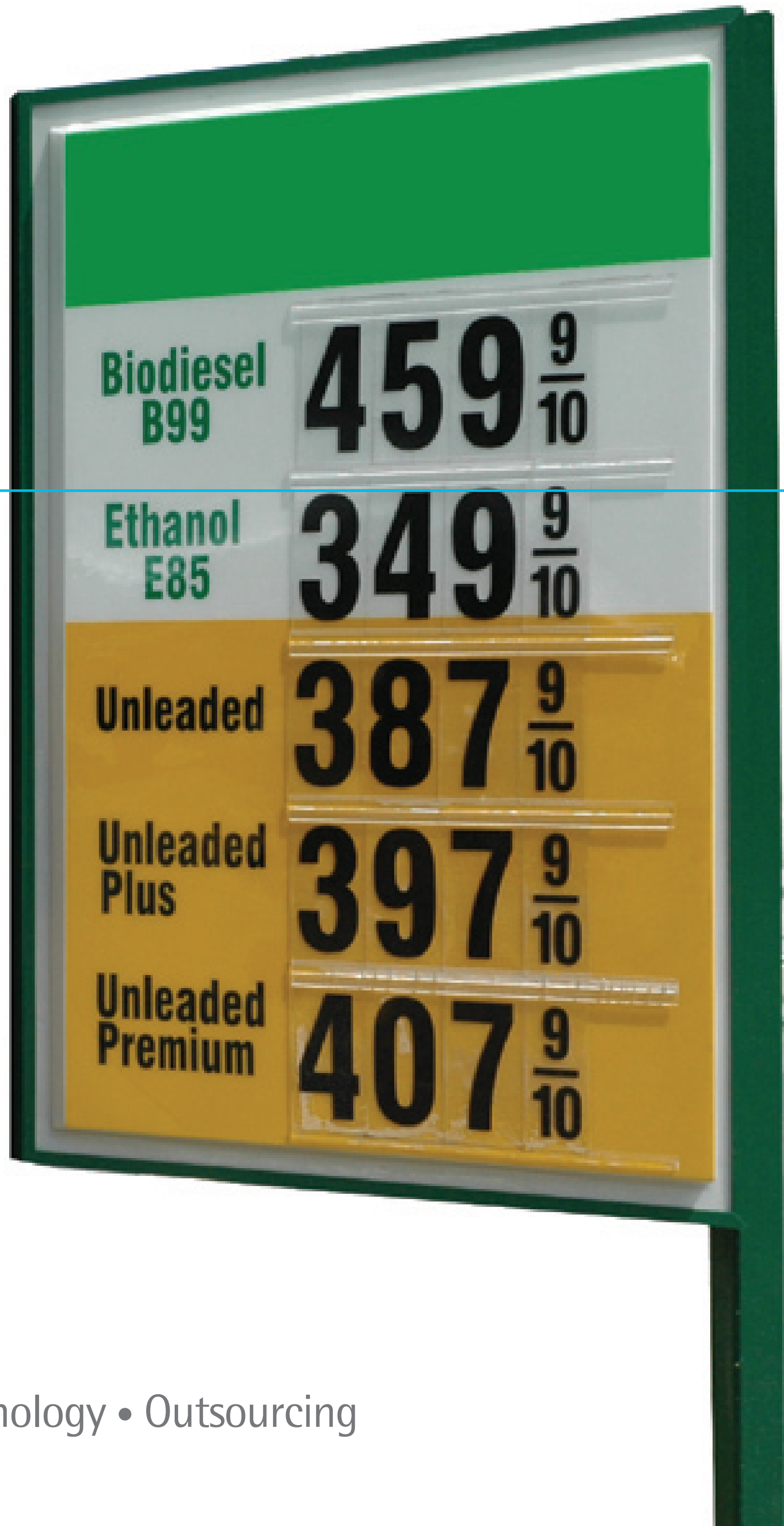
Biofuels' Time of Transition

Achieving high performance in a world of increasing fuel diversity



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Introduction

In September 2007, Accenture released a study called *"Irrational Exuberance"? An Assessment of How the Burgeoning Biofuels Market Can Enable High Performance—A Supply Perspective.* The study asserted that the current biofuels boom would be short-lived and that the biofuels industry would enter a period of "settling" as the practicalities of scaling this industry became more apparent.

As it turned out, 2007 was a tough year for biofuels development, slowing even more quickly than we expected due to:

- **Excess and stranded capacity in the United States, Europe and Brazil.** For example, the estimated idle capacity in 2007 was approximately 20 percent in the United States and approximately 30 percent in Germany.[1]
- **High and volatile feedstock prices.** Corn went from an average of $2.60/bushel in 2006 to an average of $3.75/bushel in 2007 (a 44 percent increase); soy went from $6/bushel in 2006 to $12/bushel in 2007 (a 100 percent increase).[2]
- **Low product prices.** Ethanol spot prices went from a high of $4/gallon in 2006 to an average of $2/gallon in 2007.[3]

It also looked as though the European Union (EU) governments and the public were beginning to wonder whether biofuels would do more harm than good as evidenced by articles such as:

- "The End of Cheap Food" (*The Economist,* December 6, 2007).
- "Biofuels: Crime Against Humanity" (BBC News, October 27, 2007).

But a "bust" is expected as any industry moves beyond start-up and faces the challenge of scaling. The reality has already started to set in: Biofuels won't solve all of our energy problems, but they won't cause world hunger either. They have a role to play in our energy portfolio. Biofuels are a signpost of the future diversity that we expect in transport fuels, and they can be produced sustainably or unsustainably. It is the role of regulators to ensure that the incentive system around biofuels drives sustainable production and the use of feedstocks and processes that produce a net greenhouse gas (GHG) reduction.

Despite the challenges of 2007, biofuels production will probably exceed the International Energy Agency predictions of 120 billion liters of ethanol and 23 billion liters of biodiesel before 2020. By mid-2007, ethanol capacity stood at 48.1 billion liters, with another 100.6 billion liters financed, announced or permitted. Figures for biodiesel showed commissioned capacity at 11.9 billion liters with another 68.9 billion liters financed, announced or permitted. That means that ethanol capacity at all stages by mid-2007 was equal to 148.7 billion liters and biodiesel capacity at all stages was 80.8 billion liters. Although we do not expect all of the announced capacity to be built in the next two or three years, production continues to grow significantly.[4] For example, 2007 US ethanol production was up 25 percent to 25 billion liters and biodiesel production was up more than 100 percent to 1.7 billion liters.[5]

Our earlier biofuels research gave us a foundation for understanding the supply side of the market, namely feedstocks, markets and producers and how these elements could influence the development of biofuels.

Up close: Highlights of Accenture's first biofuels study

Following are key points from our first biofuels study, *"Irrational Exuberance"? An Assessment of How the Burgeoning Biofuels Market Can Enable High Performance—A Supply Perspective* (2007).

Feedstocks

Our research indicates that first-generation biofuels will stretch much further than Accenture initially expected, and are essential to paving the way for the second generation. Key findings include:

- Ethanol from sugarcane scored high on all of our criteria, and strong potential exists to produce more ethanol from sugarcane.
- Feedstock mix will continue to differ by market, and there will be more use of new and currently underutilized feedstocks.
- First- and second-generation biofuels will be used in tandem for a number of years.
- Sustainability (particularly food and land-use change) will increasingly influence selection of feedstock.
- Higher feedstock prices and margin volatility will continue.

Regulation

Biofuels policies across the 20 markets covered in the study are a patchwork of targets, mandates, production, demand, and infrastructure incentives and capital grants with varying levels of enforceability. Policies will continue to be diverse and to evolve.

Players

A competitive market is being created with players who bring different advantages and challenges to the biofuels industry:

- Agribusiness has scale in the agricultural sector, interests in feedstock supply chain and risk management expertise, but it faces the challenge of competing with its own food business.
- Farmer cooperative groups have government support, but also the challenge of growing/building scale.
- International oil companies (IOCs) and national oil companies (NOCs) have the distribution, but biofuels erode gasoline and diesel volumes.
- Independents have the benefit of developing focused strategies for this market, but they face the challenge of scale.

Figure 1

Current patchwork of international biofuels support policies

	Ethanol						Biodiesel					
	Incentives			Mandate		Enforcement	Incentives			Mandate		Enforcement
	Prod.	Cap.	Infra.	Targ.	Mand.		Prod.	Cap.	Infra.	Targ.	Mand.	
Argentina	Yes	No	No	No	Yes	No	Yes	No	No	No	Yes	No
Australia	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No	No	No	No
Austria	Yes	No	No	No	Yes	No	Yes	No	No	No	Yes	No
Brazil	Yes	Yes	Yes	No	Yes	Yes	Yes	No	No	Yes	No	No
China	Yes	No	Yes	No	Yes	No	Yes	Yes	No	No	No	No
France	Yes	No	No	No	Yes	No	Yes	No	No	No	Yes	No
Germany	Yes	No	No	No	Yes	No	Yes	Yes	No	No	Yes	Yes
India	No	No	No	No	Yes	No	Yes	No	No	Yes	No	No
Italy	Yes	No	No	No	Yes	No	Yes	No	No	No	Yes	No
Japan	Yes	No	No	Yes	No	No	No	No	No	Yes	No	No
Nigeria	Yes	No	No	No	No	No	No	No	No	No	No	No
Poland	Yes	No	No	No	Yes	No	Yes	No	No	No	Yes	No
Slovakia	Yes	No	No	No	Yes	No	Yes	No	No	No	Yes	No
South Africa	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No	No
Spain	Yes	No	No	No	Yes	No	Yes	No	No	No	Yes	No
Sweden	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Thailand	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes
Ukraine	Yes	Yes	No	Yes	No	No	Yes	No	No	No	No	No
United Kingdom	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
United States	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	No	Yes	No

Yes No

Key:
Incentives: Prod. = Product incentive, Cap. = Capital grants, Infra. = Supply chain/demand infrastructure grants
Mandate: Targ. = Production target, Mand. = Blending mandate
Enforcement = Clear policy statement of financial penalty for noncompliance

Source: Accenture research

These players are interacting and partnering. There is no clear winner. It could be agribusiness companies such as Archer Daniels Midland Company (ADM), already one of the biggest producers of bioethanol in the United States and biodiesel in Europe; it could be NOCs such as Petrobras, well positioned to be a leader in the global trade of Brazil's ethanol and investing significantly in biodiesel production; it could be the IOCs that currently dominate retail distribution and fuels marketing; or it could be one of the independents—such as Biopetrol Industries, which is 100 percent focused on biofuels, or a cooperative-backed company such as Tereos. Most important, the key capabilities to succeed will be an amalgamation of what the different groups are bringing to the industry.

Figure 2

Comparison of perspectives and capabilities of biofuels players

	Agribusiness, food producers & chemicals	Farmer-cooperative	Oil & energy companies	Independents
Sources of advantage	Scale in agriculture sector Interests in feedstock supply chain Risk management expertise	Access to feedstock Government support	Distribution Investments in second-generation R&D Scale	Clear strategic focus Ability to adapt quickly Backing of private investors
Challenges	Strategic conflict with food business	Lack of scale	Do not own feedstock Cannibalizing own products	Lack of scale Limited access to feedstock
Global ethanol producers in top 25 (examples)	Archer Daniels Midland Cosan Cargill The Andersons Santaelisa Vale Sao Martinho	POET Glacial Lakes Corn Processors	CNPC	VeraSun US BioEnergy Corp. Abengoa Aventine Pacific Ethanol
Global biodiesel producers in top 25 (examples)	Archer Daniels Midland Sofiproteol NRG Chemical Wilmar International Cargill		Neste PNOC Repsol INEOS	Imperium Renewables Natural Fuel Ltd. Biopetrol Industries Gushan Acciona VERBIO BioCapital Brasil Ecodiesel

There are four stages of capacity: commissioned, financed, permitted and announced.

Sources: New Energy Finance; Accenture research

Companies in white are currently in the top 25 (commissioned and financed) and will stay in the top 25 when all stages of capacity are considered.
Companies in yellow are in the top 25 (commissioned and financed) but slip off the list when all stages of capacity are considered.
Companies in blue are new entrants and will be in the top 25 if all of the permitted and announced capacity is built.

An evolving biofuels industry

In this study, Accenture examines the demand side of the industry—that is, the extent to which end consumers, the automotive industry, blenders and retailers support biofuels growth. We also identify the challenges of creating scale markets in biofuels feedstock, production, transport and distribution. Lastly, we look at both supporting and competing technologies and their potential impact on the evolution of the biofuels market.

The global biofuels industry is a little like a jigsaw puzzle with individual pieces that will have to fit together to create a viable global marketplace. This report explores our findings regarding:

Consumer influence
Environmental benefits must be clear for motorists and business-to-business demand to support the growth of biofuels.

Original equipment manufacturer (OEM) role
OEMs are introducing flexible-fuel vehicles (FFVs). In addition, most cars currently on the road can take up to 10 percent of ethanol (in gasoline cars) and 5 to 10 percent of biodiesel (in diesel cars), but warranties continue to vary by vehicle manufacturer and country.

Distribution and oil company activity
There are growing pains integrating biofuels into the current fuels value chain, and NOCs are moving beyond distribution.

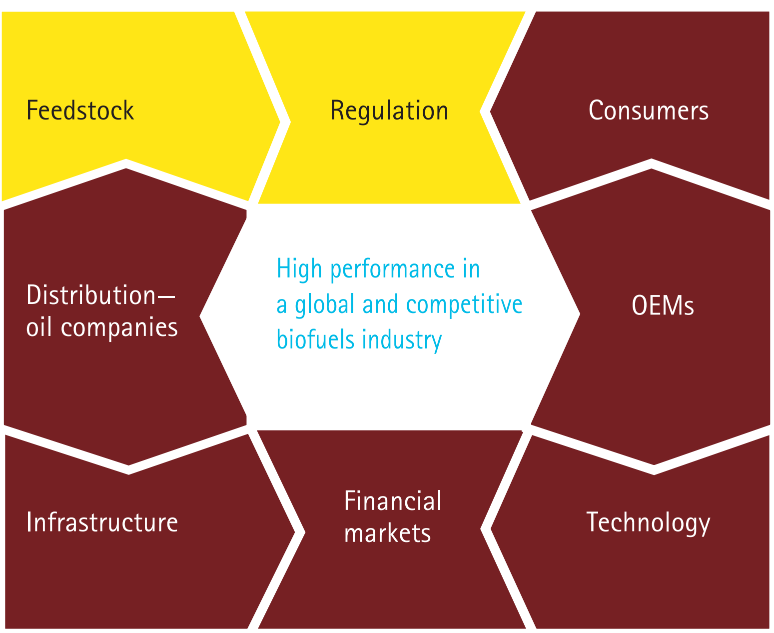
Infrastructure development
Infrastructure to facilitate operational scale and trade is critical if an efficient market is to develop.

Financial market immaturity
Paper markets (exchanges where contracts, including futures and options, are traded freely without the need for physical delivery) are still immature, and risk management for producers as well as blenders/consumers of biofuels is a significant challenge as a result.

Technology evolution
The biofuels industry has time—perhaps 10 years—to evolve into a truly global and efficient industry before competing technologies start to challenge first- and second-generation biofuels.

Figure 3

Factors that must fall into place to create a global biofuels industry



Source: Accenture research

Covered in first study
Covered in this study

What drives great companies?

Accenture is committed to uncovering the key ingredients to help each of our clients develop into a high-performance business. As part of the Accenture High Performance Business research initiative, we undertook a study (*Big Thinkers*, 2005) focusing on independent energy companies and the attributes that were common across the businesses achieving high performance. Accenture has also explored how IOCs can balance the challenges of growing business on NOCs' home turfs, while competing with them internationally (*The National Oil Company—Transforming the Competitive Landscape for Global Energy*, 2006). Accenture's first biofuels study, *"Irrational Exuberance"? An Assessment of How the Burgeoning Biofuels Market Can Enable High Performance—A Supply Perspective* (2007), explored another emerging trend—the renewed emphasis of biofuels on the global stage. This study continues our examination of the biofuels market.

Through our ongoing High Performance Business research, Accenture is committed to helping our clients in all industries achieve high performance. To review findings from our other research and experiences with more than 500 high performers, visit www.accenture.com.

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Consumer influence

The impact on GHG reduction has to be clear.

In this section, we look at the extent to which consumers of transport biofuels (retail and business-to-business) will support and shape the growth of the global biofuels marketplace. Recently, consumers have witnessed a lot of debate around the long-term impact of biofuels, as the topic has been discussed more frequently in the popular press and among politicians and world leaders.

In Accenture's first biofuels study (*"Irrational Exuberance"?*), we discussed the role of biofuels in rural development. Biofuels, in many countries, are still an opportunity to raise the income of the poor. However, the first half of 2008 saw the food-versus-fuel debate, and more recently, concerns around the indirect impacts of land-use change dramatically heightened in profile, with the World Bank, the United Nations (UN), development agencies and world leaders all expressing their concern about the impact of heightened commodity prices and its disproportionate impact on the already poor. Some non-governmental organizations (NGOs) and media commentators have sought to make it a "biofuels-equals-bad" discussion, citing "perverse" incentives for switching land previously used for growing food crops to growing energy crops with associated effects (for example, deforestation and reduction of biodiversity).

