Biofuels: From boom to bust?

Five lessons from a decade of growth and decline

By Fernando Martins and Juan Carlos Gay

BAIN & COMPANY

Fernando Martins is a partner with Bain & Company in São Paulo. Juan Carlos Gay is a Bain partner in London. Both work with Bain's Global Oil & Gas practice.

The authors would like to acknowledge the contributions of Kusi Hornberger and Vitor D'Agnoluzzo, consultants in Bain's São Paulo office, and Luiza Mattos, a manager in Bain's Rio de Janeiro office.

The biofuels industry began to take off in the early 2000s as government subsidies around the world made ethanol and biodiesel cost competitive with other transport fuels like gasoline and diesel. The world's three largest biofuels markets experienced dramatic annual growth in ethanol consumption between 2003 to 2010: 24% in the US, 15% in Brazil and 44% in the EU. Ethanol made up nearly 7% of the world's transport fuel consumption in 2011, up from just over 2% in 2003 *(see Figure 1)*. And from a smaller base, the 39% per year growth of biodiesel consumption was also impressive *(see Figure 2)*.

Why then, after seven years of rapid growth and strong government support, is the industry in crisis today? A range of problems has stunted growth across markets, including rising production costs, inadequate infrastructure for blending ethanol, wavering government support for subsidies and tax credits, and waning consumer interest. Concerns over biofuels' impact on food prices, along with tighter budgets due to the global economic crisis in 2008 and 2009, have left many governments less willing to support the industry. Hardly anyone is enthusiastic about biofuels anymore.

Three leading markets

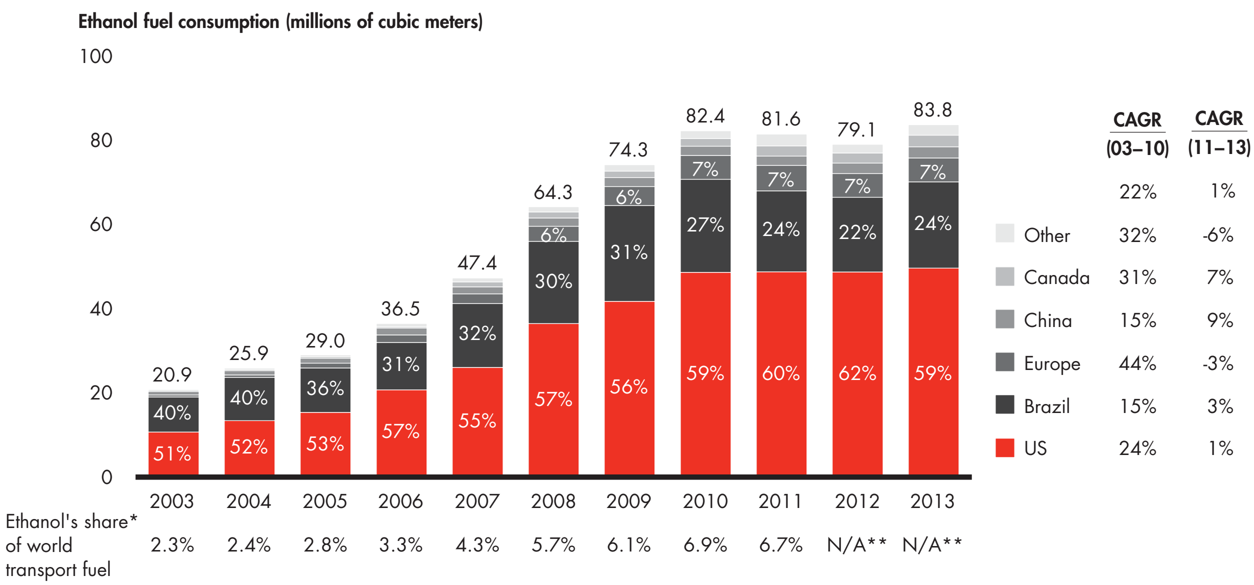
This was certainly not the case a decade ago, when three parallel developments sparked a surge in global demand for biofuels:

- The advent of the **flex-fuel engine** (for ethanol and gasoline);
- **New policy mandates** pushing for greater use of biofuels as alternatives to traditional fossil fuels;
- **Subsidies** in the three most important regions: Brazil, the US and Europe.

Within each of these major markets, these three forces played out somewhat differently.

