with petrol and 1 percent to 5 percent with diesel. Tariff exemptions are made for imports of biofuel equipment and possible financial support extended to producers and downstream players. In 2005, the import tariff for ethanol was lowered from 1 percent to 10 percent. All ethanol is now imported, primarily from Brazil. Shell will distribute E10 at 50 stations by the end of 2006. Surplus sugarcane will be used for domestic ethanol plants. There are plans to establish 12 new sugarcane plantations for ethanol production. Plantation biomass could supply 2 percent to 11 percent of economy's projected energy consumption by 2010.

Chinese Taipei

POTENTIAL ETHANOL FEEDSTOCK: sugarcane, sweet potatoes; plan to use 1 billion liters, or 10 percent of petrol consumption
BIODIESEL FEEDSTOCK: recycled cooking oil, sunflower, soybean and rapeseed oil
NUMBER OF PLANTS: 3
PRODUCTION: 1 million liters; plan to use 100 million liters, or 1 percent of projected diesel consumption

As a major net importer of food and agricultural imports, Taiwan has little surplus biomass for biofuels production. There is some attention to more efficient uses of fallowed riceland for production of biofuel feedstocks such as sweet potatoes, sunflower, soybean, and rapeseed. Modest biodiesel production is used to power city sanitation trucks. Taiwan's sugarcane ethanol costs of production are more than twice Brazil's. Some government-sponsored research is promoting development of cellulosic ethanol technologies.

Thailand

ETHANOL FEEDSTOCK: cassava, molasses, sugarcane
NUMBER OF PLANTS: 6 in production; 18 added in 2006
PRODUCTION: 300 million liters
Biodiesel feedstock: palm oil, reused cooking oil
NUMBER OF PLANTS: small-scale trial programs
PRODUCTION: 1.8 million liters

Thailand, the world's second-largest sugar exporter after Brazil, wants to reduce the cost of oil imports while supporting domestic sugar and cassava growers. Its ethanol program, begun in 1985, will be strengthened this year by requiring a 10-percent ethanol-petrol blend. This along with a ban on the petrol-based fuel additive, methyl tertiary butyl ether (MTBE), will promote expansion of ethanol production, requiring 1 billion liters per year production capacity. Incentives to encourage production and marketing include waiving excise tax on ethanol blends, investment concessions for new plant construction, and an eight year corporate tax holiday for ethanol producers. The Biodiesel Promotion Program, established in July 2001, plans to raise biodiesel production to 3.1 billion liters by 2012, accounting for 10 percent of expected diesel consumption.

United States

ETHANOL FEEDSTOCK: corn, sorghum, barley, cheese whey, beverage and brewery waste, sugar, and various starches
NUMBER OF PLANTS: 101; 7 expanding and 42 under construction
PRODUCTION: 16.4 billion liters (2005)
BIODIESEL FEEDSTOCK: soybeans, other oilseed crops, animal fats, recycled fats and oil
NUMBER OF PLANTS: 65 in operation; 58 plants under construction
PRODUCTION: 345 million liters (2005)

Production is promoted with US$0.135 per liter (US$0.51 per gallon) federal tax credit on ethanol production and US$0.143 per liter (US$0.54 per gallon) tariff on imported ethanol. Phase out is planned in 2006 of methyl tertiary butyl ether (MTBE), a petroleum-based oxygenate found to contaminate ground water; ethanol is the preferred substitute. Fourteen states provide producer incentives, ranging from US$0.0026 per liter to US$0.106 per liter. Incentives are also offered for small ethanol plants (up to 227 million liters per year) US$0.0264 per liter (US$0.10 per gallon), covering up to 57 million liters per year.

The Energy Policy Act (EPACT) of 2005 established a Renewable Fuels Standard (RFS), requiring use of 28.4 billion liters (7.5 billion gallons) of biofuels by 2012. This target should be reached well ahead of schedule and should account for more than five percent of near-term petrol consumption. It also provides funds to develop commercially viable technologies for converting cellulose to ethanol, incentives to promote production of cellulosic ethanol, and incentives for expanded biodiesel production. EPACT provides petrol station owners a 30 percent tax credit up to $30,000 to install pumps and tanks for E85 (estimated total cost of $200,000 per station).

STATE POLICIES: Iowa targets an ethanol blend of 10 percent in 2009 and 25 percent in 2019. The Missouri Renewable Fuel Standard Act requires that all gasoline sold in Missouri contains at least 10 percent agriculturally derived, denatured ethanol by volume unless exempted by the federal Environmental Protection Agency, by Jan. 1, 2008. Hawaii, Montana and Minnesota require that petrol must contain 10 percent ethanol. Washington State requires petrol and diesel to contain 2 percent renewable fuel.