This ignores wider global socio-economic trends, as well as the nonhomogenous nature of biofuels, especially those of second and third generation. The more considered reaction was UK Prime Minister Gordon Brown's letter to the "Group of Eight" (G8) in which he wrote: "There is a growing consensus that we need urgently to examine the impact on food prices of different kinds and production methods of biofuels, and ensure that their use is responsible and sustainable."[6] This reflects UK government policy as set out by the Department of Transport "to proceed with caution, seeking to take advantage of the environmental opportunities offered by biofuels, while putting in place the safeguards to avoid the potential disadvantages. We are working to ensure that the biofuels we use come from sustainable sources, and save the largest amount of GHG emissions possible; and we are working internationally to make sure other countries do the same."[7]

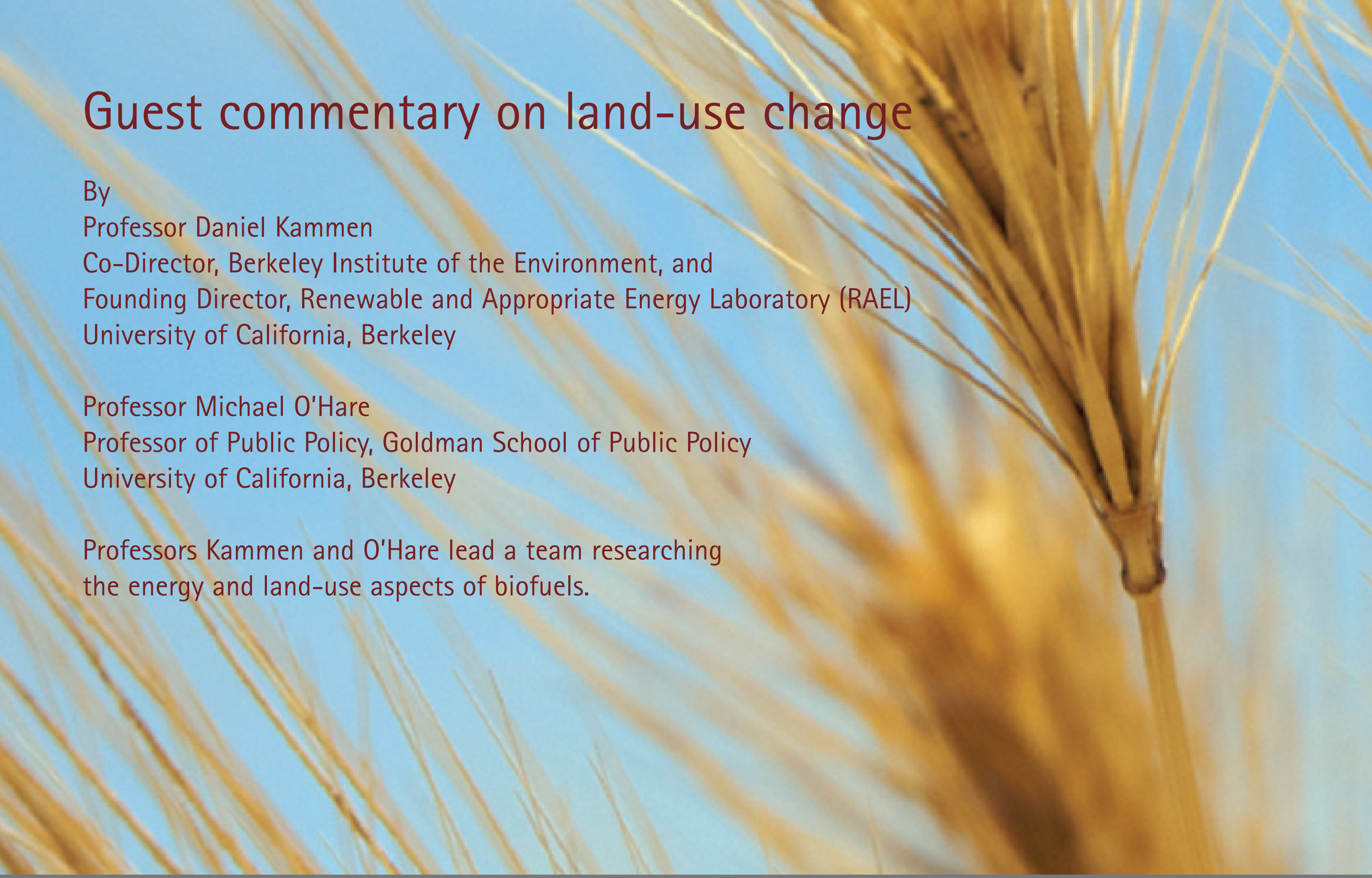
Definition: Land-use change[8]

Land-use change is the diversion of land from one function to another. For example, when forested land is cleared for agriculture or when houses are built on farmland, the function of that land has changed in a way that cannot easily be reversed. The importance of these changes for biofuels is that recent research indicates that they affect the carbon balance in the atmosphere, and hence the real sustainability of a variety of biofuels.

In the example of deforestation to create cropland, burning or decay of trees (and other vegetation) cleared from the site releases very large amounts of CO_2. If the cleared land was a wetland with peat soil, the conversion discharges are even greater. Beyond this initial release of emissions, the land will no longer absorb carbon dioxide as a growing forest did before it was cleared. Additionally, the new use of the land may contribute to ongoing emissions as crops are turned over. If products such as fertilizers or pesticides, which can be carbon-intensive, are used on this land, the problem is compounded further.

The global warming effects of indirect land-use change are more difficult to calculate, but potentially very large. Consider a farmer in the United States who decides to grow corn to turn into ethanol instead of grazing cattle on his land and growing soybeans. This would not be counted as a direct effect because the land was already being used for agriculture. However, the cattle would have to be grazed somewhere, and this displacement might cause the farmer to clear some woodland to keep his livestock.

At the same time, as the farmer and many of his colleagues decide to grow corn instead of soybeans, total US soybean production goes down, and there are fewer soybeans to export. This, in turn, causes soybean prices to rise on the international market. The causal chain from growing biofuel feedstock instead of feed corn in Iowa (for example) can be long and end far from the original biofuel production; one such sequence is successive displacement of US soybeans by corn, Brazilian cattle pasture by soybeans, and then Brazilian forest by cattle expansion. These indirect effects are clearly difficult to estimate, yet they may be crucial in determining the carbon impact of first- and second-generation biofuels: even cellulosic feedstocks such as switchgrass, if grown on land that could or would otherwise grow food or feed, will have an indirect land-use change effect that needs to be considered.



Guest commentary on land-use change

By
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Professors Kammen and O'Hare lead a team researching the energy and land-use aspects of biofuels.

Current analysis of the global warming (GW) effect resulting from the substitution of biofuels for petroleum recognizes that land-use change (LUC) induced when biofuel feedstocks compete for land with food and feed production for biofeedstocks may be large, not only reducing the GW advantage of [some] biofuels over petroleum but reversing it. The discussion is especially influenced by two recent journal articles (Searchinger, Heimlich et al. 2007 and Fargione, Hill et al. 2008). (This effect was noted in the 2006 modeling work conducted by our group when we developed the EBAMM model [Farrell et al. 2006], but was not included in that analysis; we are currently running economic models of land-use change for a variety of feedstocks, including cellulosic, corn and sugarcane. EBAMM is available as open-source software at http://rael.berkeley.edu.)

The LUC effects of biofuels are proportional to the land area converted to agriculture from natural conditions, or shifted into biofuel production from a former use for food crops. At any moment, we assume that if a unit of biofeedstock is grown, or used for fuel instead of food, some amount of land will be converted from natural cover to agriculture (not, generally, to growing more of the particular feedstock used for fuel, and not, generally, the same acreage as used for the biofeedstock), because the worldwide demand for food is quite inelastic. Each kind of natural cover replacement has a characteristic release of GHG to the atmosphere from burning or decay of vegetation; forests have especially large carbon stocks that are released on clearing.

It is important to note that this effect is determined by assessing the impact through an economic model of crop (food or biofuel) substitution patterns, as well as the natural ability of different land types and standing biomass to sequester, or store, carbon.

This point is vital, because the direct effect, namely the value in terms of energy prices, security or greenhouse gas impact (as was covered in Farrell et al. 2006 and Kammen et al. 2008), is one that can be physically measured. Thus, inclusion of indirect land-use effects in assessing a given biofuel's GW effect mixes a physically measurable effect with one mediated by an economic and land-use model.

Biofuels that would not incur this indirect land-use "penalty" include crops such as algae-based fuels grown in tanks on nonarable land; biofuels made from waste, such as urban garbage; and biofuels made from biomass grown in ways that do not compete with food or nature, such as biofuels made entirely from waste materials from agriculture, or those derived from waste cellulosic material from forest operations. The trick, of course, is ensuring that the feedstock is truly a waste material, and not one that encourages expansion of production or cultivation because of new access to the biofuel market.

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In focus: The food-versus-fuel debate

The food-versus-fuel debate is about whether the use of agricultural output for energy purposes competes with its use for food purposes either directly (where the same crop could be used for either food or fuel) or indirectly (where land use for energy crops displaces food crops) and leads to food shortages and/or higher food prices as a result. The debate has been around for a long time, but it was the steep rise in global food prices that started in 2006 that has catapulted the debate to global prominence. The Food and Agriculture Organization (FAO) of the United Nations estimates that between March 2007 and March 2008, global cereal prices rose by 88 percent, with corn up 31 percent, rice up 74 percent, soy up 87 percent and wheat up 130 percent.[9] Similarly, the World Bank estimates that global food prices rose by 83 percent over the 36 months to February 2008, with a 181 percent rise in global wheat prices over the same period.[10] There is a question of whether these rising global food prices are contributing to high food inflation in many countries, and pushing millions of people in poorer countries deeper into poverty. Others echo this concern, pointing out that the world's poor will be forced to buy less food; buy cheaper, less nutritious food; or depend on aid to survive. Some analysts believe these higher food prices will continue through 2010, posing significant hardship for many and potentially creating sources of social instability.

The logical question, therefore, is, To what extent have biofuels contributed to these global price rises? Critics point to the fact that in 2007, up to 100 million tonnes of grain were processed into bioethanol and up to 8 million tonnes of vegetable oils were processed into biodiesel. A particular finger is pointed at US bioethanol production, which accounted for 24 percent of the 2007-2008 corn harvest and is anticipated to increase.[11] However, it is also worth looking at the other factors that have contributed to the current supply-demand imbalance:

- **Changing dietary habits** in many Asian countries, with the expanding middle classes consuming more meat, creates an associated upward pressure on livestock feed demand. Unlike bread,[12] which has the dynamics of a "necessity good" (relatively constant long-term per capita consumption, hence driven by population growth), meat has the dynamics of a "luxury good" (per capita consumption influenced by income, hence driven by economic growth). Taking China as an example, meat consumption per capita has increased from 25 kilograms in 1995 to 53 kilograms in 2007, or a compound annual growth rate (CAGR) of 6.5 percent in this period. Because it requires approximately 5 kilograms of grain to produce 1 kilogram of meat, this amount represents a significant indirect demand for feed. Furthermore, this level of Chinese meat consumption is still significantly below that of Western countries, so a further rise can be expected.
- **Reduced food reserves** as a result of recent changes in trade policy (removing farm subsidies and support programs that previously led to surpluses and stockpiling) has meant less of a buffer to increased demand.
- **Natural disasters have had an impact** on major grain production areas, including droughts in Australia, parts of Europe, Turkey and the Middle East; exceptional rains in India; and cyclones in Southeast Asia. For example, the drought in Australia led to winter crop production falling from norms of 35 million tonnes to 15.7 million tonnes in 2006-2007, with only partial recovery in 2007-2008 to 22.6 million tonnes.[13]
- **Domestic policy responses** by several grain-exporting countries trying to shield their populations from price rises by putting taxes or restrictions on exports (for example, Cambodia, China, Egypt, India and Vietnam for rice; Ukraine and Russia for wheat, etc.) have reduced the incentives for increased production and thereby exacerbated the problem for other countries that rely on imports.

The neglect of agriculture in many developing countries due to several reasons has become a bigger problem now that other countries have another market for their crops. Reasons for neglect include the inability to compete with highly subsidized outputs from developed countries; disconnects between global and lower local prices that provide disincentives for farming; the absence of physical and market infrastructures to enable small growers to engage in exports; inadequate agricultural labor forces due to the impact of HIV/AIDS; and limited development assistance for agricultural projects versus those in education or health.

There are also two other factors that have contributed to rising prices:

- **High oil prices**, which affect costs throughout the agricultural value chain, including those of fertilizers; mechanized activities (such as irrigation, cultivation and harvesting); and transport of inputs and outputs. Analysis of US farming figures indicates that fuel and fertilizers account for 40 to 50 percent of operating costs for corn[14] and 20 to 25 percent for soy;[15] hence, any rises in these inputs are likely to be passed to consumers.

- **Increased investment in commodities.** An analysis of CME Group futures shows that commodity-index funds controlled 4.5 billion bushels of corn, soybean and wheat through these futures in January 2008, up 66 percent since January 2006.[16] Speculators are competing with each other and traditional market participants (growers and grain merchants), leading to some of the latter taking action such as not guaranteeing prices beyond 60 days.

In volume terms, bioethanol accounts for more than 90 percent of the biofuels market, and 90 percent of bioethanol production comes from just two crops: sugarcane and corn. However, corn price rises have been the smallest among those of grains (contrast the 31 percent rise over the year to March 2008 with the 78 percent rise in rice, which is not a common biofuel feedstock nor subject to substitution as animal feed).[17]

Raw sugar prices actually fell in early 2007 and struggled for many months to recover, given the physical market fundamentals of a significant surplus of supply over demand. The International Sugar Organization (ISO) estimates that in 2006-2007, world production was 166 million tonnes versus world consumption of 154.8 million tonnes, and that in 2007–2008, world production will be 168 million tonnes versus world consumption of 159.13 million tonnes. Indeed, the ISO points out that the rally in prices in early 2008 reflects heavy commodity fund investment, leading to a disconnect with fundamentals.

Much emotive sentiment assumes that future growth in biofuels will take place through food-based feedstocks (and this will be true for sugarcane), but many feedstocks already are independent from food market developments. Existing nonfood raw materials such as waste oil, tallow, jatropha, cassava, etc. will be increasingly used in biofuels production. In reality, the current high oil prices provide incentives for development of second- and third-generation biofuels, especially given the growing focus of governments on sustainability.


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In 2007, Accenture conducted a Climate Change Survey.[18] One of the findings of the survey was that consumers would be willing to pay more for transport fuels as long as the impact on GHG reduction was clear.

The same survey showed that 89 percent of consumers would switch energy (oil and gas) providers if they felt the provider was proposing products that reduce carbon emissions.

Take-up of biofuels by the average motorist will be dependent upon three things evolving at the same time: the availability of new biofuels, the availability of new fuel vehicles and the infrastructure that supports the new biofuels. One without the others has limited effect. For example, FFVs form a significant proportion of new-vehicle sales in some places, but many times are driven on fossil fuels because of the scarcity of biofuels refueling sites. Given the uncertainty of first-mover investment and dependence on another party to realize the returns of this investment, the joint changes naturally take time, except where these changes have emerged due to specific government pressure or incentives.

The business sector can move faster than individual motorists, although there are still technical challenges in switching in bulk to biofuels. Developments will be gradual as organizations work out how to do this economically (for example, by securing adequate supplies, without voiding existing manufacturer warranties on engines, etc.). The National Biofuels Board estimates that more than 700 major fleets in the United States are using biodiesel commercially.

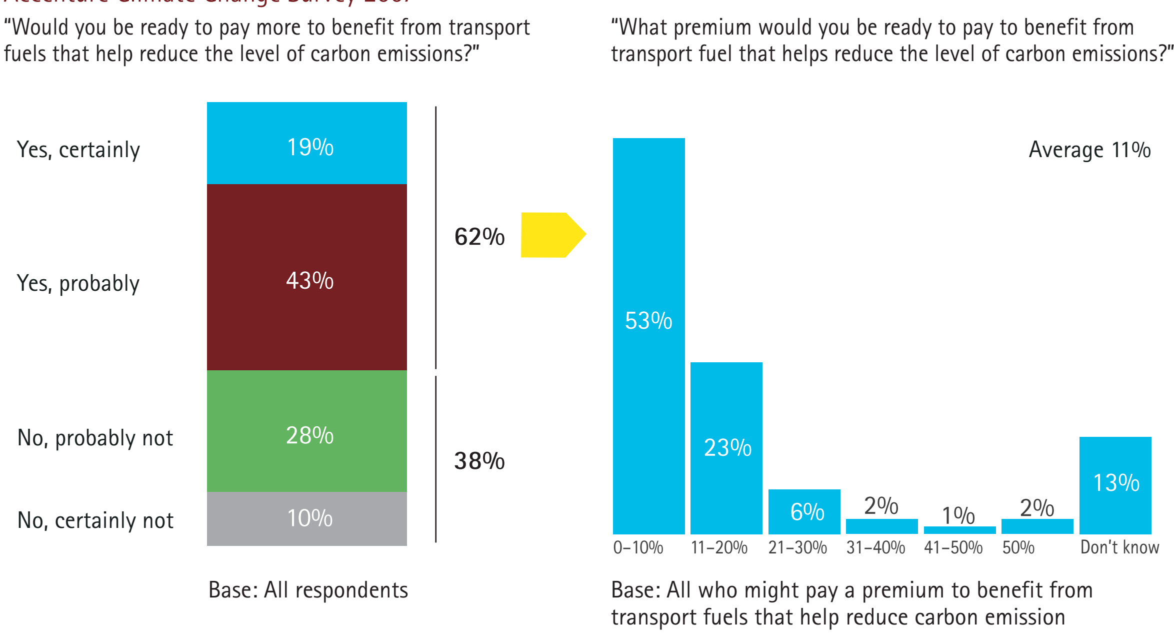
In this study, we chose to highlight a few examples of biofuels consumption in the following sectors:

- Public services
- Passenger transport (buses, coaches and rail)
- Freight transport
- Retailers
- Airlines

Figure 4

Consumer attitudes toward low-carbon transport fuels

Accenture Climate Change Survey 2007



Source: Accenture research

Public services

While governments are expected to guide sustainability through the legislative and regulatory environment, their supporting role as consumers is often underrepresented.

In most countries, the state (meaning a combination of national, regional and/or local government) controls or influences public services that have a significant transport element—for example, education, health, waste and recycling, parks, emergency services, and the armed forces. Table 1 gives examples of countries where biofuels have begun to form part of this transport element.

While it was inevitable that such development would start off in an uncoordinated manner, it is recognized that there are opportunities for countries (especially within a region) to share ideas, information and experience about switching public-sector fleets to biofuels. The EU, in particular, is funding several coordination programs, including:

- **Bio-NETT**—"Developing a supportive framework for encouraging the growth of local markets for biofuels as a low-carbon fuel for local authorities and other public-sector transport fleets across the EU."
- **Bioethanol for Sustainable Transport**—"Stimulating a self-supporting market for bioethanol-fueled vehicles through collaboration of several cities, vehicle manufacturers, biofuels producers and universities."
- **Biofuels Cities**—"To build and maintain a European Partnership—in which biofuel end users, suppliers and those actors setting the frameworks for biofuel application are invited to form new partnerships for projects and engage in exchange and networking."

Table 1

Public services biofuel activities

	Central agencies	Local agencies	Emergency services	Armed forces
Australia		Several city councils (e.g., Adelaide, Brisbane, Sidney, Hobson Bay) trialing B20 in their public fleets. South Australian state government using B5 in Adelaide metropolitan trains and buses; Western Australian state government using B5 in its Transperth bus fleet. Other state governments (e.g., Victoria, NSW) encouraging use of biofuels for public vehicles where available and cost-effective.		
Austria	The Austrian Federal Procurement Agency signed contracts to substitute a portion of the federal fleet to alternative-fuel cars (e.g., ethanol, biogas, hybrid) within the next years.	Public bus fleet in Graz, Styria, running on B100 since 1994. A feedstock is used cooking oil.	Part of the emergency services fleet will be changed to alternative-fuel vehicles within the next years.	
France		Partenaires Diester is grouping 30 French cities that run their public transport on a B30 blend.		
Germany	Conversion of fleets of some state-owned enterprises (e.g., Wismut GmbH) to biodiesel. German Taxi Association adopted biodiesel use in mid-1990s.	Several municipal public transport fleets (e.g., Heinsberg and Neuwied) operating on biodiesel.		
India	Government-owned Indian Railways trialing biodiesel blends (B10+).	State road transport corporations (e.g., Andhra Pradesh, Gujarat, Haryana, Karnataka) and Pune Municipal Council trialing biodiesel blends.		
Japan	Environment Ministry cars running on E3. Rollout to other government cars expected in coming years.			
Sweden	National government has set requirements for 85 percent of cars procured or leased by its departments to be green (powered by biofuels or other renewables).	Stockholm moving toward target of 100 percent "green vehicles"[a] by 2010. Several cities (e.g., Trollhättan) have switched their municipal fleet to run on 100 percent biogas.	National government has set requirements for at least 25 percent of emergency vehicles to be "green."	
United Kingdom	Following review by Government Car and Dispatch Agency (GCDA) in 2005, all new government vehicles added to the fleet throughout the United Kingdom will be either hybrids or diesel vehicles that will run on 5 percent biodiesel. GCDA also uses B5 in all of its London-based vehicle fleet.	Several local authorities (e.g., Dorset County Council, Cheshire County Council) using biodiesel as part of their fuel mix. Somerset County is trialing E85 as part of European BEST project,[b] and also engaging in Bio-NETT.	Several police authorities (e.g., Dorset Police, Tayside Police and London Metropolitan Police) using biodiesel as part of their fuel mix. Avon and Somerset Police are trialing E85 as part of European BEST project.	
United States	Federal agencies subject to EPAct 1992 (requires from 2000 that 75 percent of light-duty vehicles acquired to be alternative-fuel vehicles) and to Executive Order 13423 (requires 10 percent per year increases in non-petroleum-based fuels relative to 2005 baseline and running to 2015). The National Park Service is introducing biodiesel into many national parks (e.g., Everglades, Yellowstone, Yosemite).	Many cities (e.g., Austin, Berkeley, San Francisco) have switched their municipal fleets to run on biofuel blends. Others (e.g., Cincinnati, Oklahoma City, St. Louis) have converted their public bus fleets to run on biodiesel blends.	Many cities (e.g., Albuquerque) running emergency vehicles on biofuel blends.	The US military is the single largest user of biodiesel (Air Force, Army, Navy and Marines all use B20 in their fleets).