Brazil. Brazil produces more sugarcane than any other country, and because sugarcane is the key feedstock for low-cost production of ethanol, Brazil quickly became the second-largest producer and consumer market for ethanol. In 2003, Volkswagen and GM both introduced

Figure 1: Global ethanol consumption

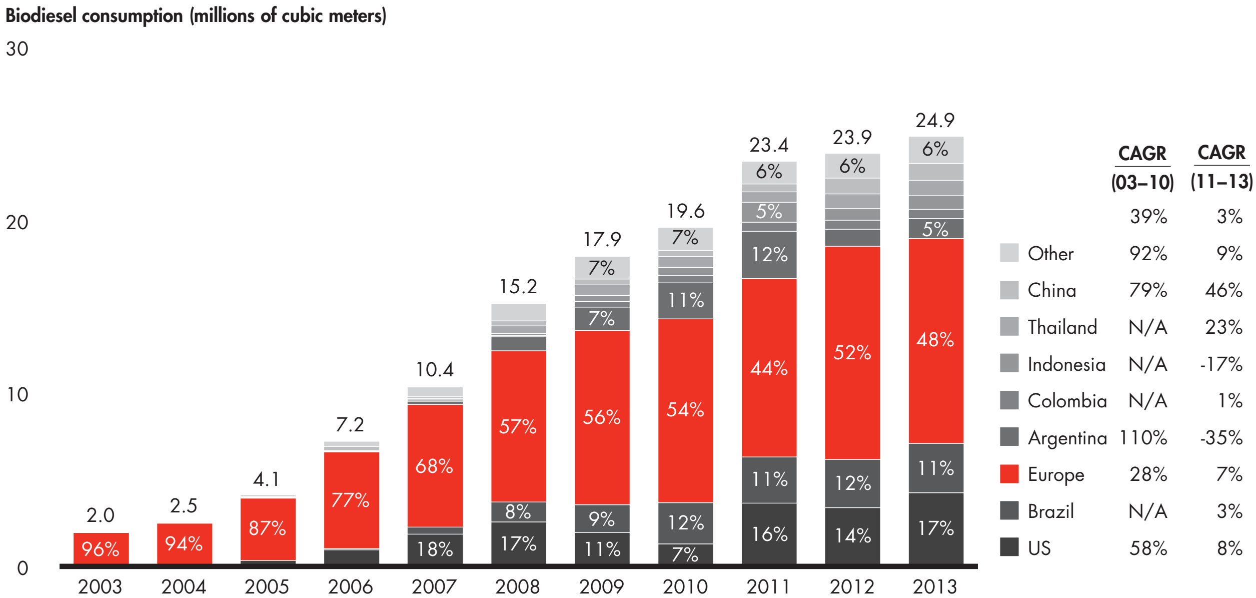


* Ethanol's share=ethanol/(gasoline+ethanol) ** Data not available

Notes: Europe refers to all European states, including non-EU member states; for 2011–2013, percentages are based on data from USDA, except for Brazil's, which are based on data from UNICA; data for all other years is from EIA.

Sources: EIA; UNICA; USDA; Bain analysis

Figure 2: Global biodiesel consumption



Notes: Europe refers to all European states, including non-EU member states; 2011–2013 percentages are based on data from USDA; percentages for all other years are based on data from EIA.
Sources: EIA, USDA, Bain analysis

flex-fuel vehicles in Brazil—followed quickly by other carmakers—radically transforming the consumer market. Brazil's experience with ethanol dates back to the 1940s, but now, for the first time, consumers could decide at the pump whether to buy gasoline or ethanol.

Ethanol's resurgence was encouraged through financial support by the Brazilian Economic and Social Development Bank (BNDES)[1] and lower taxes than on gasoline. With this support, ethanol consumption grew from 34% of automobile fuel consumption in 2005 to 50% by 2009.