SOURCES: Presentations at the 10th Pacific Food System Outlook meeting in Singapore, May 17-18, 2006, including those by Fatimah Mohamed Arshad, Ching-Cheng Chang, Pierre Charlebois, Don Gunasakera, Ronnie Natawidjaja, Hosein Shapouri, and Ruangrai Tokrisna; Renewable Fuels Association website; F.O. Lichts, World Ethanol and Biofuels Reports; Bangkokpost.com

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The agency's three divisions—Food and Rural Economics, Market and Trade Economics, and Resource Economics—conduct research, perform commodity market and policy analysis, and develop economic and statistical indicators. The executive and legislative branches of the US federal government use ERS information to help develop, administer, and evaluate farm, food, rural, and resource policies and programs.

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Singapore Management University

http://www.smu.edu.sg

Officially incorporated in January 2000, Singapore Management University (SMU) is Singapore's third largest university. Its educational and administrative practices are modeled after American institutions, in particular the Wharton School of the University of Pennsylvania, which has played a central role in SMU's development. To deliver its world-class curriculum, an outstanding faculty has been selected to advance its teaching and research programs. Besides recruiting some of the best academics in their field, SMU also taps successful businessmen for their specific expertise and management skills to combine academic rigor with hands-on business savvy.

Singapore Manufacturers' Federation

http://www.smafederation.org.sg/control.cfm

The Singapore Manufacturers' Federation (SMa) was established in 1932 by 17 founding members. Its main aim is to promote manufacturing and the manufacturing sector in Singapore. With more than 2,800 corporate members ranging from multinational corporations to small and medium-sized enterprises, SMa carries out a myriad of activities to enhance the competitive edge of its members.

Singapore Ministry of Foreign Affairs
http://www.mfa.gov.sg
The Singapore Ministry of Foreign Affairs advances and safeguards the interests of Singapore and its citizens through effective diplomacy and support for causes that promote diplomacy. Its Foreign Service has its headquarters in Singapore and operates a network of diplomatic missions around the world.

Singapore Petroleum Corporation
http://www.spc.com.sg
The Singapore Petroleum Corporation (SPC) is a regional oil and gas company with interest in oil and gas exploration and production, refining, terminaling and distribution, marketing and trading of crude and refined petroleum products. It is an associated company of Keppel Oil and Gas Services Pte Ltd, a wholly-owned subsidiary of Keppel Corporation Limited. SPC was established in 1969 to promote Singapore's development as a refining center.

Tecman Holdings Pte Ltd
http://www.tecman.com.sg
Tecman Holdings Pte Ltd is a local Singaporean company with interests in corporate management, business and financial consultancy, Christian book rooms, and supply of a wide range of church-related products.

PACIFIC ECONOMIC COOPERATION COUNCIL

The Pacific Economic Cooperation Council (PECC) is an independent, policy-oriented organization devoted to promoting economic cooperation in the Pacific Rim. PECC brings together senior government, academic, and business representatives from 23 economies to share perspectives and expertise in search of broad-based answers to economic problems in the Asia Pacific region.

Founded in 1980, PECC now comprises member committees from the economies of Australia; Brunei; Canada; Chile; China; Colombia; Ecuador; Hong Kong, China; Indonesia; Japan; Korea; Malaysia; Mexico; New Zealand; Pacific Islands Forum Secretariat, Peru; the Philippines; Singapore; Chinese Taipei; Thailand; the United States; and Vietnam as well as the Pacific Island Nations. France (Pacific Territories) and Mongolia were admitted as associate members in April 1997 and April 2000, respectively. The Pacific Basin Economic Council (PBEC) and Pacific Trade and Development Conference (PAFTAD) are institutional members of PECC.

PECC's governing body is the Standing Committee, which meets once a year and consists of the chairs of the PECC committees from each member economy. The day-to-day administrative and coordinating functions are carried out by an International Secretariat based in Singapore. Each member committee sends a high-level tripartite delegation from government, business, and academia to the PECC General Meeting held annually.

In 2005 PECC reorganized its work program into two types of activities. PECC will focus on 2 to 3 signature projects known as task forces on issues of importance to policy makers in the near and medium term. PECC's flagship publication will be its annual State of the Region report. The report will include analysis of the current economic situation in the region as well as an examination of emerging issues.

A number of other studies undertaken by PECC Member Committees are self-funded, addressing transpacific issues of interest to the PECC organization.

At the regional level, PECC's most important link with government is through APEC. PECC is the only nongovernmental organization among the three official APEC observers. PECC representatives attend APEC ministerial meetings, senior officials meetings, and working group meetings. PECC also works with other international organizations such as the World Trade Organization, the Organization for Economic Cooperation and Development, the Asian Development Bank, the World Bank, and United Nations' agencies.

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