[a] Green vehicles are those that either use biofuels or emit less than 120g CO_2/km (typically hybrid or electric vehicles)

[b] Bioethanol for Sustainable Transport

Source: Accenture research

Passenger transport

Passenger transport companies are under as much pressure as any other part of the transport industry to demonstrate their commitment to sustainable business. Indeed, several road and rail public transport companies have begun to position themselves with customers as environmentally friendly alternatives to personal car use or aviation.

Many of these companies are therefore investigating a range of methods to improve their emissions profiles to strengthen this differentiation. One of the most immediate options available is increased use of biofuels. Following are some examples:

- **Arriva** announced in 2007 that it is trialing B20 biodiesel for the first time on its buses. Arriva is aiming to reduce total carbon emissions by around 14 percent. The 75 buses in the trial in the United Kingdom will carry around 130,000 passengers every week.[19]
- **FirstGroup** has supported the introduction of B5 across its UK fleet in collaboration with BP, its fuel supplier. It is currently testing biodiesel for its UK rail fleet. As biodiesel availability in the United States increases, FirstGroup is also committed to introducing B5 where possible.[20]
- **Stagecoach** is the first company to trial B100 for its fleet in the United Kingdom in partnership with Argent Energy. The vehicles on trial in Scotland have specially designed dual fuel tanks, and Argent provides bulk storage of biodiesel at the Stagecoach depot. Stagecoach is also offering customers discounted travel for providing used cooking oil for the project.[21]
- **Veolia Environmental Services** has announced that it is developing its first biodiesel project in France, with a plant outside Paris expected to produce 60,000 tons of biodiesel per year. Veolia will use the biodiesel for its fleet of waste collection and passenger transport vehicles.[22]
- **Virgin** launched the United Kingdom's first biodiesel train service in 2007, with B20 being used in trains traveling between England and Wales.[23]

Freight transport

Freight transport is a key market for biofuels to be able to penetrate—there are already several large logistics providers either trialing or moving to biofuels, generally because of their stated commitments to reducing environmental impact.

The freight transport sector is one of the largest in any major economy, and the majority will be road—as opposed to rail or barge—freight (for example, spending on US freight transport is estimated at more than $500 billion, of which spend "on truck freight" is estimated at $400 billion; in Europe, road freight transport accounts for 77 percent of inland freight transport).[24] These companies include:

- **US Postal Service.** The US Postal Service operates one of the largest alternative-fuel vehicle fleets in the world. Some 38,000 vehicles are powered by alternative fuels, including ethanol (E85) and biodiesel fuels.[25]
- **McDonald's with Keystone Distribution.** Keystone Distribution UK is the UK distributor for McDonald's and therefore engaging in McDonald's program to use biodiesel made from used cooking oil from the fast-food chain. Every vehicle in the 155-strong delivery fleet will be converted to run on the fuel.[26]
- **Linfox.** In September 2006, the company announced that it was going to trial the use of biodiesel in its Australian fleet, with fuel provided by Axiom Energy.[27]
- **TNT.** As part of its global "Driving Clean" program, the company is running a pilot in Amsterdam using biodiesel made from rapeseed oil to power a fleet of more than 50 vehicles.[28]
- **J D Wetherspoon and DHL.** DHL is carrying out a small pilot in the United Kingdom in partnership with J D Wetherspoon and Argent Energy in which Argent will use waste cooking oil from Wetherspoon pubs to produce biodiesel for the DHL trucks.[29]
- **SDL.** The Austrian company has been running its truck fleet on biodiesel, produced from McDonald's used cooking oil.[30]

Retailers

Retailing is a sector that relies on customer perceptions and buying values—hence, it is not surprising that the intensity of the biofuels debate in recent months has made many large retailers scale back their public support for biofuels.

Those that continue to be high-profile are:

- **Safeway US.** In January 2008, the company announced that it had converted its entire US fleet of more than 1,000 trucks to bio-diesel as part of its GHG Reduction Initiative. It believes that this will reduce CO_2 emissions by 75 million pounds annually. In addition to its commitment to alternative fuels, Safeway is also dedicated to the use of solar and wind power and, in September 2007, was awarded the California Governor's Environmental and Economic Leadership Award in the area of climate change.[31]
- **Tesco.** The company has introduced biofuels into its distribution fleet in the United Kingdom.[32]

There are also several business-to-business goods suppliers that have moved toward biofuels, including Corporate Express. In January 2008, the company announced that it is now fueling the majority of its truck fleets in Colorado and Kansas with B20 as part of its US Sustainability Policy activities. It also plans to transition more of its US fleet to biofuels once cost and availability criteria allow it to do so.[33]

Airlines

Even airlines are looking to biofuels as a possible way to reduce their emissions. Because of the physical and chemical properties of jet fuel, aviation is not a segment that is traditionally associated with biofuels, despite consuming more than 55 billion gallons of fuel per year.

However, the use of biofuels in aviation has emerged recently with both Virgin and Air New Zealand publicizing their biofuels activities. We have been interviewing airlines to get their views on the subject, and these themes have surfaced so far:

- **Volume.** In our research, we have not found an airline that has ruled out using biofuels if biofuels prove technically and commercially viable. Indeed, the most bullish are looking for 5 to 10 percent of fuels to come within five to 10 years.
- **Blend.** Airlines need a biofuel that can be blended into existing oil-derived aviation fuel or is an organic replicant (that is, it has all the technical properties of aviation fuel but happens to be derived from organic material rather than fossil fuels).
- **Industry.** Aviation is a collaboration between airlines, airports, fuel distributors and providers of specialist services. For biofuels to succeed, all these parties must buy into the concept.
- **Hubs.** Competition to be an airline hub is another incentive for biofuels as a scenario where state-owned carriers, airports and NOCs create "biofuels hubs" as a differentiator.
- **Portfolio.** Airlines will have a portfolio of routes. Some routes will use biofuels; others will not.
- **Securing supply.** While some airlines are content to move biofuels forward by influencing policy, others are prepared to vertically integrate (potentially as far as owning conversion plants with feedstock supplied under long-term contracts from affiliates).

In summary, we believe that demand will be there from both average motorists and businesses as long as governments manage the sustainability issues. As we discussed in our *"Irrational Exuberance"?* study, for governments, what is important is the domestic agenda and setting policy that balances three key objectives: energy security, reinvigorating agriculture and climate change.

Case study: Impact of biofuels on growth in sub-Saharan Africa

Due to its climate, sub-Saharan Africa shows long-term potential for biofuels production. It has many countries with a tropical climate, vast arable land, a large workforce and a strategic location relatively close to the fuel-hungry European markets. There is also a plethora of socioeconomic issues—including HIV, extreme poverty, rising inflation, lack of infrastructure and rampant unemployment—that these developing countries must address in order to improve the lives of the majority of their citizens and compete favorably in the global market.

Can the potential of biofuel production in this region be sustainably unlocked and help alleviate some of these socioeconomic issues?

Rural development benefits

Government commitment to biofuels is driven by the impact biofuels could have on rural development.

For example:

- Kenya envisions using the "nucleus farming approach" to grow jatropha, where small farmers cooperate with commercial farmers to increase production and also transfer skills and equipment.[34] This approach has been used with great success in the past for cash crops such as coffee.
- In South Africa, the strategy is to invest in underdeveloped regions such as parts of the Eastern Cape.[35] Achieving the modest 2 percent biofuels scenario will still have a significant positive impact, according to the feasibility study findings included in the strategy. The jobs-to-investment ratio for the creation of a biofuels industry is about 100 times higher than for crude oil refineries, making it attractive to developing countries wanting to increase employment levels. The industry will be able to create 25,000 sustainable jobs, mainly in rural areas where jobs are sorely needed. This will boost economic growth by 0.05 percent, as well as achieve a balance of payments saving of approximately $223.7 million by reducing importation of crude oil.[36] In terms of environmental benefits, the industry will create a greenhouse gas emissions saving of approximately $13.2 million per annum.[37] This will require only 1.4 percent of arable land in South Africa. Currently 14 percent of arable land is underutilized; thus there is sufficient land available to sustain the predicted growth in biofuels in the long term.
- In Mozambique, there are currently 22 projects under way, including a $408 million biodiesel plant in a joint venture by the national oil company Petromoc and Brazilian companies.[38]

Additional benefits

Biofuels will bring the additional benefits of an increased supply of animal feed, energy for cooking and lighting, and a feedstock for electricity generation.

By-products such as protein oil cake from sources such as soybeans can be used for animal feed. In South Africa, these by-products currently are being imported. These by-products can also be used as a source in gasification plants and fertilizer production. Jatropha oil is also a substitute for tallow and has been used in soap production.

Sustainable energy for cooking and lighting is of crucial importance for rural development in sub-Saharan Africa. Six hundred million people in Africa currently do not have access to energy;[39] their primary method of heating is using wood fires and paraffin stoves. Several initiatives are under way to promote the use of ethanol gel-based lamps/stoves.[40] These devices are cost-efficient and safe; the gel lasts longer than paraffin and burns with a carbon-free flame, so it does not cause respiratory problems and is nontoxic. If the device is overturned, the gel will extinguish the wick.

Biofuels can also be used for electricity generation. An example of this is the implementation of a large-scale jatropha-fueled rural electrification project in the village of Garalo in southern Mali.[41] Based on a long-standing request of the population to have access to modern energy, the commune of Garalo is setting up 1,000 hectares of jatropha plantations to provide the oil for a 300-kilowatt power plant. This plant will provide clean electricity to more than 10,000 people for more than 15 years, thereby transforming the local economy. It does so by providing power for productive use in small industries and businesses, generating employment, and supplying power for social uses in schools, the maternity clinic, community buildings and domestic use.

Food versus fuel

The raging debate regarding food versus fuel is particularly pertinent to sub-Saharan Africa, the poorest region in the world, where many countries are currently net importers of food. The rapid increase in international food prices has not been limited to biofuel-producing crops. Other food staples such as rice, beef, poultry and dairy products have also shown drastic increases.

Various political, economic and social factors have contributed to this rapid increase. Reduced production and increased consumption in emerging economies, lower levels of stock, country-specific conditions (climate, political situation, legislation, subsidies, etc.), increased demand for biofuels production, speculative buying, hoarding by some major consumers, and the higher cost of energy, fertilizer and transport are some of the key elements that have combined to create the current situation.[42]

For low-income, food-deficit countries in Africa, the import bill for cereal (maize, wheat, rice) is projected to increase by 74 percent, according to the UN agency's *Crop Prospects and Food Situation* report.[43] This situation has a tremendous impact on the poor. Food represents about 10 to 20 percent of consumer spending in industrialized nations, but as much as 60 to 80 percent in developing countries.[44]

The first priority for African governments is food supply; hence, in most policies drafted, the intent is to ensure that this priority is met before producing biofuels from surplus crops. In South Africa, maize has been specifically excluded from the biofuels strategy due to food-supply concerns.

Particularly in sub-Saharan Africa, the use of basic interventions can have a tremendous impact on agriculture. In Malawi, fertilizer subsidies and lesser ones for seed, abetted by good rains, helped farmers produce record-breaking corn harvests in 2006 and 2007.[45] Corn production leapt to 2.7 million metric tons in 2006 and 3.4 million in 2007 from 1.2 million in 2005, enabling the country to export maize to neighboring countries. These interventions show that it is possible to supply biofuels in Africa without compromising on food requirements, making use of better farming initiatives and utilizing available land. In Zambia, currently only 15 percent of the 25 million hectares of arable land is being used for food production.[46]

Political will

The biofuels industry is particularly attractive to African governments due to the following reasons:

- Reduced dependence on fuel imports
- Opportunity to create sustainable jobs in marginalized areas

Regional level

- Policies such as the Action Plan for Biofuels Development in Africa have been formulated to provide a general framework and alignment among countries regarding the research and development of their biofuels industries.[47]
- The Southern African Development Community (SADC), which comprises 14 countries, will become a free trade area within the next few months, enabling easier product flows between countries.[48] The SADC Energy Protocol, which includes fuel specification rationalization, is intended to encourage inclusion of biofuels in the regional pool and develop regional biofuels specifications.[49]

Country level

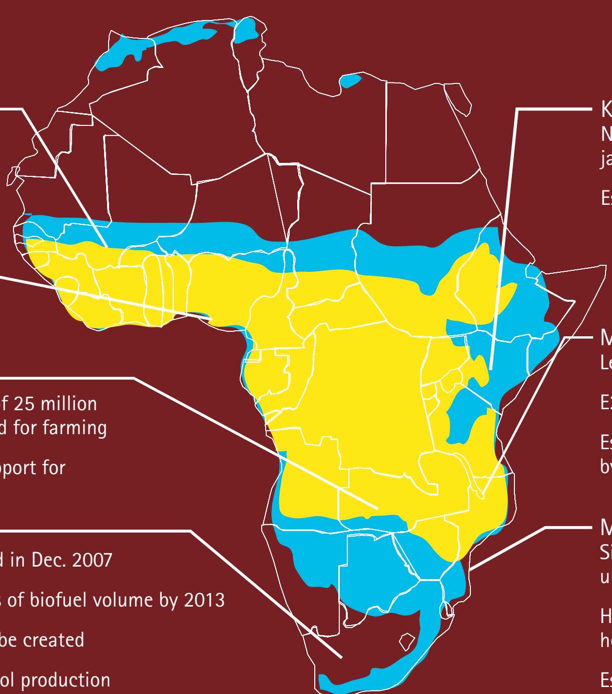
- Malawi has established a firm legislative commitment to develop the biofuels industry. It prescribes a mandatory blending level of 20 percent for ethanol and 10 percent for biodiesel.[50]
- Other African countries are in the process of conducting feasibility studies and formulating legislation based on their specific needs and strengths. For example, Nigeria is the world's largest producer of cassava and intends to use its major crop to produce ethanol.[51]
- South Africa released its biofuels strategy in December 2007. The strategy adopts a short-term focus (five-year pilot) to achieve a 2 percent biofuels penetration level (400 million liters per year by 2013) and prescribes a nonmandatory blending level of E8 and B2. It also provides for a 50 percent fuel levy exemption for biodiesel, a 100 percent fuel tax exemption for bioethanol and cooperatives for small-scale farmers.[52]
- Organizations comprising public-private partnerships (for example, South African Biofuels Association, Biofuels Association of Zambia) also have been formed to encourage industry development.

Way forward

Biofuels provide an opportunity to harness Africa's vast biomass resources for the benefit of all its people, but to do that, more research on better-yielding crops, production methods and use is needed, as is the political will to ensure that partnerships are integrated and implemented. Accenture believes that biofuels have the potential to help the world's poorest people develop an income source—a product that can demand a fair price on the world stage. However, managing the development of this new industry through its many growing pains (including increasing food prices) will continue to be a challenge for governments.

Figure 5

Main biofuels initiatives in sub-Saharan Africa



Mali
Large-scale rural electrification project using jatropha oil to power generators installed

Nigeria
Producing ethanol from cassava

Zambia
Currently only 15 percent of 25 million hectares of arable land used for farming

Significant government support for jatropha as biodiesel crop

South Africa
Strategy document released in Dec. 2007

Estimated 400 million liters of biofuel volume by 2013

Estimated 25,000 jobs will be created

Maize excluded from ethanol production due to food security concerns

Kenya
Nucleus farming approach to plant jatropha for biodiesel

Estimated 207 million liters of biofuel volume by 2010

Malawi
Legislation in place

E20 and B10 fuel spec

Estimated 47 million liters of biofuel volume by 2010

Mozambique
Significant investments and projects under way to produce and refine biofuel

Has 36 million hectares of arable land; only 5 million hectares currently farmed

Estimated 57 million liters of biofuel volume by 2010

600 mm annual rainfall and average minimum temperature greater than 2°C, equivalent to 10.8 million square kilometers

300 mm annual rainfall and average minimum temperature around 2°C, equivalent to 5.8 million square kilometers

Rainfall and temperature information source: Keith Parsons, "Jatropha in Africa: Fighting the Desert and Creating Wealth," August 21, 2005, www.ecoworld.com

2

Original equipment manufacturer (OEM) role

A crucial link in the biofuels chain is the attitude of car manufacturers (OEMs), because the biofuels industry can only flourish if consumers have access to vehicles that can run on ethanol or biodiesel.

Recently, there have been headlines about OEMs making direct investments in the production of biofuels:

- **GM** has created a partnership with and taken an equity stake in Chicago-based Coskata Inc., a biology-based renewable-energy company working to commercialize a unique technology that affordably makes cellulosic ethanol from almost any renewable source. The process takes material as diverse as garbage, old tires and plant waste to produce cellulosic ethanol.[53]
- **DaimlerChrysler** has a partnership with India's Central Salt & Marine Chemicals Research Institute and Germany's University of Hohenheim for research and development on producing biodiesel from jatropha plants.[54]

To what extent is this support real versus hype? For some time, the automotive industry has faced pressure from consumers and regulators to develop equipment that allows for increasing diversity in transport fuels and a shift away from gasoline and diesel. With transport contributing 14 percent of total global CO_2 emissions, OEMs have increasingly looked at ways to mitigate the impact of the sector as a whole. This has led to innovation, such as the introduction of the hybrid, and a new focus on research into powertrain development. However, with limited budgets for R&D, OEMs will only develop those technologies that provide a reasonable commercial opportunity. Here, as elsewhere, biofuels are competing with alternatives such as hydrogen, electric hybrid and fuel cell for support. And, of course, biofuels must present a compelling case for moving beyond business as usual.

Accenture believes that OEMs will assess the feasibility of biofuels in four areas:

- Effect on existing vehicle models
- Potential for new vehicle models
- Regulatory incentive
- Supporting consumer infrastructure

On the following pages, we look at the automotive industry's reaction to biofuels in each of these areas.

Effect on existing vehicle models

Most OEMs now specify that blends of up to 10 percent ethanol are covered in their warranties on new cars, but it is not always clear how this relates to older models.

During the closing months of 2002, the addition of ethanol to fuel caused controversy in Australia. It was reported that retailers had been selling fuel blended with 20 percent ethanol without declaring this to consumers.[55] The change reportedly caused issues with reliability, and OEMs responded by stating that ethanol used at these blends invalidated warranties and would cause damage to engines.

Fast-forward to early 2007: Drivers in the United Kingdom started experiencing problems with reliability after filling up at supermarket filling stations. At the time, the addition of ethanol to gasolines at blends of 5 percent was (wrongly) reported as a possible cause.[56] Car manufacturers were quick to distance themselves from the problem, with dealerships stating that this "fuel fault" was not covered by warranties. Eventually, the supermarkets involved were left with a hefty repair bill once the real culprit (silicon) had been identified.