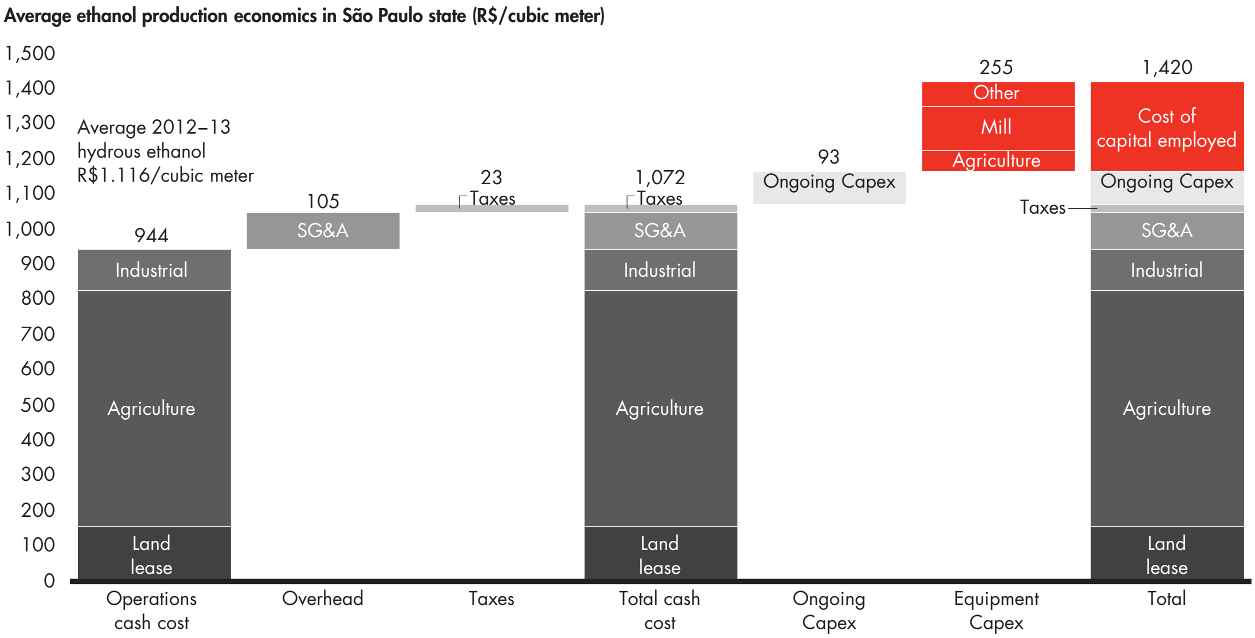
But then ethanol became more expensive than gasoline for several reasons: shortages of skilled biofuel engineering talent combined with rising costs for manual labor (to harvest and process sugarcane), raising production costs while the government began monitoring labor and environmental regulations much more strictly, increasing the cost of compliance. These and other factors crimped producer margins, which are now so low they barely cover production costs and cannot support capital expenditure investments *(see Figure 3)*.

In addition, Brazil's federal and state governments became concerned about rising inflation and reduced taxes on gasoline to hold down its price, even as ethanol costs grew. Between 2008 and 2013, ethanol lost its competitive advantage against gasoline, even in the sugarcane-growing state of São Paulo.

United States. The US is the largest ethanol market, producing and consuming about 60% of the global supply. Corn is the main feedstock for ethanol in the US, and it has traditionally been heavily subsidized by national and state governments. Corn is less efficient and less environmentally friendly than sugarcane for making ethanol. On average, an acre of sugarcane produces twice as much ethanol as an acre of corn[2], and corn ethanol produces twice the greenhouse gas emissions (GHG) *(see Figure 4)*. By some measures, it costs $122 more to produce a cubic meter of corn ethanol than it costs to produce the same volume of gasoline from oil.

Biofuels have been around in the US since the 1930s, but the market began to take off more seriously when the government introduced a series of tax credits in the 1970s. In 1978, the government introduced a 40-cents-

Figure 3: Ethanol production economics for an average Brazilian producer



Notes: Assumes mill produces 100% of its crushed sugarcane; does not include potential upsides from co-generation.
Source: Bain analysis

per-gallon tax break for producers, which has been set at 51 cents since 2005. The tax credits did little to promote adoption of biofuels until around 2000, when rising oil prices made alternative energy more competitive.

