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The future of second-generation biomass

To make bioconversion commercially competitive, the industry needs swift advances.

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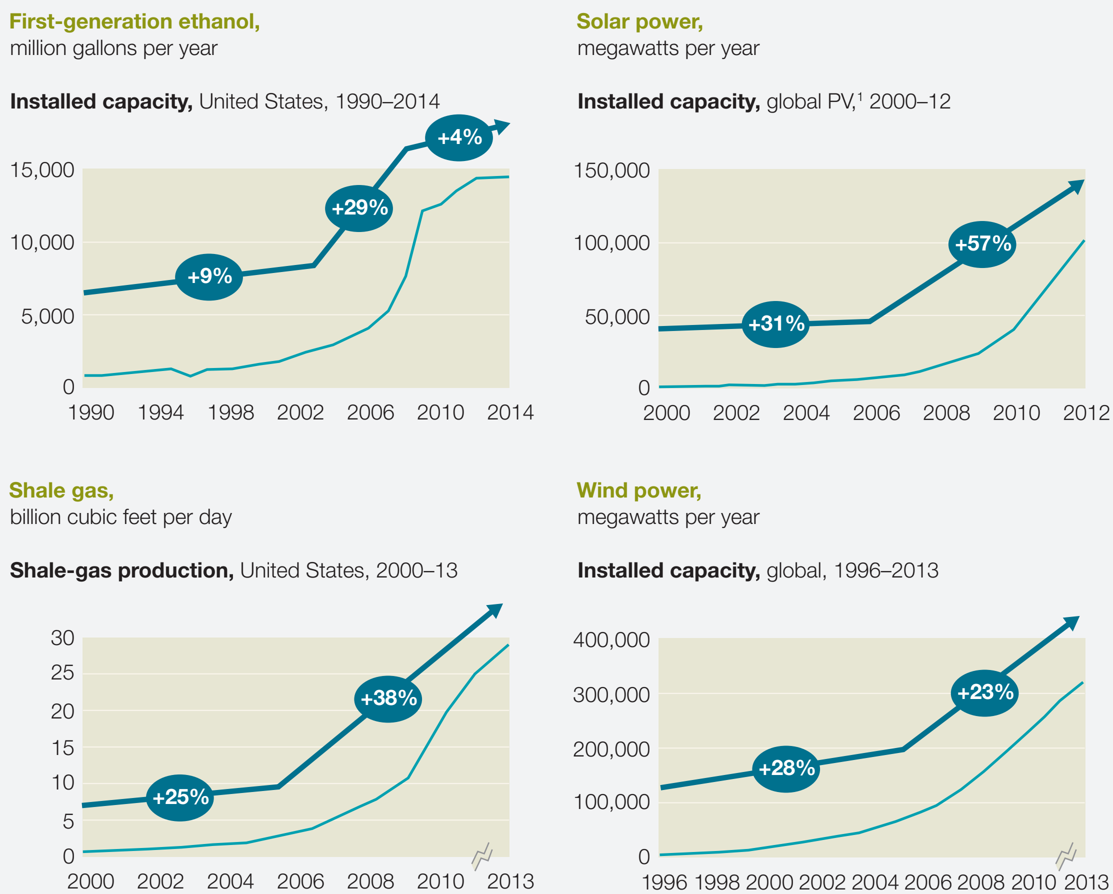
The promise of the second-generation (2G) bioconversion industry is that it will transform cellulose-based, nonedible biomass and agricultural waste into clean and affordable high-value fuels or chemicals. (The first-generation, or 1G, technology converts edible biomass.) In this way, 2G could offer an alternative source both of energy and of chemical-industry inputs, which other renewable technologies cannot provide.

That is 2G's potential, but the industry failed to deliver on this promise for almost a decade. However, there has been progress in recent years. Since the inauguration of the first commercial-scale 2G plant, in 2013, eight more have opened around the world, of which some, not surprisingly, are failing, while others are progressing. Most are in North America, two are in Brazil, and one is in Europe—all markets with mature 1G biomass industries and governments that support cellulosic ethanol.