The potential for damage to engines from ethanol has been the cause of much debate. At low blends of up to 10 percent, it is fairly well-established that the risk is extremely small, at least in modern engines. However, at levels above 10 percent, it is not clear exactly when damage to older engines might become a problem. The main issues concern the potential corrosive effect on some engine components. Ethanol increases gasoline's ability to carry water without separating. Theoretically, this means that metal components in engines will be exposed to more water and will carry a higher risk of corrosion. In addition, ethanol may cause damage to rubber components such as fuel seals. Again, this is generally not a concern at up to 10 percent but may become a problem above that percentage. Finally, it is possible that richer ethanol blends loosen deposits in the engine, potentially blocking filters. The real bone of contention is defining the precise level of blended fuel that is safe.

OEMs are understandably cautious on warranty issues for existing and older models. Additionally, consumers are wary of any change to their fuel that could invalidate a warranty. This lack of clarity on warranties and the potential for misinformation can create a great deal of confusion for consumers with older cars. The general advice is to consult the manufacturer on its exact policy for any model. This situation is hardly likely to encourage a sense of security in using ethanol. By setting the warranty level at 10 percent, OEMs are creating a natural limit on the contribution of ethanol to transport fuel with the existing stock of vehicles.

The situation for biodiesel is less transparent. So far, there is little evidence that biodiesel causes any long-term damage to engines at any blend level. There is an issue with loosening of engine deposits clogging filters, but this is easily remedied. However, OEMs are still testing whether biodiesel is truly safe at all levels, and at present, there is no consistent advice on what is or isn't acceptable. For example, most OEMs state that B5 is the maximum that should be used in their engines in the United Kingdom.[57] Confusingly, in Germany, some OEMs cover B100.

The reason for the difference is perceived problems with the quality of biodiesel available in markets other than Germany. This illustrates the need for global fuel-quality standards—another frequent message from OEMs. The EU standard for biodiesel (EN 14214) is implemented in the legislation of each member state, but the national versions have different parameters for cold filter plugging point (CFPP). The CFPP characterizes the low temperature operability of diesel fuel.

OEMs are working toward a consistent international warranty standard, but until one appears, the natural limit for biodiesel seems to be B5.

Potential for new vehicle models

With the natural limit for older vehicles currently set at around E10 and B5, introduction of FFVs, which can run on variable ethanol blends between E0 and E85, would allow for much greater ethanol blending as standard.

FFVs have been around since 1998 in the United States and 2003 in Brazil, with more than 30 models available in these countries. The Brazilian ethanol story became truly successful only after FFVs took a significant share of the market.

The US manufacturers are highly supportive of FFVs, on their own turf at least. In a statement released in March 2007, the CEOs of GM, Ford and Chrysler urged President Bush to create the supporting infrastructure for FFVs. In the statement, the three Detroit automakers pledged to double their production of FFVs by 2010. They further stated that it could be possible to make FFVs 50 percent of their total production by 2012.[58]

2007 was an important year for FFVs in Europe with the introduction of five new models from GM (which owns Saab), PSA Citroën and Renault-Nissan. There certainly has been progress in countries such as Sweden, where 15 percent of Volvo's sales (Volvo is owned by Ford) are FFVs, and in France, where there is a strong movement toward E85. However, in the United Kingdom, FFVs are not selling nearly as well. The different levels of consumer take-up are mainly due to regulatory issues discussed later in this report. FFVs are well-established in Brazil, having been introduced in 2003. Indeed, FFVs have been key to allowing ethanol to take its 45 percent share of transport fuel provision.

Asia, on the other hand, is further behind. US manufacturers are aiming to improve their FFV offer in Asia, and this is clearest in countries such as Thailand, where government support is strong. Table 2 summarizes the global FFV situation.

Table 2

Global FFV situation

United States

Sample FFV manufacturers

DaimlerChrysler	Ford	GM
Nissan	Toyota	

FFVs available since 1998; about 31 models

Six million FFVs on the road

1,557 locations for E85 fuel

In the majority of vehicles, the use of up to 5 percent biodiesel is acceptable under warranty.

The use of E10 is covered under warranty by every manufacturer.

Brazil

Sample FFV manufacturers

Citroën	Fiat	Ford
GM	Honda	Nissan
Renault	Toyota	Volkswagen

FFVs available since 2003; about 35 models

In 2006, 86 percent of cars and light commercial vehicles sold were FFVs.

Europe

Sample FFV manufacturers

Citroën	Ford	GM
Nissan	Renault	

FFVs available since 2001; now about 10 models

Expect more government support (e.g., Sweden, France)

All vehicles in the European Union are under warranty up to 5 percent of biofuels usage, which is the EU biodiesel standard. Warranties for higher blends differ by manufacturer and country.

Asia

Sample FFV manufacturers

Ford	GM

Thailand is the most developed market in the East for FFVs due to government support and proactive measures from OEMs such as Ford and GM.

Ford introduced E20-compatible Focus in Thailand.

Sources: Accenture analysis; company websites; One Source; National Ethanol Vehicle Coalition website; EthanolRFA; European Biodiesel Board

As stated above, the real question for OEMs is whether this is a commercial opportunity. From a cost perspective, a 2007 U.S. Government Accountability report quotes automobile manufacturers suggesting that the additional production cost per vehicle for FFVs ranges from $30 to $300.[59] Accenture research suggests that the average is toward the far lower end of that range or even below it. Though this may still be significant on an aggregate basis, the unit cost has relatively little impact on pricing. Indeed, Ford has gone as far as offering FFVs at equal prices to its regular models in the United Kingdom. Certainly, of all of the alternative propulsion systems in development, the cost of converting to FFVs is the lowest. So, on a cost basis, FFVs seem a reasonable offer. However, regulation and infrastructure have a large part to play in their commercial success, as discussed on the following pages.

There is also the challenge that investment dollars for OEMs are very limited. For example, GM and Toyota are already committing significant resources to the race to launch the plug-in hybrid by 2010. Given the fact that biofuels will not be the only fuel source in the future, OEMs will also need to invest in other technologies.

Regulatory incentive

Throughout the biofuels story, regulation plays a key role. In *"Irrational Exuberance"?* we talked about a patchwork of regulatory opportunities for producers. The same is true for OEMs.

As discussed above, OEMs are pushing quite hard on FFVs in the United States. A major reason for this push is the Corporate Average Fuel Economy (CAFE) law, first enacted in 1975 following the 1973 Arab oil embargo. Under this piece of regulation, manufacturers are penalized if the average fuel economy of their cars sold in the United States falls below a certain level (measured in miles per gallon). In addition, if a manufacturer exceeds the standard, credits are earned that can be used to offset deficiencies in future years.

FFVs provide an attractive avenue for OEMs to gain credit under this system. Indeed, according to the Energy Information Administration, virtually all FFVs have been produced so far with the sole aim of gaining credits under this system.[60] The main problem with this legislation is that it calculates the fuel economy of FFVs with the assumption that they will be using E85 50 percent of the time. Given the lack of E85 available on the market, this is clearly an overestimate. Nevertheless, it is estimated that Ford saved itself $135 million in fines from 2003 to 2005 by switching some production to FFVs.[61] That saving provides a new perspective on the estimated change in production cost for FFVs. OEMs are effectively using FFVs to meet their CAFE obligations for the lowest possible cost.

In Europe, regulation is responsible for the disparity seen in consumer take-up between countries such as Sweden and the United Kingdom. In Sweden, consumer benefits for FFV owners are generous and include tax savings, insurance cuts and bonuses. In the United Kingdom, consumers receive a small reduction in fuel duty that is not enough to even make up E85's lower mileage. As a result, FFVs are much more popular in Sweden than in the United Kingdom.[62]

And in Asia, where we have discussed the slow introduction of FFVs, there is hardly any regulatory incentive other than in Thailand.

Supporting consumer infrastructure

Awareness and access to E85 have to be good enough for consumers to differentiate between buying a regular model and an FFV.

Even in the United States, where there is a clear incentive for OEMs to produce FFVs, the vehicles still have to appeal to consumers and generate sales before the manufacturers achieve any benefit. As of April 2008, there were approximately 1,557 locations for E85 in the United States, mostly in the Midwest, close to a supply of ethanol. To put that in context, the largest numbers of privately owned FFVs are located in Texas, California and Florida. In early 2008, these states had only 38, 10 and 13 sites offering E85, respectively.[63] Putting an E85 outlet within five miles of the majority of US motorists would require a total of 20,000 sites, according to Phil Lampert, executive director of the National Ethanol Vehicle Coalition. The switch to E85 obviously has an associated cost for retail sites. Illinois officials estimate conversion costs of around $3,350 per site based on the state's conversion of 64 sites. However, the cost of a new E85 dispenser is quoted at $7,000 higher than regular gasoline dispensers. Without government support here, it is difficult to see what incentive there is for equipping a gas station with E85.[64]

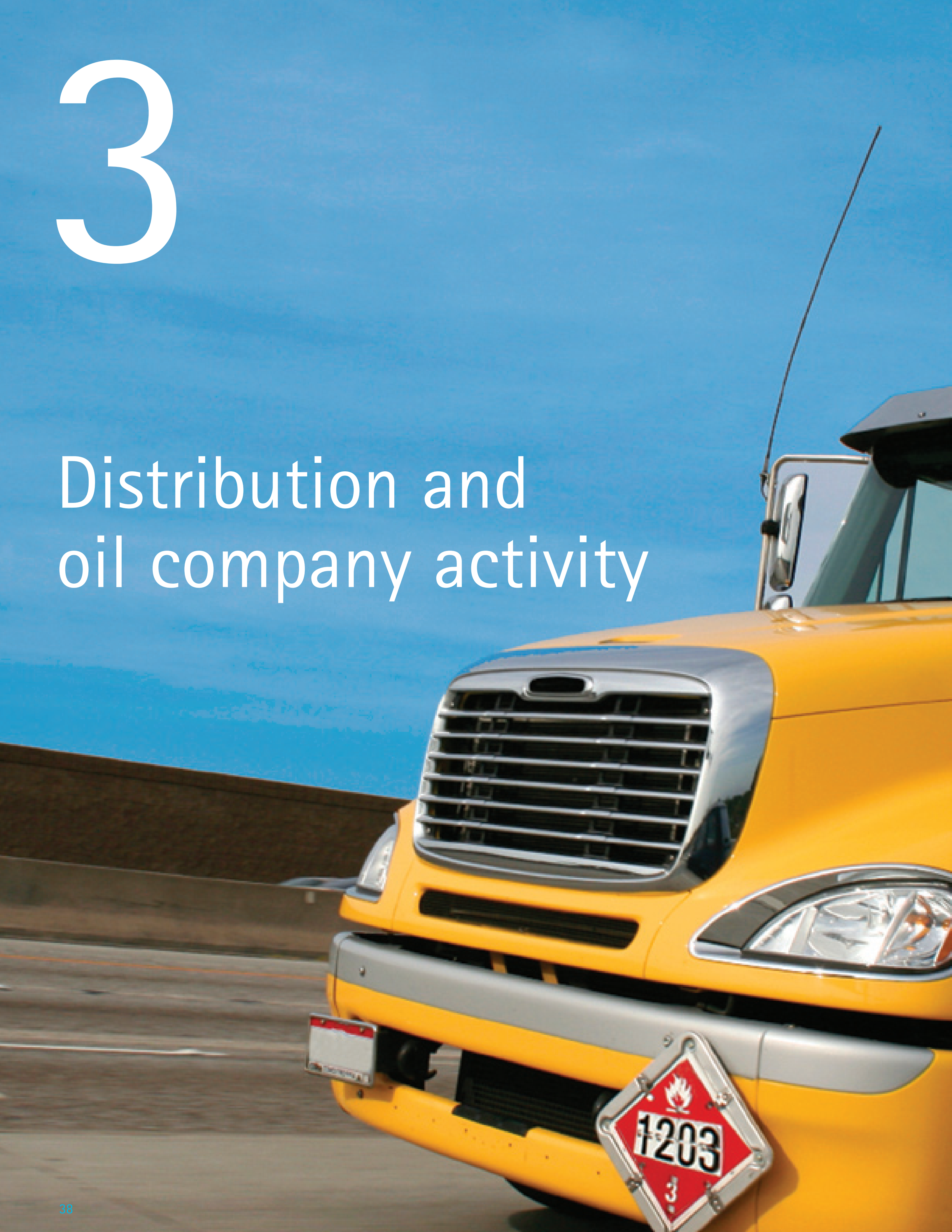
France has taken a more strategic approach to the introduction of E85. With strong government support, a biofuel charter of 2006, signed by a number of stakeholders including Ford and even hypermarket fuel retailers such as Carrefour, specified measures to convert stations to E85, to increase the numbers of FFVs on the market, to increase the production of ethanol and to put in place the necessary economic and tax conditions to enable E85 bioethanol to be competitive with fossil fuels. It is this kind of integrated approach that is likely to allow biofuels to move beyond the low-level blending currently prevalent.

In summary, OEMs are very supportive of biofuels and will play a significant role in the incorporation of biofuels in transport fuel beyond the E10 and B5 level. OEMs are understandably cautious about the effect on existing model warranties, and only the widespread introduction of FFVs, supported by government, will allow OEMs to move to higher blends. This is happening in the United States and Europe. As a result, we will continue to see an increasing percentage of production of FFVs and of cars able to take higher blends of ethanol and biodiesel.

But the infrastructure challenges, regulatory uncertainty and continued demand for clean engine technologies mean that OEMs will continue to have a portfolio approach to powertrain investment (that is, investing in cleaner and more efficient gasoline and diesel as well as hybrid/plug-ins, hydrogen/fuel cells, electric, etc.). If regulation pushes OEMs to switch from regular gasoline models, as with CAFE, biofuels are ahead for now in the competition with other fuels given the relatively low switching cost for FFV technology.

3

Distribution and oil company activity



Integrating biofuels into the fuels value chain on a global scale will result in "growing pains" for the next few years.

IOCs and NOCs are investing in infrastructure to blend biofuels to scale as compliance with mandates becomes a more urgent issue. They are working through the various practical challenges of integrating ethanol and biodiesel into the hydrocarbon supply chains. Among the challenges facing IOCs and NOCs are developing and integrating biofuels-specific processes because the stages preceding blending are different from those in the integrated oil supply chain.

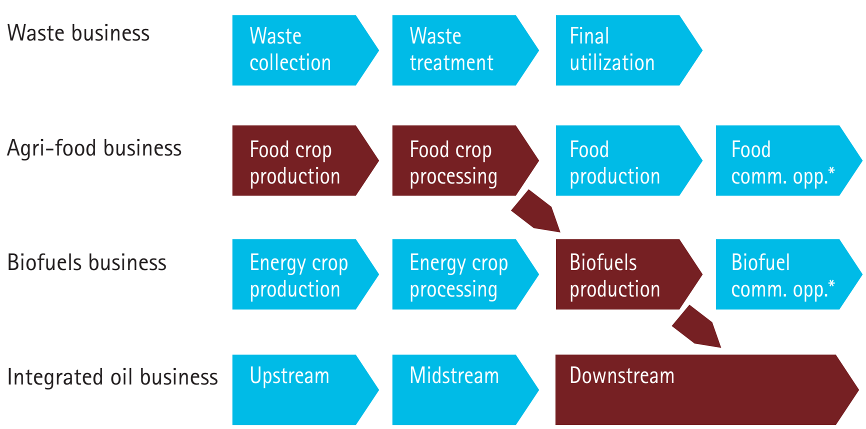
Most integrated oil companies do not produce biofuels. The point at which biofuels enter the fuels value chain will be the sourcing of ethanol and biodiesel supply. As a result, only selected elements from the biofuels process model are relevant to the integrated oil company, and the challenges for an integrated oil company will be around effectively integrating biofuels into its current processes.

The first part of this section focuses on the key challenges that integrated oil companies face in integrating biofuels into their fuels value chains:

- Securing supply
- Trading and risk management
- Storage of supply, blending and distribution
- Managing changes to the retail sites
- Implications for marketing and product development

Figure 6

Integrating biofuels into the established fuels value chain



*Commercial opportunity

Source: Accenture research

Securing supply

The key challenges for oil companies that have to secure supply are:

- Developing a feedstock strategy.
- Managing diverse and often small suppliers.
- Making decisions regarding contract terms and pricing.

For most integrated oil companies, there is no agriculture or production. Biofuels are sourced through long-term contracts (for example, Shell and Ensus in the United Kingdom)[65] or non-operated joint ventures (such as BP and D1).[66] There are many different producers and types of biofuels. In addition, due to the volume of feedstock requirements and the fragmented agricultural industry, the number of required suppliers and the extent to which suppliers are globally distributed increase the complexity of securing supply. The key challenges in this area are:

- **Feedstock strategy.** There are many options and implications on GHG emissions for the type of feedstock used. Given the dependency on weather and potential variable yield, it makes sense to have more than one type of supply.
- **Number of suppliers.** Although there are some large, international agribusiness companies, in many markets, agriculture/biofuel production is dominated by small producers. Integrated oils need to manage this new portfolio of suppliers.
- **Length of contract.** Given the eventual evolution of trading, both physical and paper markets and the volatility in supply/demand balances, it is a challenge to determine the right length for the contract.
- **Pricing in contract.** Long-term contracts make up more than 90 percent of biofuels volume. As a result, there is little price transparency and a challenge in how to price (for example, source fix price, indexed to unleaded gasoline).

Trading and risk management

The emergence of trading in biofuels is bringing together the oil and agriculture markets.

There is more international trade in oil than in anything else, whether measured by volume or value. Oil is traded both in its crude form and as a refined product. Physical markets primarily are concerned with surpluses or deficits of oil and are based on matching the needs of buyers and sellers. These flows, dictated by economics, logistics and temporary imbalances in supply and demand, are key to the efficient operation of the oil market.

Risk management across the hydrocarbon value chain, particularly to manage operational risk, is mature. Most oil companies are organized in product trading verticals (for example, crude traders versus refined products traders versus carbon traders versus gas traders). Some oil companies will use the paper markets to manage their risk and take on more exposure, while others will focus on aligning physical supply and demand. Risk appetite, risk strategy toward price, demand and operational risk and appetite to use derivative products will vary dramatically across oil companies. Regardless, these paper and physical markets are quite mature.

Enter biofuels—new correlations, new feedstocks and by-products (both with very large and equally mature commodity markets), and new agribusiness and commodity houses (much more experienced in cross-commodity trading). This is a much more complicated equation than oil companies will be used to, and given their product-verticals structure, oil companies will face the challenge of understanding the cross-commodity nature of biofuels and how to manage the risk as buyers/blenders of biofuels.

Oil companies will need to consider trading in multiple products to manage their risks. Agriculture trading houses also are now actively trading in oil products. The mix of products that will need to be considered in a trading and risk management strategy—gasoline, diesel, corn, sugar, wheat, soy, palm, animal feed, glycerin, ethanol, etc.—is increasing, and with this cross-product interplay, risk management is becoming more complex.

Storage of supply, blending and distribution

Given the need for integrated oil companies to build storage at their refineries/terminals, a number of practical challenges arise:

- How much storage is required to optimize supply and blending operations?
- Should this be oil companies' own investment or service providers'?
- How can different grades/standards be accommodated?