These oil price increases—along with corn farmers looking for new markets and growing public concern over both MTBE[3] contamination of ground water and GHG emissions caused by traditional fossil fuels—led most states to introduce ETBE[4] as an alternative oxygenate gasoline additive. These factors also prompted the federal government to encourage ethanol demand by setting consumption mandates. In 2005, the Renewable Fuel Standard (RFS), which originally required 7.5 billion gallons of renewable fuel to be blended into gasoline by 2012, was created under the Energy Policy Act (EPAct). Then in 2007, the RFS was expanded to include biodiesel and other biofuel categories, and the target was increased to 36 billion gallons by 2022. Finally, in 2009, it was further revised to require that 16 billion gallons should come from advanced cellulosic biofuels. These mandates ignited the industry, and corn prices skyrocketed to levels that eliminated the need for subsidies to corn farmers *(see Figure 5)*.

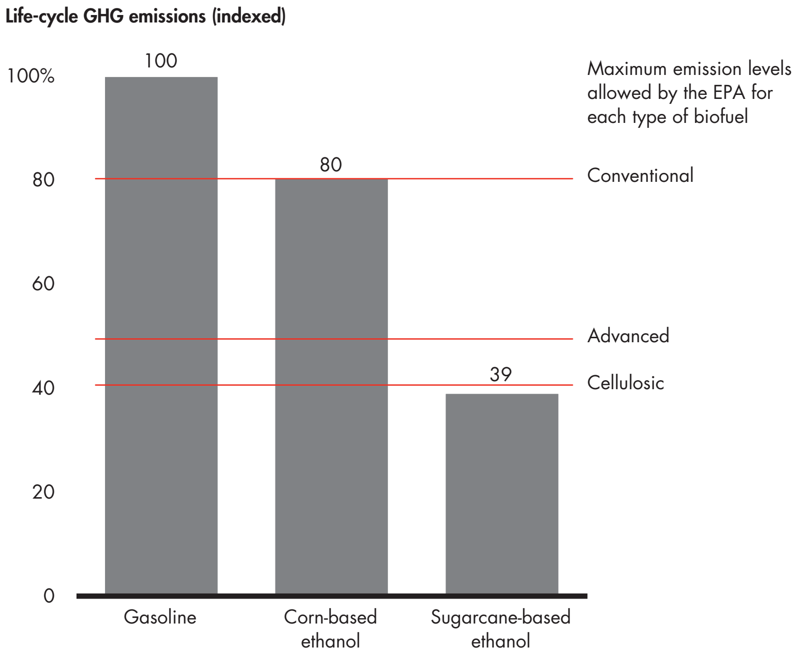
So why has biofuels production and consumption in the US been flat since 2010?

The 2009 global economic crisis and tepid recovery are partly to blame: Americans have been driving less and buying smaller, more fuel-efficient cars. And banks, facing tighter balance sheets, were less willing to lend for new biofuels projects—especially cellulosic biofuel plants, which are considered riskier.

And until 2010, there was an oversupply of biofuels, which reduced profitability. The industry also failed to produce advanced biofuels (those not based on corn) because of both technical and commercial challenges.

The 2007 mandate stipulated that the US should consume 250 million gallons of cellulosic ethanol in 2011 and increase consumption to 500 million gallons in 2012. Yet almost none has been produced to date. In the US and Brazil, only a few small plants are operating or under construction, and the expected production capacity in 2014 is only 89 million gallons and 44 million gallons, respectively. Actual production, however, will be much

Figure 4: Carbon emissions of ethanol from corn and sugarcane



Source: EPA (quoted by Platts)

EPA definitions of biofuels

Conventional biofuel is ethanol derived from corn starch. It must generally achieve a 20% GHG emissions reduction compared with baseline life-cycle GHG emissions.

Advanced biofuel is any renewable fuel (other than ethanol derived from corn starch) derived from renewable biomass, achieving a 50% reduction in GHG emissions. Cellulosic biofuels and biomass-based diesel are examples.

Cellulosic biofuel is renewable fuel derived from any cellulose, hemicellulose or lignin—that is, derived from renewable biomass, achieving a 60% reduction in GHG emissions.

less. In 2013, the industry in the US produced only about 280,000 gallons—less than 1% of the original target. Even after the EPA significantly lowered 2013 targets, from 500 million gallons to 6 million gallons, actual production was still just a fraction of these requirements.[5] Refiners had few options other than to pay fines and pass cost increases on to consumers.