Biofuel is incorporated into the integrated oil supply chain through the blending and distribution process. There are two primary options for this process. First, the biofuel can be transported to refineries or downstream terminals where blending occurs. A challenge here is that biofuel plants are not necessarily in the same areas as terminals or areas of large demand. In Germany, for example, most large biofuel plants are in the former East Germany and therefore a long way from the Rhineland refineries, so key challenges to overcome are transportation costs and logistics. Also, the terminal will require additional storage/blending tanks to handle the biofuel and finished grade product. This has an associated capital expenditure cost, plus a requirement for space and planning permission.

Alternatively, new storage and blending facilities can be constructed adjacent to the biofuel plant, and the oil is transported from the oil refinery or terminal to the new storage and blending facility. Again, there is a significant capital expenditure cost.

In the first scenario, there is an increased dispersion of biofuels, and in the second scenario, an increased dispersion of fossil oil. This raises challenges regarding stock management and working capital optimization.

In addition, refinery operations are generally established to manufacture product for supply markets within a geographic area. The different blends of biofuels, different mandates/targets by countries and the many options that companies have in meeting these mandates/targets have created a much more complex optimization equation:

- Can oil companies make all of their refineries capable of high optionality between different blend stocks and satisfy a wide range of product slates?
- Should they instead focus different refineries on different product slates with more limited optionality?
- Can refineries continue to produce exports for the same markets as today when product slates change in those markets?

In a world where refineries are adapted to manufacture a different and more varied range of products, there will be an impact on manufacturing costs due to different utilization of crude feedstocks to make new blend stocks. Investment will also be needed at the refinery to make the blend stocks required for finished biofuel grades. For example, existing blend stock tanks and associated pipe work may need to be upgraded, augmented or replaced.

Managing changes to the retail sites

In most countries, marketing gasoline grades with a significant ethanol content will require equipment changes at the retail site. It is widely considered that a grade containing more than 15 to 20 percent ethanol will be too corrosive for existing storage tanks.

This will therefore require replacing or relining tanks at significant cost. Fuel dispensers and other sundry equipment will also need to be upgraded, potentially leading to new pump or site configurations. Oil companies will face the challenge of phasing investments carefully across their networks and integrating them with existing site upgrade programs.

For example, in the United States, according to Energy Information Administration forecasts, moving toward E85 is necessary to achieve the Renewable Fuel Standard mandated by the Energy Independence and Security Act of 2007. The National Ethanol Vehicle Coalition is pushing to expand the availability of E85 (currently estimated at less than 1 percent of US ethanol consumption) in order to accommodate the approximately 6 million E85-capable vehicles on US roads. In addition, the three largest US automakers—DaimlerChrysler, GM and Ford—estimate that half their lines will be E85-compatible by 2012. However, increasing E85 consumption would require the installation of new dispensers and underground tanks that would cost gasoline station owners thousands of dollars.

The extent to which this capital expenditure can be passed through to the consumer in highly competitive retail markets is not clear. Furthermore, investment in retail equipment could impose a significant burden on dealer-owned and independent sites. Oil companies will need to seek ways to incentivize investment or bear the cost themselves.

Implications for marketing and product development

As fuels marketers increase the biofuel volumes they sell, current product slates will be adapted. Marketers face a choice between adding more biofuel components to existing products or creating new products with high biofuel content to sell alongside their current grades.

Most gasoline vehicles on the road today cannot run on gasoline grades with ethanol content above 10 percent. Until there is a significant penetration of FFVs in the vehicle fleet, there will be a constraint on the amount of ethanol that can be added to existing grades. This will force sellers to retain a low-ethanol grade for the medium term even in markets with aggressive targets for biofuels.

But in the longer term, high-biofuel products are likely to become a key component of the product slate. Adding these products to the slate will pose challenges. The energy content of ethanol per unit volume is lower than that of regular gasoline, so high-ethanol grades must be sold at a lower price to be an attractive product for consumers. The profitability of these grades for the marketer is strongly linked to the relative prices of ethanol and crude oil. When ethanol prices are high (relative to crude), these grades would be sold at a reduced margin by the marketer unless there are government subsidies (in the form of lower duty rates).

High-ethanol grades offer the possibility of a differentiated branding and pricing strategy:

- A grade such as E85 (a blend of 85 percent ethanol and 15 percent gasoline by volume) may be marketed as a "green" product and targeted at a niche segment of environmentally aware consumers.
- Alternatively, the high-octane content of E85 may allow it to be sold as a premium grade to those looking for better engine performance. This could mean selling it at a price higher than that of regular gasoline on an energy-equivalent basis. Recent experience of E85 pricing in the United States indicates that this effect has been observed in the market.[67]
- The increased penetration of biofuel grades will give oil companies an opportunity to reevaluate their current premium and differentiated fuel strategies.

Committing the supply chain to bringing new biofuel grades to market will entail significant challenges and investments for integrated oil companies. In an environment where the pace of change in different markets is not yet clear, infrastructure solutions that provide flexibility will be highly desirable.

This section so far has focused on the challenges that integrated oil companies have in integrating biofuels (produced by other companies) into their fuels value chain. Integrated oil companies make up a very small percentage of existing capacity today, and based on what has been financed, permitted or announced, this situation will not change in the next five years for IOCs. However, this is not the case for many NOCs, which will become some of the biggest producers in biofuels in five to 10 years as they move aggressively into production.

What is most surprising to us is that NOCs are doing much more than working on the distribution challenges. They are investing in production facilities and in some cases even moving into agriculture.

In ethanol:

- Petrobras announced joint investments in a sugarcane ethanol production project with partner Mitsui.[68]
- Sinopec formed a joint venture with China Oil and Food Group (COFCO) in Guangxi province to grow cassava and install production capacity of 1 million tons.[69]
- China National Petroleum Corporation (CNPC) is planning to build capacity of 600,000 tons in Sichuan to produce ethanol from sweet potatoes.[70]

In biodiesel:

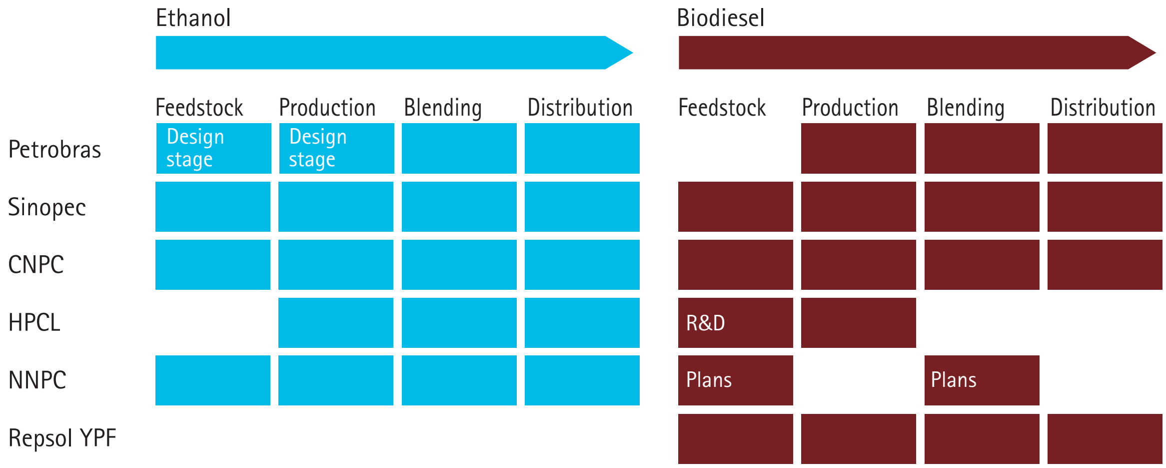
- Repsol YPF has teamed with Acciona for building and developing biodiesel production plants in Spain, with an output of more than 1 million tons per year.[71]
- StatoilHydro acquired a 42.5 percent holding in the Lithuanian biodiesel plant Mestilla.[72]
- MOL is planning construction of a biodiesel plant in Komárom, Hungary.[73]
- Neste Oil/OMV will build a second-generation synthetic biofuel production plant in Austria with vegetable oil and animal fat as the raw materials.[74]

The challenges presented by integrating biofuels into the fuels value chain will result in fundamental changes to the value chain:

- New processes and systems will be needed to deal with the additional complexity caused by the introduction of new and different products.
- New players will emerge in different parts of the biofuels value chain.
- Optimization activities across the value chain will need to adjust to and account for opportunities created by the introduction of biofuels.

Figure 7

Current biofuels activity (including planned activity)



Source: Accenture analysis

Case study: NOCs and bioethanol in China

Supported by the Chinese government's *Medium- and Long-term Development Plan for Renewable Energy in China,* the country's bio-ethanol market has grown rapidly in recent years.

Since 2002, China has adopted E10 gasoline in 10 provinces. As a result, 30 percent of China's population is using E10 for vehicles. The Chinese government's *Medium- and Long-term Development Plan for Renewable Energy in China* aimed for China's bioethanol production to be 10 million tons (12.65 billion liters) in 2020.

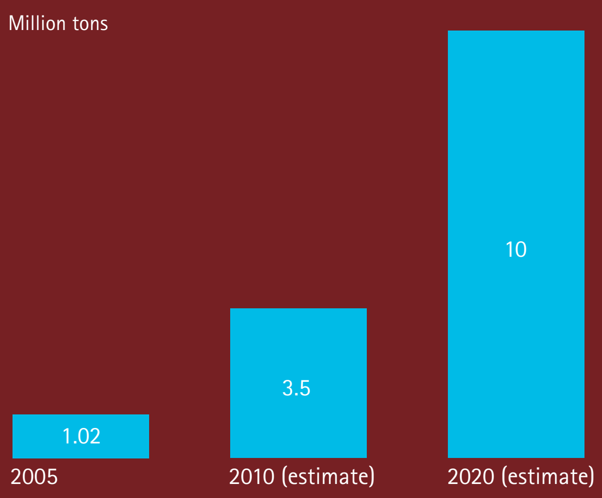
State-owned enterprises play a dominant role in China's bioethanol industry. China Oil and Food Group (COFCO) is in a leading position, but Chinese NOCs are catching up. CNPC and Sinopec dominate distribution channels and the retail network. The industry sees collaborations between the major players across the value chain, and further consolidation is expected.

COFCO, being the leading player in China's food and agriculture industry, grew in the bioethanol industry by leveraging its advantage on feedstock resources. COFCO's strategy is to be the dominant player in upstream and midstream. It has aggressively grown production capacity in the past five years and already accounts for more than 50 percent of total production capacity in China. Encouraged by the central government, COFCO now owns a nonprimary food source feedstock (cassava) production plant in Guangxi province. It will continue to invest heavily in upstream and midstream in the future to secure its leading position.

Sinopec and CNPC, as two of the three integrated NOCs in China, are also very active in the bioethanol sector. With their well-established distribution and retail networks, both Sinopec and CNPC dominate biofuels distribution, a trend that is expected to continue over the next few years.

Figure 8

China's bioethanol market size (government plan)



Source: Chinese government's *Medium- and Long-term Development Plan for Renewable Energy in China,* http://www.gov.cn/zwgk/2007-09/05/content_738243.htm

CNPC aims to be an integrated player in the bioethanol market. Its strategy is to invest in all segments along the value chain. CNPC has signed agreements with the State Forestry Administration, Sichuan province and Yunnan province to build 400,000 hectares of bioethanol feedstock cultivation base in total. It also aggressively invests in building or purchasing bioethanol and biodiesel production capacities.[75]

Sinopec is the leader in downstream and controls more than 60 percent of the bioethanol distribution channel in China. In the past few years, Sinopec has been more focused on the downstream. It has invested in midstream only as a minority shareholder in order to secure supply. The company has no upstream operations in place yet; however, it intends to grow in an integrated way. For example, in March 2008, Sinopec successfully signed an agreement with a local government to build a 500,000-ton production factory and support feedstock base in Hubei province. This project will be the foundation step for Sinopec to enter the upstream and become an integrated player.[76]

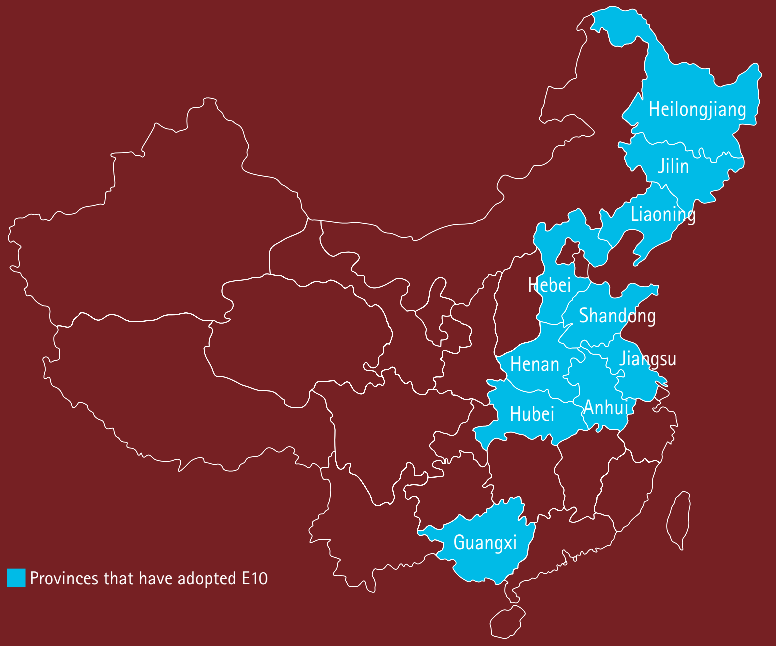
Key challenges Chinese NOCs are facing to further develop bioethanol business:

New entries

Other NOCs (for example, the China National Offshore Oil Corporation, or CNOOC) and non-state-owned companies (such as Daohuaxiang Group) will enter the bioethanol market, especially in upstream and midstream segments.

Figure 9

Bioethanol use in China, 2008



Sources: Chinese Ministry of Transport; Accenture research; http://www.ndrc.gov.cn/zcfb/zcfbtz/tz2006/t20061218_101433.htm; http://www.ndrc.gov.cn/gyfz/zhdt/t20080509_210293.htm

Shortage of feedstock

A potential food crisis is becoming a global concern. Because its country has the largest population, the Chinese government regards food supply as the top priority. Primary food source feedstocks (such as rice and corn, which are major sources of food in China) will not be allowed for producing bioethanol in new facilities—existing plants that already use one of these as their feedstock will be allowed to continue doing so. In the next three to five years, all bioethanol producers will face the challenge of feedstock supply.

Unprofitable business in the short term

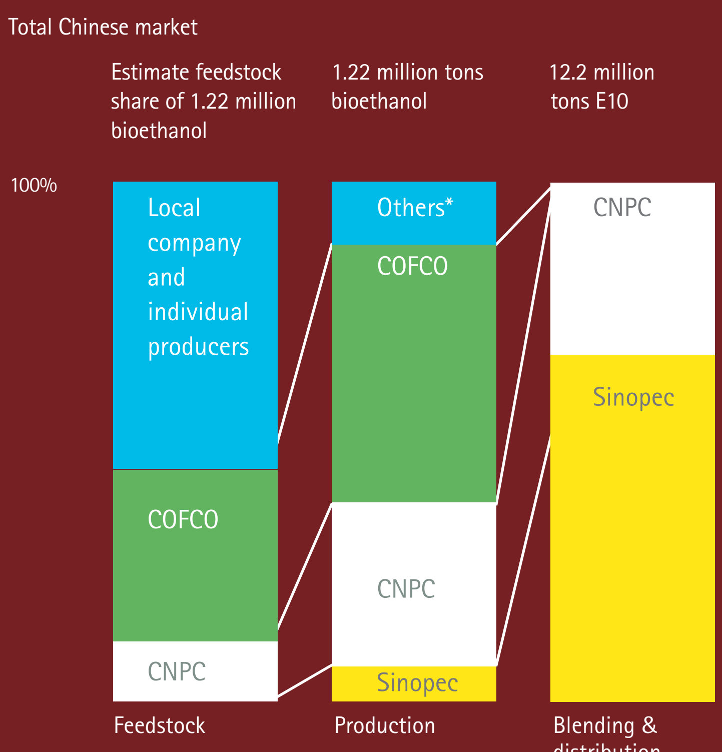
The bioethanol industry is still not market-oriented. China's National Development and Reform Commission (NDRC) has a strict control on bioethanol along the value chain. The license to produce bioethanol needs to be approved by the NDRC. The price of bioethanol and some feedstocks is regulated by the NDRC.

Feedstock costs constitute more than 80 percent of total costs of bioethanol, and agricultural product prices in China increased more than 40 percent between 2004 and 2007, creating an uneconomical business.[77]

Despite the rising price of feedstock, the Chinese government reduced the subsidy for bioethanol produced from primary food source feedstock; the majority of existing production comes from these sources. The subsidy for ethanol from primary food source feedstock is expected to be reduced further after 2008. As long as the ceiling price is set by the government, producing bioethanol seems unprofitable. Some reports suggest that the producer will lose around $100 to $120 for 1 ton of bioethanol produced.[78]

Figure 10

Chinese bioethanol industry value chain



*Other shareholders of production facilities are all state-owned companies.

Source: Accenture analysis

Accenture believes that NOCs will continue to play an active role in China's bioethanol industry. NOCs have made the decision that biofuels will be part of their business portfolios. In addition to ensuring that business strategy and objectives support this decision, these are some specific actions for NOCs to consider:

Adopt the right investment portfolio along the value chain and ensure collaboration

Given the "local" characteristics of bioethanol, NOCs need to choose the right strategy between cooperation and integration. The feedstock segment is fairly fragmented, and we expect to see a level of consolidation in the future. The correct investment strategy will not only emphasize the competitive advantage of integration, but will also offset any disadvantages by partnering locally and collaborating along the value chain to maximize returns.

Secure the feedstock supply

Given the shortage of supply, feedstock strategy becomes extremely critical with options to build, buy or ally. All three majors, COFCO, CNPC and Sinopec, have invested in building their own feedstock production bases. COFCO's Guangxi province cassava cultivation base has already moved into the production stage, and COFCO will make an additional investment to expand this base.

Be a research and development leader, particularly in nonprimary food source or nonedible feedstock-producing technology

To meet the challenges from feedstock and marginal profit of producing bioethanol, NOCs should first focus on bioethanol feedstock R&D, particularly on nonprimary food source or nonedible feedstock-producing technology. A good technology based on these feedstocks will help the company not only easily obtain bioethanol production licenses, but also improve the profit margin. The player who can produce bioethanol profitably based on feedstocks preferred by the government will have a substantial competitive advantage.

Innovate with the business model

NOCs should think "outside the box" on their business model. For example, CNOOC, another Chinese NOC, has signed agreements with Indonesia's government to produce bioethanol locally and to export abroad for better economic return.

Strive for operational excellence

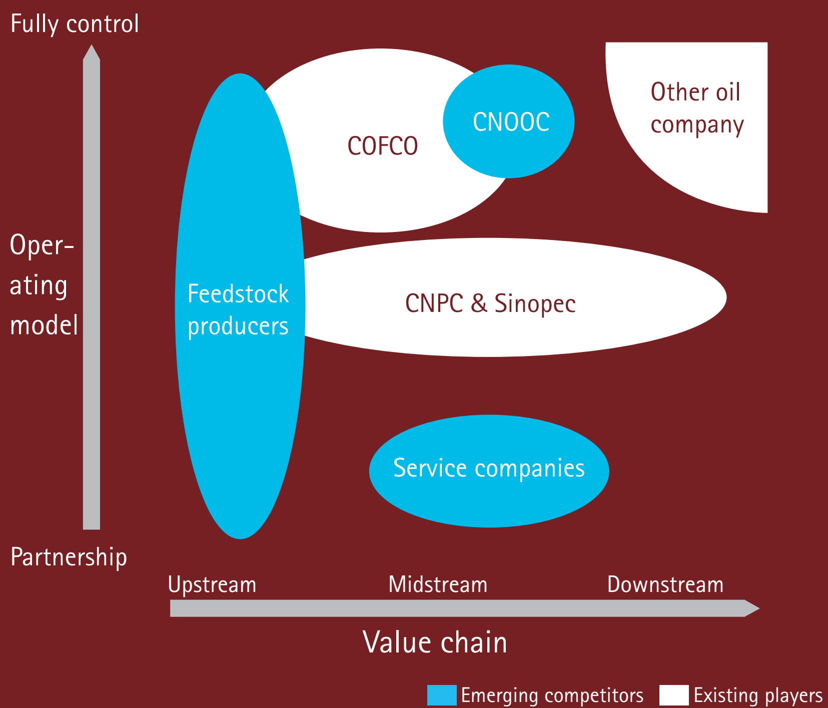
Bioethanol is a thin-margin business. Business sustainability requires excellent execution abilities to manage feedstock supply, bioethanol production, transportation and distribution in a cost-efficient way. A competitive cost structure will give the company more flexibility to accommodate market changes—for example, oil price volatility.

Clarify objectives and organization

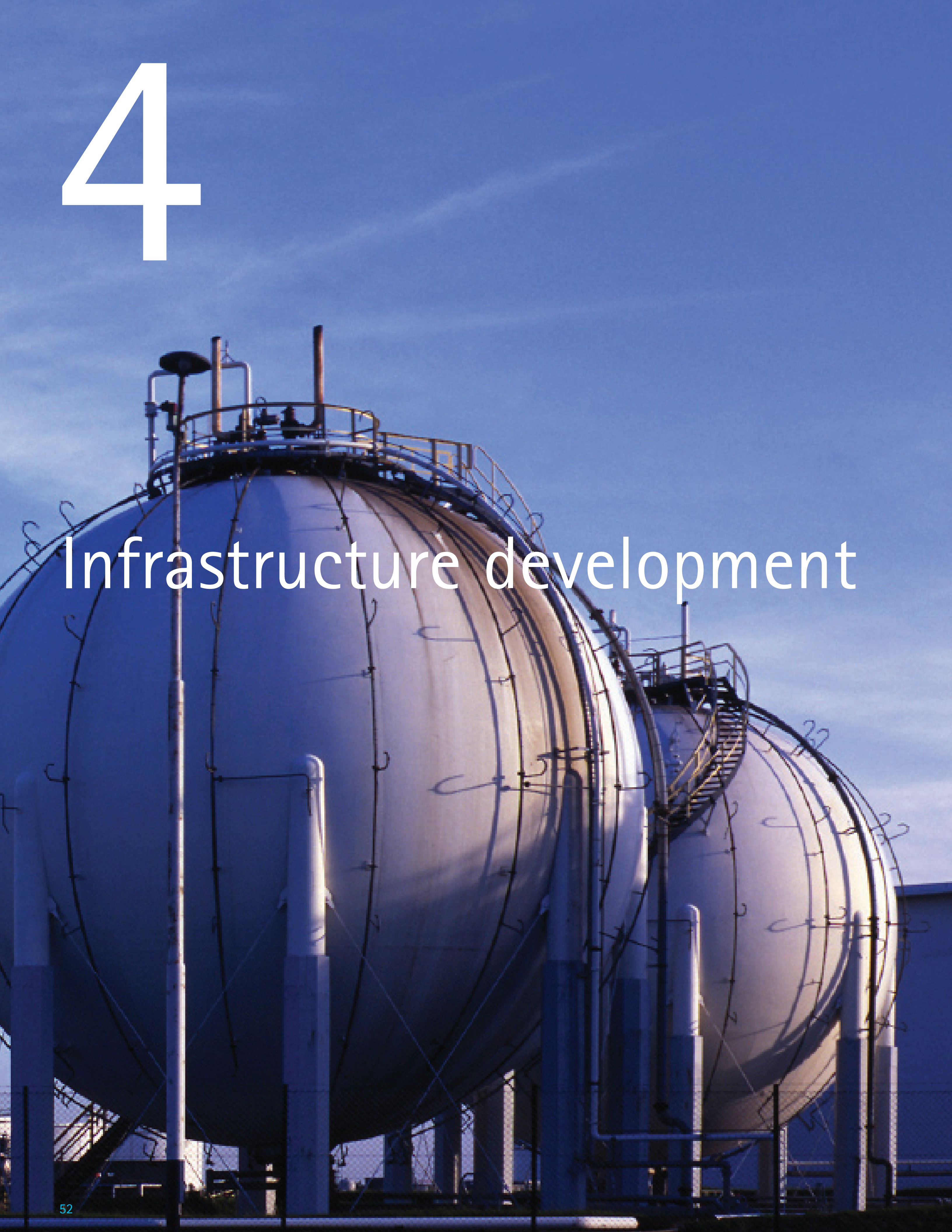
NOCs need to better align their commitment to bioethanol business objectives with their corporate vision. NOCs also need to consider new organization structures to support further bioethanol development and improve efficiency.

Figure 11

Chinese ethanol market



Source: Accenture research and analysis



4

Infrastructure development

Infrastructure investment is critical to achieving global scale and trade.

In the United States and Brazil, demand is dislocated from supply. In Europe, the situation is different, with multimodal transport options of barge, rail and road as well as widely distributed supply creating different challenges. In this section, we look at infrastructure in three regions—Brazil, the United States and Europe—to understand the current situation and its implications on the creation of a global and efficient biofuels industry.

Brazil: Ethanol will gain competitiveness through infrastructure investments

International ethanol trade is expected to hit 12-16 billion liters in 2012-2013, and Brazil's ambition to participate with 9 billion liters of this market may be challenged by infrastructure capacity and cost-competitiveness. Local currency (R$) valuation, escalating capital expenditures on greenfields, agricultural costs and increasing distance from new mills to the coast make the investments in pipelines, storage capacity in ports and integration of modals even more important to keep Brazilian ethanol cost-competitive. With that scenario in mind, Petrobras, Unica (Mills Association), Copersucar, Cosan, São Martinho, private equity firms and international players such as Vopak are planning investments to fill this market gap. Accenture's view is that the players who connect to this part of the ethanol value chain will differentiate themselves from traditional mills and traders by capturing agility, flexibility and greater control, as well as increased access to international clients.

The supply sources of ethanol in Brazil are concentrated far from the coast and continue moving toward the central region of Brazil. Approximately 60 percent of current ethanol production is located in the countryside of São Paulo state, 340 kilometers from the port of Santos, which is the most representative Brazilian port for ethanol exports. Land availability and lower investments to build new ethanol mills are continuously pushing ethanol supply sources to Mato Grosso do Sul, Mato Grosso, Goiás and Minas Gerais states. These four Brazilian states represent the new frontier of ethanol production and are located about 950 kilometers from the coast. This geography of Brazilian ethanol mills implies that 27 percent of current exports must travel more than 500 kilometers to get to the closest port.

The Brazilian supply chain is based mostly on truck transportation. Compared with networks of developed countries that have similar widespread geography, such as the United States and Canada, the Brazilian supply chain network lags on pipelines and rail transportation.

The Brazilian port infrastructure availability also represents a significant challenge, with the port of Santos concentrating around 72 percent of total ethanol exports, followed by Paranaguá with 15 percent and Maceió with 7 percent. These attributes of the Brazilian supply chain lead to highly inefficient logistics that represent 6 to 21 percent of total ethanol costs from production to port.[79] The production costs of Brazilian ethanol range from $300 to $330 per cubic meter, and the logistics costs from the mills to the ports are $20 to $70 per cubic meter, depending on mill location.

United States: Short-term solutions, but pipeline investment remains uncertain

The large volumes of ethanol established by US federal mandate are also incentivizing US pipeline owners to explore ways of overcoming current technical constraints.

Ethanol production capacity expansion is occurring faster than originally anticipated. In 2008, an estimated 4 billion gallons of ethanol production capacity will come online. Once all of the new construction currently under way is completed, the US ethanol industry will be able to supply more than 13 billion gallons of ethanol. This represents nearly 10 percent of the nation's gasoline demand.[80]

This unparalleled ethanol growth occurs at a time when the logistics industry capacity is challenged. Currently, the ethanol is moved domestically from production points to fuel terminals via tanker trucks (67 percent), railcars (30 percent) and barges (3 percent). Ethanol is then blended with gasoline before shipment via tanker truck to gasoline retailers. However, all these transportation modes are nearing capacity with E10 supply, and the supply of current shipping options (especially railcars) is limited.[81] In an attempt to accommodate the growing need for ethanol distribution, the transportation and pipeline industries are moving forward with innovative solutions.

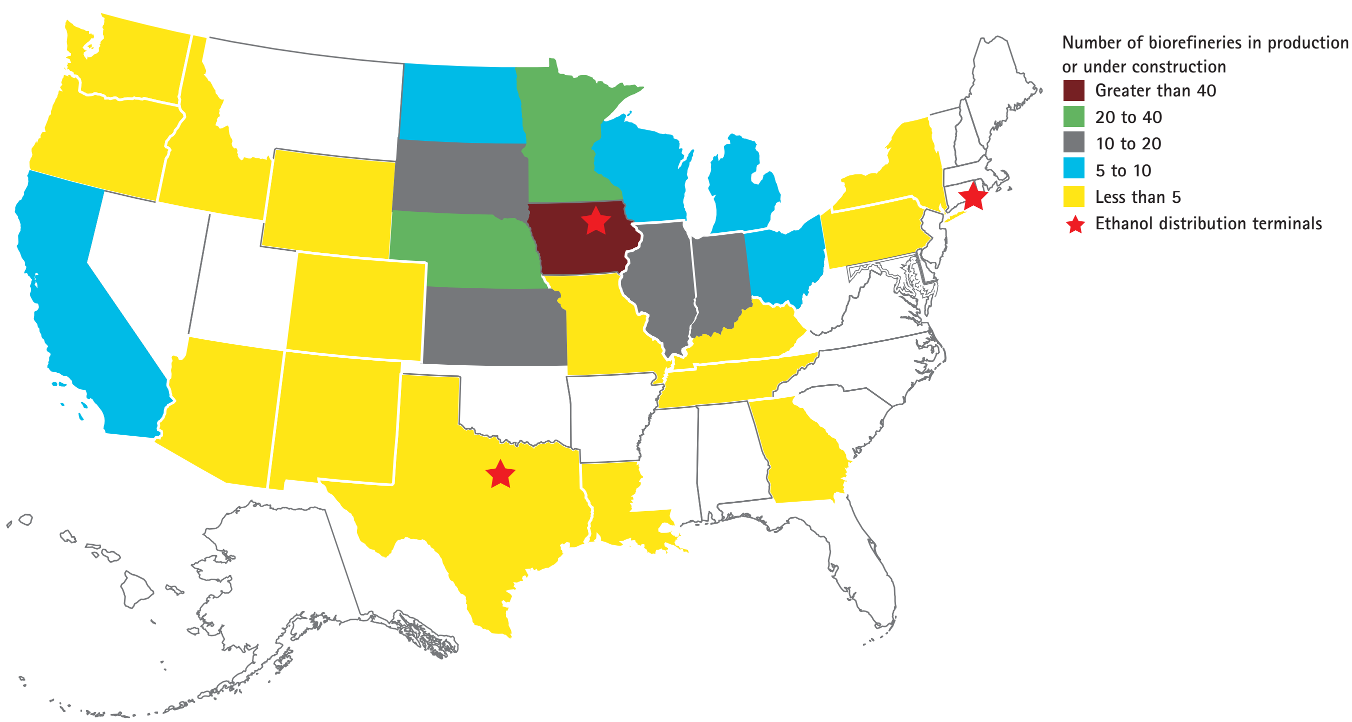
Short-term solution: Ethanol trading and distribution terminals

The expansion of high-volume destination terminals with multimodal capability is the most noteworthy solution to ensure ethanol distribution in a more cost-effective manner. Situated in highly strategic locations, these destination terminals streamline the constrained ethanol marketing and distribution process through:

- High storage capacity.
- Expedited turnaround times by using railcar pooling and unit trains (trains that carry one product from the same origin to the same destination).
- Lower shipping costs through optimized shipping routes.

Figure 12

As terminals come online in the United States, the bottleneck around the central portion of the country is lessened



Sources: Accenture analysis; Renewable Fuels Association data

Manly Terminal LLC (Manly, Iowa) is one of the leading ethanol distribution and trading centers. The company estimates that by the end of 2009, this terminal will be located within 300 miles of more than half of all US ethanol production.[82]

Gateway Terminal LLC (New Haven, Connecticut) and Dallas Forth Worth Rail Terminal LLC (Arlington, Texas) are the other main ethanol distribution centers currently operational in the United States. The characteristics of these terminals are presented in Table 3.

Long-term solution: Ethanol pipeline dedicated system

According to the Renewable Fuels Association and the Association of Oil Pipe Lines, the construction of new ethanol pipelines and conversion of existing pipelines to ethanol-exclusive use are the only ways to economically and safely move ethanol on a large scale from producers to users. Even though pipeline operators are interested in investing in ethanol distribution, they foresee great challenges.[83] A pipeline from the Midwest to the East Coast could be a multibillion-dollar project:

- Currently, small individual production facilities relative to volumes are necessary to support a pipeline.
- There is a high risk of stress corrosion cracking.
- Incompatibility of fuel-grade ethanol with the existing pipeline infrastructure is a concern.
- Moving ethanol from the Midwest to the coasts is in the opposite direction of existing pipeline transportation.

Despite these challenges, Magellan Midstream Partners L.P. and Buckeye Partners L.P. have begun a joint assessment to determine the feasibility of constructing a dedicated ethanol pipeline. Estimated at more than $3 billion, the proposed pipeline system would gather ethanol from production facilities in Iowa, Illinois, Minnesota and South Dakota to serve terminals in major markets such as Pittsburgh, Philadelphia and the New York harbor.[84]

On the other hand, some pipeline operators are seeking ways to make their systems compatible with ethanol or ethanol-blended gasoline. Even if such modifications are technically possible, they will likely be expensive and could further increase ethanol transportation costs.

Table 3

Main ethanol distribution terminals in the United States

Ethanol terminal	Companies involved	Characteristics
Manly Terminal LLC (Manly, Iowa)	1. Iowa Northern Railway Company 2. LB Transport/MinnIowa Distributing Inc. 3. KAG Ethanol Logistics	• Storage capacity: more than 520,000 barrels • Multimodal capability: truck and rail • Distribution points: the entire North American rail network
Gateway Terminal LLC (New Haven, Connecticut)	1. Eagle Marine Industries 2. SCF Agri/Fuels LLC	• Storage capacity: 500,000 barrels • Multimodal capability: barge, rail (70 cars and 100 unit trains) and truck; possibility of using a fuel pipeline in the future • Distribution points: from the Midwest to all points in the South, North, East and West
Dallas Fort Worth Rail Terminal LLC (Arlington, Texas)	1. U.S. Development Group LLC 2. Direct Fuels 3. Union Pacific Railroad	• Storage capacity: 130,000 barrels • Multimodal capability: rail, truck and pipelines • Distribution points: North and Central Texas

Sources: Gateway Terminal LLC: L. Jarrett, "Gateway Terminals LLC," *STL Commerce Magazine*, March 2008, http://www.stlcommercemagazine.com/archives/march2008/groundup.html; Manly Terminals LLC: Ethanol Market website press release, June 29, 2007, http://www.ethanolmarket.com/PressReleaseManly062907; Dallas Fort Worth Rail Terminal LLC: Reuters, "Dallas Fort Worth Rail Terminal LLC Begins Operation of New Ethanol Handling and Distribution Terminal in Arlington, Texas," March 13, 2008, http://www.reuters.com/article/pressRelease/idUS152961+13-Mar-2008+BW200803

The possibility of distributing ethanol via a pipeline system is still uncertain. With the exception of possibly funding pipeline feasibility studies, there has not been much direct government financial support. Pipeline professionals are asking for much more, such as changes to federal tax laws to ensure that transportation of ethanol by pipeline will be treated the same as the transportation of natural resources. For the short term, ethanol distribution centers seem to be the right solution to enhance ethanol distribution efficiency. However, the long-term ethanol distribution infrastructure capacity remains unclear.

Europe: Incremental approach not the most efficient given the volumes coming onstream

In Europe, because of the way that product moves around—barge, rail and truck—and the current network of demand and supply, the view from the storage and transport companies we interviewed was that there is no bottleneck in the movement of biofuels around Europe and that the market can grow incrementally:

- "Any increase in demand for capacity will be incremental and will be easily managed as part of the natural increase in demand… but this increase would happen even without biofuels."
- "There is no need for any major investment in specialized infrastructure for biofuels supply."

To test this assertion, we created a map of Europe (EU27) that includes biodiesel and bioethanol plants split between those that will be commissioned by 2010 (based on units that are already commissioned or have financing secured) and those that will possibly be commissioned by 2010. These are further split by capacity. The map also includes refineries split by size and all of the depots.

Although not all of the announced capacity in Europe will be built (announced/planned capacity in EU27 is estimated at 17,554 million liters compared with financed/commissioned capacity of 18,714 million liters),[85] it is still evident that infrastructure will become increasingly important to:

- Open up opportunities of low-cost production and trade in Europe.
- Create a more efficient biofuels supply chain.

Open up opportunities of low-cost production and trade in Europe

Excess capacity in Germany is blocking development in low-cost Central and Eastern Europe (CEE)/Ukraine countries.

A German biofuels association has confirmed that industry biodiesel operating rates were estimated to be around 70 percent in 2007.[86] This excess capacity is the consequence of a "perfect storm" of:

- Reduced tax breaks for biodiesel.
- B99 "splash and dash" imports from the United States (1,136 million liters and 15 percent of biodiesel consumption in 2007 compared with 114 million liters and 2 percent of consumption in 2006).[87]
- Rising feedstock prices.

These challenges have consequences beyond Germany. Germany is a key market for feedstock in the Ukraine and CEE. A struggling German market has implications for the neighboring countries. A German bullish market like the one in 2006 would pull volumes from the Ukraine and CEE, with volumes able to pass through and reach other parts of Europe.

Although Germany may never be like 2006 again, we do expect the current market conditions to improve in the next couple of years due to a number of reasons. First, the loophole in US regulation that has led to "splash and dash" biodiesel imports into Europe eventually will be closed. Splash and dash refers to producers from any country shipping B100 to the United States, "splashing" a small amount of petrol diesel into it in order to pick up a refining credit of $1 per gallon available to all, and "dashing" this back to a market with large demand such as Germany. Splash and dash biodiesel is therefore effectively subsidized compared with biodiesel produced in Europe. In April 2008, the European Biodiesel Board lodged an anti-dumping and anti-subsidy complaint against unfair US "B99" exports.[88] Second, increased sustainability awareness is favoring European-sourced biofuels. Finally, enforcement of the EU 2020 blend mandate of 10 percent of transport fuels should aid the German market.