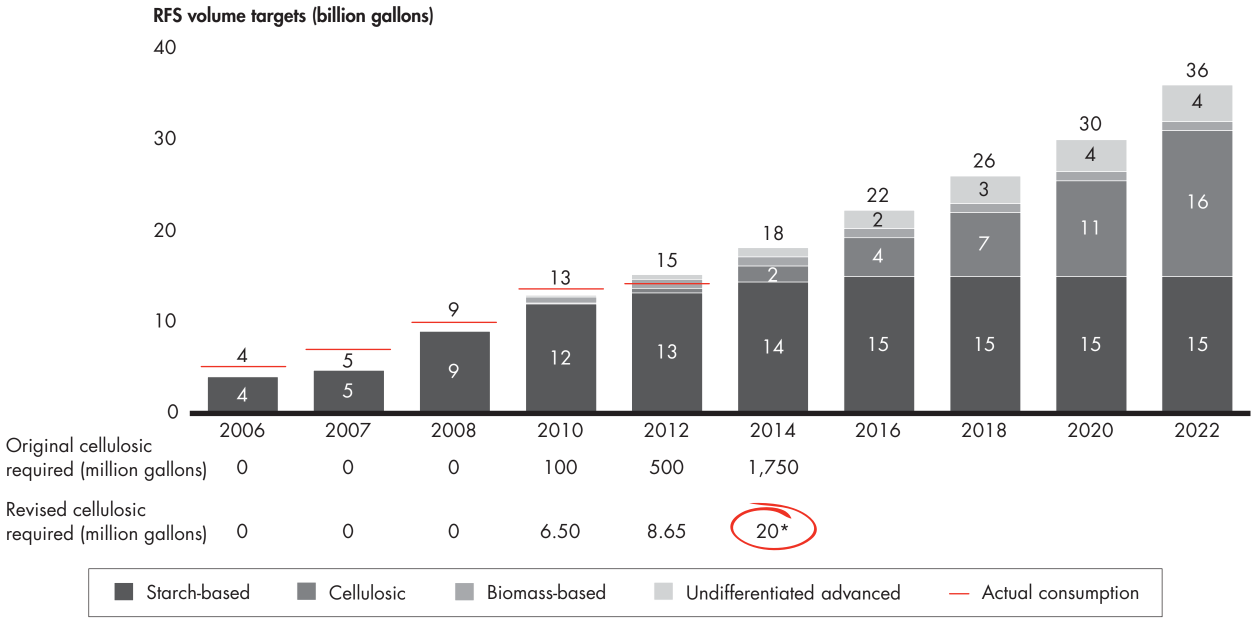
While the science and R&D around cellulosic ethanol has evolved dramatically since 2008 and production costs seem to have fallen, it is unclear whether this technology can supply enough biofuels in the short or medium term.

Finally, public support for biofuels has waned. The mandates grew out of a public belief that biofuels were good business and a way to keep the US competitive and green. Corn-based ethanol, however, has proven to be less environmentally friendly than other versions, and production costs are high. The food-for-fuel trade-off has pushed food prices up, raising concerns about global food security. For all of these reasons, general public support for biofuels has weakened and hurt demand.

Europe. Biodiesel, not ethanol, is the main biofuel consumed in Europe, due to a long tradition of diesel autos, especially in Germany and Scandinavia. As in the US, European policy makers saw biofuels as an important part of the energy mix in the early 2000s and set out to encourage growth. In 2003, the European Commission set a goal of reaching a 5.75% share of renewable energy in the transport sector by 2010. In 2009, a new directive aimed to reach a 10% mix of biofuels within all transport fuels by 2020 and reduce overall GHG emissions by 35%.

The EU's goals are similar to those of the US, but it takes a less directive and more decentralized approach, allowing member states to tailor their rules in ways that suit their domestic objectives and make the policies palatable. For example, the EU does not specify volume targets, but encourages use of sustainable biofuels that generate fewer GHG emissions without a negative impact on biodiversity or land use. Policies vary significantly from one country to another: Italy's biofuel blend targets are only 3.5%, for example, while in France, they are as high as 7%.

Figure 5: Target mandates for biofuel under the US's Renewable Fuel Standard (RFS)



* EPA proposal not yet legislated
Sources: US Department of Energy; EPA; USDA; Bain analysis

Europe lacks enough suitable farmland to meet the 10% mandate from the EC directive on its own, and locally producing biodiesel costs $344 more per cubic meter than buying diesel in the local market. Thus, Europe imports most of its biodiesel from the US, Argentina and Indonesia.