In this situation, biodiesel operating rates will return to a utilization rate higher than 70 percent and may again use low-cost feedstock from the CEE/Ukraine. New capacity may also be installed in the CEE and Ukraine, as demonstrated by Green Fuel Corporacion in Bulgaria (biodiesel) and Bio-Tech-Energy Kft in Hungary (ethanol).

Spain's excess volumes will need to be distributed to other markets in the EU.

Based on what has been announced, Spain's biodiesel capacity will increase by almost 10 times between 2006 and 2010 (see Figure 13). Although we do not believe that all of this capacity will get built, it is likely that supply will exceed domestic demand.

The large volumes of biodiesel production will require substantial quantities of feedstock. This is most likely to be soybean, because it is the most readily available feedstock for biodiesel and because the meal derived from soybean crushing is needed by the Spanish compound feed industry. Argentina will become a supplier of soybean feedstock to Spain. The world's three largest soybean exporters account for 90 percent of global exports, with Brazil at 41 percent, the United States at 35 percent and Argentina at 14 percent.[89] Due to reduced imports from Brazil and the United States, the share of imports from Argentina to Spain increased in 2007.

Research initiatives such as Repsol YPF's €23 million research and development project to "extend the availability and utilization range of local raw materials" will expand the feedstock availability within Spain.[90] A large proportion of Spanish biodiesel capacity is being built on the coast near the main ports, facilitating export to markets in Europe. The following could become export markets for Spanish biodiesel:

United Kingdom
- Little domestic feedstock
- Expected to be an importer
- Short on diesel

Italy
- Although there is current idle capacity and Italy is a net exporter, 2010 demand is expected to be greater than supply
- Little domestic feedstock

France
- Although supply seems to be growing at pace with demand, the market is 73 percent diesel
- Will need imports (feedstock or products) to grow supply

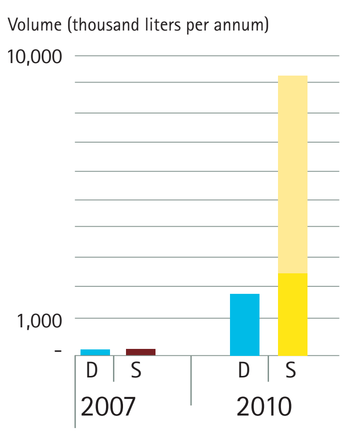
Create a more efficient biofuels supply chain

As per the discussion on distribution, there are significant challenges to integrating biofuels into the fuels supply chain, and the right infrastructure will help address these challenges. Of all the markets, Europe is one where biodiesel (and to a lesser extent, ethanol) is traded across borders. In *"Irrational Exuberance"?* when we discussed Europe, we said, "Biodiesel already moves freely within the EU, with a number of countries exporting a significant proportion of their production to other EU markets." The challenge in Europe is that it is almost too easy to grow incrementally, adding on infrastructure capacity as a plant is built. Stepping back and looking at the volumes that need to flow, an incremental approach to infrastructure may not be the most effective way to scale this market.

In summary, infrastructure to support scaling biofuels is developing in Brazil, the United States and Europe. However, the investment will continue to be fragmented, occurring at different speeds and levels. The challenge is how long it will take before biofuels have the infrastructure to allow them to be truly global and efficient and to support volumes that will encourage the move from long-term contracts to traded markets.

Figure 13

Projected biodiesel supply and demand in Spain in 2010



Projected demand in Spain based on EU mandate (demand) and planned capacity (supply)

D=Demand S=Supply ■ Production ■ Demand ■ Commissioned or financed capacity ■ Permitted or announced capacity

Sources: Accenture research; Energy Information Administration; Renewable Fuels Association; European Biodiesel Board; EU member states report on implementation of Directive 2003/30/EC; New Energy Finance; U.S. Department of Agriculture Global Agriculture Information Network

5

Financial market immaturity

Financial markets are still immature, and risk management is a significant challenge.

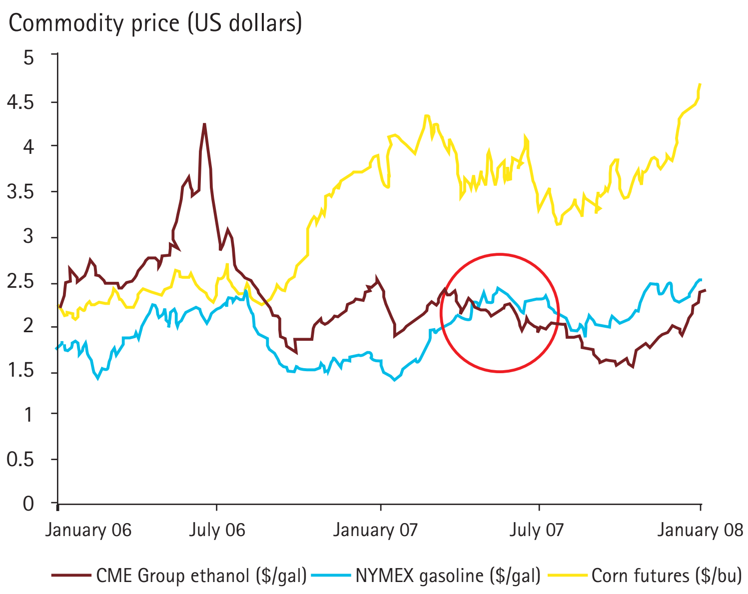
In order for biofuels to become a global industry, trading exchanges must develop that allow buyers and sellers to trade products efficiently across international borders. Exchanges provide for a global biofuels industry in several ways. First, as more volume is traded on the open market, pricing becomes more transparent to all players. Second, as the mandated level of biofuels rises, which it will do in Europe, freely traded exchanges allow players to adjust to short-term shortages and surpluses using the international markets in a way that long-term contracts do not allow. Third, as paper products, such as derivatives, are developed from the underlying physical delivery contracts, financial markets provide the opportunity to manage risk using futures and options, and risk management is a crucial capability for players extending their operations to large scale.

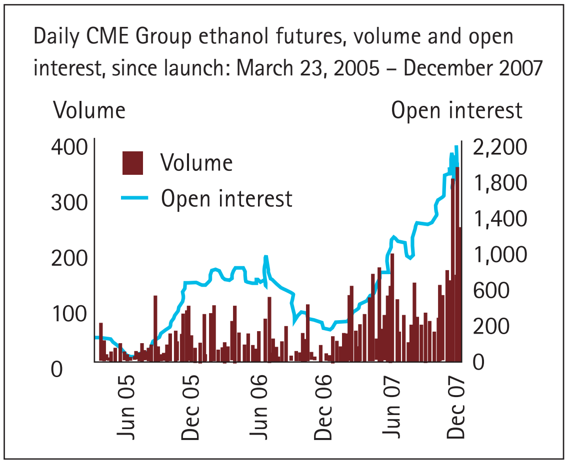
Financial markets have developed around feedstocks in major hubs. These include the Brazilian Mercantile and Futures Exchange (BM&F), New York Mercantile Exchange (NYMEX) and Rotterdam in Europe. These exchanges have also developed spot markets in biofuels themselves and are slowly introducing financial instruments such as ethanol futures to aid risk management. So far, biodiesel futures have not been developed, and it is suggested that they will appear in three to five years, either on one of the mentioned exchanges, at the CME Group or on one of the Southeast Asian exchanges such as the Bursa Malaysia.

As mentioned, the development of a forward price for biofuels traded in futures contracts allows players to manage risk more effectively. The CME Group exchange has the longest-established contracts, with an ethanol futures contract available for more than two years. We looked at the volumes being traded in the futures market and also the correlation between ethanol, gasoline and corn prices. Until the second quarter 2007, the volumes being traded in ethanol futures were extremely small, indicating that players were using a different avenue for risk management. Looking at the correlation between gasoline and ethanol, we noticed that historically there was a sufficient correlation (0.5–0.6) to allow players to hedge their price risk using unleaded gasoline derivatives (see Figure 14). The strength of this correlation is affected by oversupply of ethanol or rising feedstock costs. In 2007, where this correlation weakened significantly, cross-commodity hedging with gasoline failed to manage risk effectively. Since then, we have seen a rise in the volume of ethanol futures being traded, though it should be noted that trading volumes are still very small (just over 2,000 contracts) compared with open interest in corn, which is about 1.45 million contracts.

Figure 14

CME Group ethanol futures versus NYMEX gasoline, January 1, 2006–present





Source: CME Group

Because there is little liquidity and length, it is a struggle to use the paper markets for risk management.

Sources: CME Group data; Accenture analysis

It should also be noted that these volumes are not yet large enough to create a truly liquid market and also that the ethanol futures available today lack the length available in gasoline futures. Additionally, the ethanol market still lacks price transparency, given that 90 to 95 percent of volume is currently traded in long-term contracts. This suggests that should a sufficient correlation with gasoline be reestablished, players are likely to revert to using gasoline futures to manage ethanol price risk once again. However, given the volatile relationship between gasoline and ethanol prices, this option does not provide the long-term risk management tool that is needed. Accenture believes that paper markets will develop further because:

- There is no meaningful alternative to manage risk.
- Spot trading will develop at physical hubs, increasing price transparency.
- International trade is growing and with it the number of importers/exporters.
- There is a trend toward cross-commodity trading groups/platforms.
- Banks and speculators will enter the market.

For the players involved, this development means that risk management is likely to require involvement in one or more of the following:

- Commodities markets
- Long-term fixed-price contracts
- Value chain integration
- Outsourcing risk management to service providers (these could include members of any of the biofuels value chain)

As with infrastructure, the evolution of the financial markets will take time and will come only with significant physical volumes. Increasing physical volumes will drive spot markets, which will in turn create the price transparency and liquidity required for paper products to grow. Risk management will continue to be an issue as well as a competitive advantage.

6

Technology evolution

Technology currently supports the development of biofuels, but there are game changers on the horizon.

We have separated technology into "supporting" and "competing" technologies.

Supporting technologies are those that will make the position of the current players in the market stronger, supporting the creation of a global agriculture-based (but not necessarily food) biofuels industry. Competing technologies are those that threaten the position of the players in the market today and fundamentally challenge any assumptions and forecasts of the growth and penetration of biofuels.

Supporting technologies

- Technology is successfully stretching first generation through improving yields. Corn yields per hectare have increased by 53 percent since 1980. Drought-tolerant corn seed that may boost yield in dry areas by 40 percent are under development. Sugarcane breeding programs and genetic improvement have improved ethanol yield per hectare of sugarcane by 40 percent since 1985.[91]
- Second-generation technologies will leverage the infrastructure and knowledge of those participating in first generation. Sixteen commercial-scale cellulosic ethanol plants will be built by 2010, with a capacity of more than 1.1 billion liters. In parallel, the ability to upgrade first-generation plants, as pioneered by POET's Project Liberty in the United States, will reduce the stranding risk for first-generation producers. Alternative feedstocks, such as corn stover, sugarcane residues (bagasse) and straw, will be utilized via cellulosic ethanol technology.[92]
- More biofuels pathways, such as diversifying the product mix, are under development (for example, butanol).

Competing technologies

- Third-generation biofuels bring a new nonagricultural science (technologies such as artificial photosynthesis, algae biodiesel and synthetic biology) and new players into the market (GreenFuel, Amyris).
- Electric. Plug-in hybrids from GM (Volt) and Toyota (next-generation Prius) are in development and will be available around 2010.[93] Supporting infrastructure is gaining momentum, as is the case with Project Better Place. In this venture, $200 million has been raised to develop a grid of electric charging spots at parking locations and battery exchange stations. Electric technologies draw even more new players into the transport fuels arena as utilities such as EDF (Electricité de France) become involved. Along with Elektromotive Ltd., EDF is already rolling out recharging bays across the United Kingdom.[94] And in North America, GM recently announced a collaboration with the nonprofit Electric Power Research Institute, which includes 30 top electric utilities. The purpose of the alliance is to focus on infrastructure requirements for plug-ins.[95]
- Hydrogen. Though it is still more than 10 years away, hydrogen is a technology where we are seeing significant OEM and private investment.

Competing technologies will arrive and challenge biofuels—they will need to do so if we are to crack the dual problems of climate change and energy security. Competing technologies are central to the diversity in transport fuels we foresee.

The challenge for the biofuels industry is to carve out its place and to become as global and efficient as possible before these technologies arrive.

Case study: Arrival of the plug-in hybrid

Consumer take-up of hybrid cars is one recent development that demonstrates the emergence of alternative transport solutions. The first models, powered by gasoline and battery, overcame initial skepticism from much of the auto industry to establish themselves as a growing niche market. Toyota, which pioneered the concept with its Prius model released in 1997, is the market leader in this technology, with total worldwide sales of the Prius now exceeding 1 million units.[96] Many other major manufacturers have launched their own hybrid models, and 2007 saw a total of approximately 350,000 hybrids sold in the United States. With gasoline prices running at a sustained high level, hybrid sales are expected to continue to grow, with the Energy Information Administration predicting that 2 million hybrids will be sold per year in the United States in 2030. Fuel economy, after all, is a major concern for all motorists, not just those looking to reduce GHG emissions.

The plug-in hybrid electric vehicle (PHEV) is the next step in developing a car with the capacity to run on electricity and gasoline. With the addition of a second battery pack, the PHEV can store greater levels of electricity and is charged by plugging into a standard household electrical outlet. With more electric power in reserve, the vehicle is capable of operating in pure-electric mode for longer periods of time and at much higher speeds than current hybrids. The added electrical power also produces substantial gains in fuel economy and a reduction in total tailpipe emissions versus current conventional hybrid systems.

The PHEV is significant in that it indicates the growth in diversity in transport fuel. As the capacity of the electric battery grows, consumers will have more control over the balance of different fuels used in their cars. If grid electricity offers a more economic propulsion option, PHEV owners will be able to choose to run on electricity for a greater portion of their journeys. For example, in *An Innovation and Policy Agenda for Commercially Competitive Plug-in Hybrid Electric Vehicles*, a paper written by three professors at the University of California at Berkeley (D. M. Lemoine, D. M. Kammen and A. E. Farrell), the cost of fueling a PHEV using electricity versus gasoline is compared. The conclusion was that at today's gasoline prices (at the time of the report's publication, gasoline prices were averaging between $3.75 and $4.25 per gallon in the United States), using electricity, particularly off-peak electricity (outside of traditional working hours), is very competitive. The breakeven point is $1.50 per gallon—that is, electricity customers paying the standard baseline electricity rate would be indifferent (on a pure energetic basis) when choosing between gasoline and electricity if gasoline prices were $1.50 per gallon. This potential for choice within each vehicle introduces fuel-on-fuel competition at the consumer level. It also shows that the parties involved in transport fuel will diversify. For the PHEV, utility companies become the supplier and will have the opportunity to develop new offers for transport customers.

Some automotive manufacturers initially questioned the practicality of PHEVs, saying consumers preferred the convenience of hybrids that did not have to be recharged. However, anecdotal consumer trends have caused them to reconsider. A small number of hybrid owners have started converting their own cars into plug-ins. Though obviously heavily frowned upon by the manufacturer, a number of small companies have offered to convert cars for a (sometimes significant) fee.

Whether these consumers make any gain is debatable. Home conversions use heavy batteries that are just an extra load once they have discharged and the engine switches back to gasoline. Nevertheless, this demonstrates that motivated consumers are interested enough in the plug-in option to make a further investment and jeopardize their warranties. Furthermore, the response to PHEVs at trade shows has been enthusiastic. The Chevrolet Volt was so popular at its unveiling in January 2007 that the company has stepped up its ambition and now aims for a 2010 consumer launch. In fact, GM recently announced an alliance with the nonprofit Electric Power Research Institute to focus on ensuring that the plug-in infrastructure is ready in the United States and Canada when the Volt goes to market.[97] The Volt also potentially points to a future overlap with biofuels. One of the aims is to have a model that is both plug-in hybrid and flex-fuel, running on E85.

Toyota is also pursuing PHEVs, announcing several developments over the last year. Toyota aims to build its first fleet of plug-ins for commercial customers by 2010.[98]

Ultimately, the success of plug-in technology will depend on four things:

Battery technology

GM has signed contracts with battery supplier A123Systems, and Toyota is working with Panasonic.[99] Manufacturers will have to balance the equation relating storage capacity, battery weight, fuel economy, vehicle range and cost to produce an affordable, light, high-capacity battery for PHEVs to attract consumers. And once the concept is proved, integration of the battery into the rest of the car's systems and scale-up of battery manufacture will still have to occur. There are several research hurdles to overcome before this will be achieved.

Infrastructure

As has been widely noted, PHEVs are only as clean as the grid to which you connect them. Running a battery on electricity from a traditional coal-fired power station potentially produces more emissions than a gasoline car—an outcome not entirely in line with the desires of most PHEV target consumers. Additionally, questions have been raised about the ability of the grid to support a large number of plug-in cars without new-generation capacity. If one assumes that most people will charge at off-peak hours, then studies generally conclude that existing capacity will suffice, but more research on consumer behavior is needed. Utilities are likely to be as interested in the take-up of PHEVs as auto manufacturers given the potential effects on their services. Indeed, EDF and Toyota are installing recharging points for PHEVs on roads, streets and parking lots in France. EDF also has a partnership with Elektromotive to install charging points in the United Kingdom.[100]

More fanciful ideas, such as widely distributed networks of charge points or vehicle-to-grid (V2G) applications, are certainly a way off.

However, there are companies working on radically new visions of the transportation business model. Project Better Place, for example, is working on a model that it likens to the mobile phone industry. It describes a future in which there will be a network of charge points and battery exchanges similar to the network of towers that create mobile phone coverage. Users will be able to stop at these stations and recharge or swap their batteries. Through a partnership with auto manufacturers, Project Better Place customers will get sizable discounts on their actual cars in return for signing usage contracts in much the same way that telecom network operators offer discounted handsets with their contracts.

Regulatory support

As with all potential transport fuel alternatives, PHEV supporters will have to make a case to regulators to gain the necessary impetus. The success of hybrids possibly makes this slightly easier for PHEVs. Recently, for example, California's Air Resources Board declared a target of "58,333 PHEVs from the 'big-six' manufacturers by 2012–2014." This target came despite the lack of concrete evidence that plug-ins are necessarily the optimal choice for consumers, the economy or the environment, with fuel-cell and hydrogen cars receiving less support.

Competition

Although PHEVs could be powered by blended biofuels, and potentially in the future, there will be FFV versions of PHEVs, by 2010, PHEVs will be competing with an established first-generation biofuels industry, with second generation on the horizon. The other emerging transport fuel alternatives will all have made some progress, and PHEVs will have to differentiate themselves in an increasingly crowded marketplace.

In summary

PHEVs represent one potential step forward in the move to a diverse portfolio of cleaner transport fuel options. Though commercialization of this technology has its own idiosyncrasies, development of PHEVs has much in common with other potential transport fuel developments. On the one hand, you have consumers creating enough heat around a potential market for established, traditional players such as GM and Toyota to take notice. In addition, in order to meet the challenge, GM and Toyota are partnering with start-ups, such as A123Systems, or nontraditional collaborators, such as Panasonic. There is also the overlap that this solution has with another established industry, in this case utilities, and the interaction with other transport fuel solutions such as biofuels. And all the time, there is the possibility that R&D, infrastructure and regulation will not keep pace with the ambition of the companies that want to succeed in this arena and that the offer never becomes truly compelling for consumers.