Still, consumption has slowed in Europe for at least three reasons. First, the economic slowdown tightened government budgets, and available funds went to other alternative energy technologies that were becoming cost competitive more quickly, like wind and solar. Private investment also shifted over to these more popular sources of renewable energy: From 2008 to 2012, investment in new biofuels projects fell by 29%, while investments in solar and wind increased by 24% and 4%, respectively. Since 2000, the EU has seen only 11 new biofuels projects, compared with 197 solar projects and 323 wind projects.

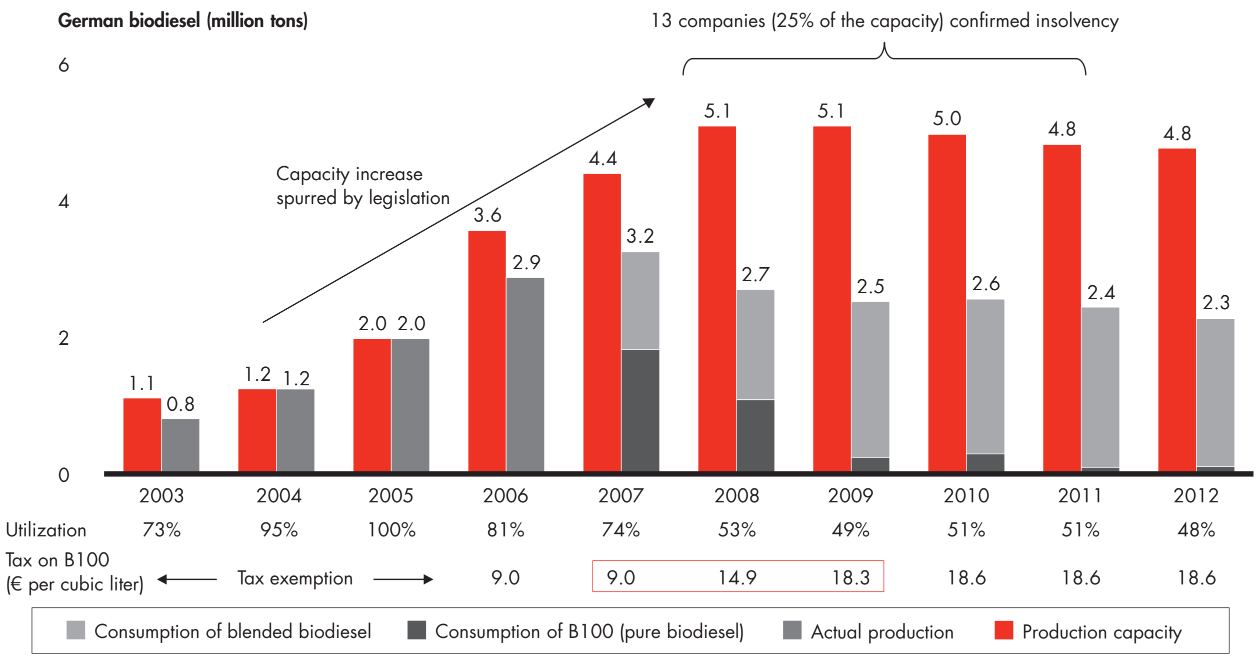
Second, the pace of new laws promoting the industry through mandates and incentives has slowed. Germany, for example, had offered a tax exemption along with its 6.25% blend target, to encourage production. By 2009, however, taxes on 100% biodiesel (B100) rose from €9 per cubic liter to €18.3 per cubic liter (closer to the taxes levied on diesel), squeezing demand for biodiesel, which is now consumed almost solely as a blend *(see Figure 6)*.

Third, policies supporting biofuels have come under pressure from groups concerned about the effects of fuel crops on food production, biodiversity, water, the land and GHG emissions. These interest groups have been pushing governments to move away from traditional biofuels (ethanol and biodiesel) and focus on advanced biofuels. As a result, the EC proposed setting a 5% cap on the use of first-generation biofuels in transport fuel and eliminating subsidies for production of biofuels based on food crops.

Two examples from emerging markets

Several smaller economies have also begun to promote biofuels over the past decade. Argentina and Indonesia now contribute about 20% of global biodiesel production,

Figure 6: Consumption and production capacity in Germany



Sources: Union for the Promotion of Oil and Protein Plants (UFOP); International Institute for Sustainable Development (IISD)

and Colombia and Thailand have grown from zero to about 6% of global biodiesel production combined. Other countries with large, fertile lands, such as those in Sub-Saharan Africa, are also developing programs to produce biodiesel.