One further conclusion from the development in PHEVs is that it is a sign of OEMs enabling increasing fuel-on-fuel competition. The assumed model for a switch from gasoline has been that new fuels will replace gasoline as stocks of alternatively fueled vehicles grow in number. But soon, in one car, drivers will have the choice of electricity, biofuel or gasoline (or diesel). The PHEV, and more broadly the hybrid story, suggests that OEMs are building the capacity for fuel switching into each vehicle.

Part of the challenge for OEMs is the R&D involved in designing components throughout vehicles that can work with differing fuel sources, aside from simply developing the technologies themselves. With the hybrid, and now with the PHEV, OEMs have laid the engineering groundwork that will allow easier incorporation of other alternatives. The experience gained in moving from first-generation hybrids with little capacity to run without gasoline, to PHEVs, which can run for greater distances on electricity alone, can be applied to the introduction of other technologies, such as hydrogen or fuel cell. The real issue for OEMs is not the use of alternative fuels, but the development of versatile powertrain systems that can run on more than one fuel. The approach of OEMs to this issue allows us to move beyond a paradigm in which one or more alternative transport fuels must be selected and backed in advance to one in which fuel-on-fuel competition is the ongoing reality.

Conclusion

To summarize, we believe that most of the elements are there for the biofuels industry to become a global market, but:

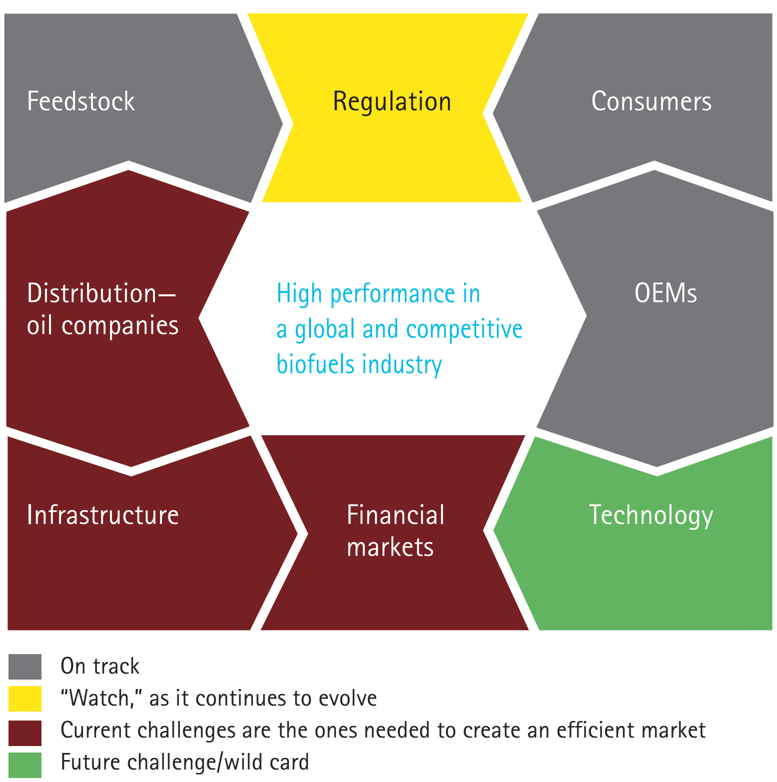
- Regulation (at the local level) is something that will continue to evolve. Understanding how this will play out in the market and anticipating the intended and unintended outcomes will continue to be critical.
- Supply chain, infrastructure and the financial markets are the biggest challenges to making this market bigger and more efficient.
- Competing technologies will change the game. Today, the "supporting technologies" have the advantage. Our current view is that market players and participants have some time, perhaps more than 10 years, to get this industry global and efficient before the competing technologies start to challenge first- and second-generation biofuels.

Perhaps the most important takeaway is that biofuels will grow up in a world filled with competing technologies. Competition will come from a host of sources, not just from gasoline and diesel. Regulation and the intent to move to a low-carbon economy will only accelerate this competition as incentives are put in place to promote innovation in technologies and fuels that will lower carbon intensity, and as markets adjust their fuel mix to the cleanest that they can access. At Accenture, we see a future filled with diversity in transport fuels and in the players who provide them.

Figure 16 shows players who are involved in the transport fuel industry today. As Figure 16 demonstrates, the future of transport fuels will include diverse groups of players. There are already indications of where the focus will lie for each group. Through our research, we have found several companies in each of the sectors listed in Figure 16 working on projects that cover the breadth of solutions shown by the arrows. Some groups, such as IOCs, have the potential and ambition to be involved in all transport fuel technologies. Other nontraditional sectors, such as chemicals, will have a narrower interest in the kind of projects they will pursue over the next 10 years.

Figure 15

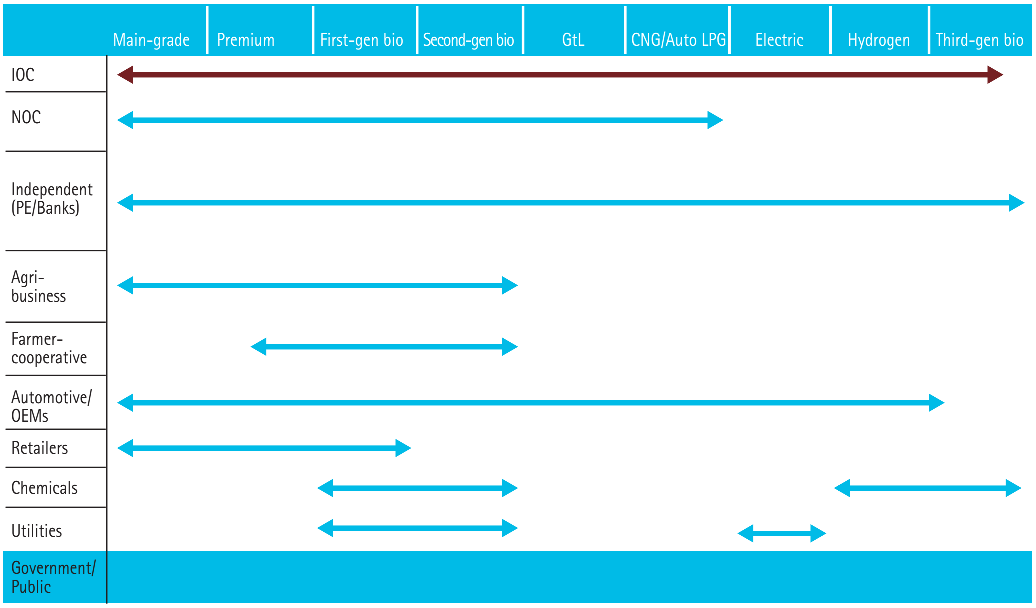
Development is needed in some areas to create a truly global biofuels industry



Source: Accenture analysis

Figure 16

Activity today in a variety of sectors will create a new transport fuel landscape



Source: Accenture research and analysis

CNG = Compressed natural gas
GtL = Gas to liquids
LPG = Liquefied petroleum gas

Biofuels will not grow up alone—it is no longer just about gasoline and diesel. As is indicated by Figure 16, there is diversity in transport fuels and in the players who provide them. This is a map of some of the transport fuel technologies and the type of players investing in them. Although the company names have been removed, this chart was based on companies that exist today and that plan to be here in 10 years. The number of new entrants and new technologies is growing, so the market will only get more diverse and competitive.

For players in the biofuels market, this means that they have to master the capabilities that will enable them to navigate through the transition to fuel-on-fuel competition as it becomes a reality. Our view is that the capabilities that are key to high performance are:

- **An effective nonmarket strategy**—navigating the patchwork of regulation, tariffs and incentives, and managing media and consumer perception.
- **Superior investment evaluation**—choosing the right mix of investments and the amount and type of capital to invest, accounting for the risks in the structure of the deals, and understanding when to consider mergers and acquisitions.
- **Partnering**—finding and keeping the right partners to share risks and access markets, skills and financing.
- **Supply chain**—aligning and optimizing the cross-border feedstock and biofuels supply chains.
- **Customer/contract management**—managing portfolios of bilateral long- and medium-term contracts and, for the players in the downstream, managing the consumer value propositions.
- **Trading and risk management**—using the physical and financial markets to manage risks and surpluses/shortfalls in contract positions.
- **Portfolio of investments in various technologies**—using diversification to manage the uncertainty of which technologies will prevail.

This does not mean that all the players will have the same strategies or that there is a particular group that is advantaged. The pieces are still falling into place, and during this time of transition, strategies are evolving. To achieve high performance, what is important is for the strategy and capability mix to be aligned—deep where it makes sense and fit for purpose in other areas.

For example, we are starting to see companies pursuing different focus areas:

- **Industry infrastructure**—companies that are investing in storage and transport, scaling their business through multicommodity plays, and contracting and partnering with both consumers and producers.
- **Marketing and trading**—companies that sell more than they produce, want diversity in both supply and demand, are in multiple markets, and are asset-light relative to volume.
- **Asset management and operations**—producers that are focusing on optimizing their physical asset base through strategic sourcing and contract management, and building supply chains to deliver supply to demand.
- **Vertical integration**—companies that are looking to control the entire biofuels value chain through ownership and control of operations. These companies need to be deep in agriculture and energy and will be very asset-heavy.

As with the commodities markets, there will be room in the market for players with different strategies. But the players who are successful will be those that master the right mix of these capabilities with depth and focus tailored to their strategies. This mix will be driven by key decisions on strategy: markets, product, partners, activities and risk appetite. The race is on to build the positioning and capabilities for success—reflecting the fact that a massive new global market is up for grabs.

Case study: LCFS—Accelerating fuel-on-fuel competition[101,102]

California's Low-Carbon Fuel Standard (LCFS) calls for a carbon-intensity reduction of at least 10 percent in California's transportation fuels by 2020 (estimated gasoline and diesel consumption in 2020 is 16.5–17 billion and 4 billion, respectively). LCFS is the most aggressive and innovative policy today focused on reducing GHG emissions, and it aims to encourage investment and stimulate the development of technologies in the production of both fuels and vehicles (versus picking a single winning solution to focus all investments). Some key elements of LCFS include the following:

- It is technology-neutral. LCFS is not a biofuel standard, but one that looks at carbon intensity. This means that it will encourage the development of alternatives that are more sustainable on a carbon basis. For example, the LCFS makes explicit the way plug-in hybrids will be counted.
- It is a hybrid of market and regulatory approaches. It is "regulatory" in that an intensity target is assigned to energy providers in one sector, and "market" because energy providers can trade credits with each other.
- It is premised on a carbon metric to avoid unintended negative social and environmental impacts. It is intensity-based (using the Global Warming Intensity [GWI], or more commonly referred to as "carbon intensity"), measured in grams of carbon dioxide equivalent per megajoule (gCO_2e/MJ) used to propel a vehicle.
- It offers a default and opt-in system. Default values that are higher than the average values for the carbon intensity of inputs and processes will be provided by state agencies. But fuel providers can provide data to support a lower GWI value.
- It offers trading and banking of credits. LCFS is structured like an emission-reduction credit program in which firms must apply to the regulator for credit based on performance beyond a regulatory standard.
- It acknowledges the need to be integrated with other regulation. For example, LCFS encourages the same fuels as AB1493 (Pavley), and while AB32 focuses on production emissions, LCFS regulates consumption emissions (although it is clear that there is potential for double regulation in fuel production, the development of AB32 and LCFS needs to be coordinated because it is not possible to specify one without the other).
- It uses innovation credits. This credit usage is associated with the cost of the carbon-intensity reduction versus the absolute reduction to encourage technological innovation.
- Financial resources exist to make the LCFS real. A key part of LCFS is AB118. AB118, approved in 2007, is a fairly unique interagency project that provides $200 million per year for seven years (about $120 million per year for projects within the California Energy Commission, and about $80 million via the Air Resources Board) to support projects to make vehicle-based carbon emission reductions real.

Two aspects of LCFS are particularly relevant to this study:

- There is a diversity of options in future transportation fuel mix. The scenarios developed to test the technical feasibility of LCFS are interesting because they are grounded in the possible but are not based on the probable—in other words, they push the envelope of potential take-up/market share of alternative transportation fuel options.
- The proposal is specific to California. Although the principles behind LCFS can be applied more broadly, its design is driven by California's situation and is an example of how regulation will promote the increased diversity in transportation fuel mixes by market.

Diversity of options in future transportation mix

The technical feasibility of LCFS was based on the examination of 12 scenarios that included various combinations of:

- Innovation in electric drive technologies (batteries, fuel cells and power electronics).
- Biofuels (existing, second-generation and new innovations).
- Increased share and penetration of FFVs.
- Increased diesel consumption.

Table 4 includes the names, descriptions and the average fuel carbon intensity (AFCI) goal that the scenario meets.

The scenarios show that the LCFS intensity target can be met in a number of different ways, and that, with the exception of expecting diversity, the future is far from certain. Table 5 lists the various combinations of assumptions (levers) in the various scenarios that drive reductions in AFCI.

Proposal specific to California

In our first biofuels study, we looked at the "patchwork" of regulation across the different markets. LCFS is an example of how policy will be focused on local considerations—in other words, California's:

- Feedstock supply potential. California has access to the feedstock that can deliver the intensity reduction.
- Electricity generation capacity and mix. California has a clean portfolio of largely non-coal generation with significant off-peak excess capacity.
- Refining industry. California has been increasing its use of heavy oil in its refineries. This, along with its gasoline specification, has resulted in a higher energy requirement (and GHG emission) in its refining.

The total estimated biomass resource in California is 84 million dry tons (approximately 6 billion gallons per year, or 22.7 billion liters per year), but not all of this biomass can or should be used for industrial purposes. The current estimate is that California has sufficient feedstock to produce 1-2 billion gallons of biofuels in state. It's this estimate that is used in the biofuels-related scenario assumptions in Table 5.

California relies much less on coal electricity than does much of the rest of the United States (which is about 50 percent coal electricity), and SB1368 limits the amount of coal electricity that can be imported. Coal makes up only 14.3 percent of California's generation. California's generation portfolio is dominated by natural gas (43.8 percent). The other types include large hydro (16.3 percent), nuclear (14.9 percent) and biomass (10.7 percent).

In addition, like many electrical systems, the electrical system in California has a great deal of under-utilized capacity because the system capacity must be built for the peak demand times. The annual minimum power demand can be less than 40 percent of the peak demand, the average demand is 60 percent of the peak demand, and there are several thousand hours of the year where demand is less than 50 percent of

Table 4

Light-duty vehicle scenario names, descriptions and AFCI goals

Scenario name	Fuel innovations	Vehicle innovations	Scenarios and carbon-intensity target (see table 5)		
			-5%	-10%	-15%
Baseline	Current technologies	Gasoline ICE dominates Increased diesel, HEVs		A*	
Electric drive	Electric charging and H_2 refueling	Significant innovation in PHEV, EV and FCV technologies	C5	**	**
Existing vehicles with advanced biofuels	Significant biofuel innovations Low-GHG biofuels (5.7% vol.) Low-GHG FT diesel blends	None required	D5	D10	**
Evolving biofuels and advanced batteries	No fuel innovation Mid-GHG biofuels (10% vol.) Mid-GHG biodiesel blends	Advances in PHEV, EV and FCV technologies	F5	F10	**
Biofuel intensive	No fuel innovation Mid-GHG biofuels (10%, 85%) Mid-GHG biodiesel blends Low-GHG fuels for G15	None required	G5	G10	G15
Multiple fuels and vehicles	Low-GHG biofuels (10%, 85%) Low-GHG FT diesel blends Electric charging and H_2 refueling	Advances in PHEV, EV and FCV technologies	H5	H10	H15
Heavy-duty compliance	(to be determined)	(to be determined)			

Notes: *No AFCI goal applies; **Not considered. No "B" or "E" scenarios are used to avoid confusion with biodiesel and ethanol blends. In the "No fuel innovation" scenarios, investment is needed to increase the use of current technologies, but no new technologies are assumed. Biofuel scenarios that assume energy crop production for mid-GHG ethanol (F and G scenarios) have large uncertainties due to feedstock production.

Key: AFCI = Average fuel carbon intensity, EV = Electric vehicle, FCV = Fuel cell vehicle, FT = Fischer-Tropsch, GHG = Greenhouse gas, HEV = Hybrid electric vehicle, ICE = Internal combustion engine, PHEV = Plug-in hybrid electric vehicle

Sources: *A Low-Carbon Fuel Standard for California Part 1: Technical Analysis*, Office of the Governor/Air Resources Board, 2007; *A Low-Carbon Fuel Standard for California Part 2: Policy Analysis*, Office of the Governor/Air Resources Board, 2007 peak demand. This means that the system could handle a great deal more demand without the need to upgrade capacity if the demand is appropriately timed.

California refineries have the dual challenge of a higher specification output (California Reformulated Gasoline—CaRFG) and a heavier crude input due to in-state heavy crude oil production. A higher specification product will require more processing and thus more energy—low-quality oil resources produce fuels with higher life-cycle emissions than high-quality oil. As a result of this, LCFS will include upstream emissions to address the differences in crude oil feedstock (for example, 20 percent of emissions of conventional gasoline are upstream versus 40 percent of emissions from gasoline made from heavy oil are upstream).

In summary, the LCFS is aggressive but designed for the characteristics of California. Other markets will have different feedstock potential and may not have the potential for PHEV or the refining challenges that California has. We expect to see more market-specific regulation because the supply/demand situations are different. However, the big challenge is how to implement and enforce this regulation given the lack of a standard GHG unit measurement approach and the evolving science of GHG emissions. This issue will continue to make the "transition" to a mature biofuels industry much more complicated than we initially anticipated.

Table 5: Scenario assumptions to achieve carbon-intensity reduction

Drivers	C5	D5	D10	F5	F10	G5	G10	G15	H5	H10	H15
Business as usual (baseline) reduction	■	■	■	■	■	■	■	■	■	■	■
Introduce plug-in hybrid vehicles	■			■	■				■	■	■
Introduce electric vehicles (EVs)	■										
Introduce fuel cell vehicles (FCVs)	■										
Increase renewable energy fraction	■										
Introduce low-GHG ethanol		■	■				■	■			
Increase ethanol blend 10%		■	■	■	■	■	■	■	■	■	■
Introduce low-GHG diesel			■								
Increase diesel fuel sales			■		■					■	■
Increase fraction low-GHG ethanol			■								
Mid-GHG ethanol (5.7% vol.)				■	■	■	■	■			
Increase FFV ethanol VMT to 50%					■	■	■	■		■	■
Introduce mid-GHG biodiesel					■	■	■	■			
Increase E85 sales to FFVs					■						
Increase number of FFVs						■	■	■			
Increase number of diesel vehicles							■	■			
Increase fraction of low-GHG FT diesel								■			
Introduce sub-zero GHG ethanol								■			■
Increase FFV VMT to 90%								■			■
Introduce low-GHG ethanol (5.7% vol.)									■	■	■
Increase CNG sales to vehicles									■	■	■
Increase biofuel sales to FFVs										■	■
Increase electricity sales to EVs											■
Introduce hydrogen for FCVs											■
Introduce low-GHG FT diesel							■	■		■	■
Increase EVs				■	■						

Key: CNG = Compressed natural gas, FFV = Flexible-fuel vehicle, GHG = Greenhouse gas, VMT = Vehicle miles traveled

Sources: *A Low-Carbon Fuel Standard for California Part 1: Technical Analysis,* Office of the Governor/Air Resources Board, 2007; *A Low-Carbon Fuel Standard for California Part 2: Policy Analysis,* Office of the Governor/Air Resources Board, 2007

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