To reduce market distortions while encouraging local production, the Colombian government implemented a combination of policies, including blend requirements (8% to 10%), tax credits for production and consumption, and special economic zones for biodiesel production[6]—all of which have been well received by investors and the private sector. However, the most interesting design lesson is the way it sets the price for biodiesel.

The Colombian government established a price stabilization fund that secures the financial sustainability of local producers by guaranteeing that they could sell biodiesel at a profit. The price is set to be the higher of two costs: the cost of locally producing crude palm oil (CPO) or its substitutes, or importing them from the international market at the benchmark international price (CPO Rotterdam). Thus, biodiesel has a higher price than local diesel. While biodiesel in Colombia is relatively expensive, the system guarantees stable local production and is set up so consumers pay most of the costs, rather than government subsidies. In order to minimize significant increases in diesel prices at the pump, biodiesel blending into diesel was capped at 8%, resulting in a 5-cents-per-liter increase in the price of diesel. Consumers appear to have adjusted to this increase, but if the government raises the blending requirement, costs to consumers would rise to unsustainable levels.

In Thailand, consumption of ethanol and biodiesel has also increased rapidly over the past decade. The government's 10-year (2012 to 2021) Alternative Energy Development Plan aims to increase consumption of biofuels to 3.3 billion liters per year by 2021, while easing ethanol laws and regulations and improving farmers' productivity.

It may be too early to assess the success of biofuels initiatives in Colombia and Thailand, but in both countries, the early signs are positive.

What have we learned?

The global biofuels industry experienced rapid growth over the past decade, but the slowdown over the last three years raises concerns. In Brazil, changes in government support have pushed some producers to the point of bankruptcy, constraining investment in future growth. In the US and Europe, the combination of an economic slowdown and the lack of commercially viable second-generation technologies at scale raises doubts about the industry's ability to meet ambitious advanced biofuels and GHG reduction targets without imposing too heavy a burden on consumers or food supply.

What lessons from the last 10 years of biofuels boom and bust can inform decisions that may help the industry grow? We see five critical lessons for governments, the private sector and other interested parties.

1. Biofuels still need government support. Biofuels are still more expensive than fossil fuels, so government support for the industry remains necessary across markets—though each region may take a slightly different approach to combining tax subsidies, investment incentives, and volume or blend mandates. Even in Brazil, which produces the most efficient first-generation ethanol, the industry suffered when the government pulled back tax credits. Today, ethanol is competitive with gasoline at the pump only in the state of São Paulo, where production costs and taxes are lowest.

Governments could, however, improve the ways they support biofuels. Many have been overly ambitious, and they could do more through smaller and more focused programs. Focusing subsidized investment in specific areas of the transport sector—for example, making city buses, car fleets and taxis run on biofuels—could do more than taking on the entire economy.

2. Mandates work better than subsidies alone. In the US, for example, the Renewable Fuel Standard revolutionized government involvement in the industry in the mid- to late 2000s. The EU followed with directives on blend targets. Based on their success, most countries today use mandates in one form or another, based on volumes or blends, to encourage industry growth.

In some cases, however, mandates may be unnecessary or even lead to market distortions. Thailand was able to boost production and consumption without mandates. Governments should carefully weigh the costs and benefits of policy options before implementing them to promote sector growth.

3. Consider policy impacts on market dynamics. Some policies intended to boost biofuels growth have led to unintended negative consequences on international markets, such as the EU's biofuels promotion policies that failed to consider the impact on trade markets. A loophole allowed producers to import large volumes of biodiesel, mix it with low volumes of domestically produced biodiesel and still have the mixture considered European enough to be eligible for subsidies. That created a large biodiesel trade market, in which Argentina and Indonesia played their cost advantages to export to Europe. The EU has closed this loophole only recently by introducing a punitive tariff on imports from Argentina and Indonesia, and Argentina has filed a trade dispute before the World Trade Organization.

The fundamentals of competition, cost and scalability will determine whether the biofuels industry can compete when subsidies disappear.

Governments need to consider the potential effects of policy changes on overall market dynamics, otherwise they can create distortions that are difficult to resolve. To avoid these problems, they should examine the international trade implications of any policy, taking into consideration the complex and interwoven links within the market.

4. Policy stability is paramount. Because the biofuels industry is extremely sensitive to policy changes, stability may be more important to growth than the actual choice of instruments. In Germany, for example, the removal of tax subsidies created excess production capacity and pushed some producers into insolvency. In the US many private sector producers are hesitant to invest in commercializing and scaling cellulosic biofuels without assurance that the government is going to stick with its advanced biofuels targets leading up to and after 2022. In Colombia, the government guarantees local producers a fair chance to compete by stabilizing the biodiesel price in the local market. Creating stability creates markets.

5. Second-generation biofuels will continue to face challenges. Because first-generation biofuels may never be competitive, even in Brazil, public and private R&D has shifted to second-generation biofuels from nonfood feedstocks. Unfortunately, second-generation biofuels are not developing as fast as expected. While the technology may already exist—companies are very secretive about their state of development—none of the key markets of Brazil, the US or Europe have scaled advanced biofuels production (and more specifically, cellulosic ethanol production) to anywhere near target levels. Second-generation biofuels will not, in theory, compete with consumers for food stock, but they will continue to face many of the same challenges as first-generation biofuels, including access to land, rising labor costs and logistics difficulties.

Biofuels will face these challenges until third-generation technologies (such as oil production from algae) reach scale—which could be decades away. The commercial sustainability of advanced biofuels is still a long way off, and continued government support will be necessary for industry growth.

Despite the waves of policy to encourage growth, biofuels is still a business like any other. The fundamentals of competition, costs and scalability will determine whether the biofuels industry and its participants can compete against other transport fuels when subsidies disappear. To survive over the long term, the industry will need to stand on its own.

Whether it is liberating trade markets to allow the most cost-efficient traditional biofuels producers to compete and win market share, or investing to scale second- and third-generation technologies, industry players should build their businesses in ways that will allow them to win, with governments participating only enough to ensure they have a fair chance to do so.

1. The Brazilian Economic and Social Development Bank (BNDES), also known as the Brazilian Development Bank, is a state-owned public company associated with Brazil's Ministry of Development, Industry and Foreign Trade.
2. Aurelie Mejean and Chris Hope, "Modeling the Costs of Energy Crops: A Case Study of US Corn and Brazilian Sugarcane," *Energy Policy 38* (2010): 547–561.
3. MTBE is methyl tert-butyl ether, a gasoline additive used as an oxygenate to raise the octane number.
4. ETBE is ethyl tert-butyl ether, an oxygenate gasoline additive made from ethanol. ETBE offers equal or greater air quality benefits as ethanol, while being technically and logistically less challenging.
5. Kevin Bullis, "The Cellulosic Ethanol Industry Faces Big Challenges," *MIT Technology Review*, August 12, 2013, http://www.technologyreview.com/news/517816/the-cellulosic-ethanol-industry-faces-big-challenges/.
6. Helena Garcia Romero and Laura Calderón Etter, "Evaluación de la política de Biocombustibles en Colombia," Fedesarollo, October 2012, http://www.fedesarrollo.org.co/wp-content/uploads/2011/08/Evaluaci%C3%B3n-de-la-pol%C3%ADtica-de-Biocombustibles-en-Colombia.pdf

Shared Ambition, True Results

Bain & Company is the management consulting firm that the world's business leaders come to when they want results.

Bain advises clients on strategy, operations, technology, organization, private equity and mergers and acquisitions. We develop practical, customized insights that clients act on and transfer skills that make change stick. Founded in 1973, Bain has 50 offices in 32 countries, and our deep expertise and client roster cross every industry and economic sector. Our clients have outperformed the stock market 4 to 1.

What sets us apart

We believe a consulting firm should be more than an adviser. So we put ourselves in our clients' shoes, selling outcomes, not projects. We align our incentives with our clients' by linking our fees to their results and collaborate to unlock the full potential of their business. Our Results Delivery® process builds our clients' capabilities, and our True North values mean we do the right thing for our clients, people and communities—always.

Key contacts in Bain's Oil & Gas practice:

Americas: **Fernando Martins** in São Paulo *(fernando.martins@bain.com)*

Europe, Middle East and Africa: **Juan Carlos Gay** in London *(juancarlos.gay@bain.com)*

For more information, visit www.bain.com