Second-generation projects have also begun attracting interest in China, India, Indonesia, and Malaysia in the form of government initiatives to coordinate action and to facilitate the establishment of a 2G ethanol market. As these trends suggest, the technology could be approaching the acceleration phase that marked the development trajectory of other industries, such as wind power, solar energy, and shale gas. In each case, growth was modest at first and then took off (exhibit).

Drawing on more than 100 interviews with executives and experts and on our work with key industry players, we have identified seven critical enablers in three challenging areas—resources, Exhibit

A new industry can take more than 15 years to reach a sizable commercial scale.



[1]Photovoltaic.

Source: Industry reports; US Renewable Fuels Association: annual capacities after 1999 and sustainable responsible impact from 1990; McKinsey analysis

management, and the market—that the 2G industry must address to ensure continued progress.

Resources

Every business needs money, inputs, and processes that work. The second-generation biofuels industry faces challenges on each count—but these can all be addressed.

Reliable, commercial-scale conversion technology

Commercial 2G plants must demonstrate that they can deliver high-yield products at a competitive price, but conversion technology is taking longer than hoped to reach the necessary scale. One problem is that these plants must process the equivalent of up to 400 truckloads[1] of biomass a day. The semisolid nature of (wet) biomass, which is often mixed with dirt and other impurities, complicates the processing. Biomass must be mechanically pretreated—for example, by extrusion, milling, or grinding—and fed continuously in preparation for hydrolysis.

What's next. The design, reliability, and processes of 2G equipment are all improving. Meanwhile, engineering is rightsizing specifications, increasing levels of process automation, and eliminating costly process aids. The race is on to become the first player to operate a stable, cost-competitive commercial-scale plant. For front-running facilities, the question is not whether their processes work but rather the strength of their operational performance—uptime, throughput, yield, and cost—and how quickly they will cut costs while improving their operations.

Access to affordable feedstock

Second-generation feedstock is abundant, but prices on the biomass cost curve vary. Some forms of feedstock, such as municipal solid waste or cellulosic trimmings from harvests, can be sourced at little or no expense. Other kinds, such as sugarcane residues (known as "bagasse"), have an opportunity cost.

There are also outlays associated with collection and transport, so it is helpful to locate 2G plants near dependable, long-term sources of biomass. The cost of sourcing (the price asked by the producer, plus aggregation and logistics) is another key factor in 2G economics. Like oil, which can cost as little as a handful of dollars to produce but often several times more, biofeedstock should be seen in the light of a cost curve: some supplies will be cheap, others expensive.

What's next. Bagasse, available mostly in Brazil, China, India, and Thailand, is one of the cheapest sources of biomass: as a by-product of sugarcane processing, it is already aggregated at production plants and often burned to produce electricity. But 2G can be an alternative to drive value. American corn leaves and stalks cost about twice as much as bagasse, in part because this "stover" (as it is called) must be collected. Investors should seek long-term agreements to ensure security of supply in areas where the cost of sourcing is lowest.

Capital

At the moment, 2G does not fit the usual risk profile for investors. Those that are willing to take risks, such as venture-capital funds, tend to see 2G as too capital intensive. Investors with abundant capital but less appetite for risk, such as pension funds, view it as too uncertain. Mainstream investors, believing that they have more attractive and less risky alternatives, have resisted 2G investments. Development to date has been driven largely by entrepreneurs, such as the Ghisolfi family of Italy and Bernardo Gradin (with Brazil's GranBio), and by forward-looking companies that want to develop new markets for biorefineries or to find new carbon routes for chemicals. These 2G developments have often received public-sector investment backing, particularly in Brazil and the United States.

What's next. At feedstock costs of $30 to $50 a ton and validated levels of technology performance, 2G production economics can compete on cost with 1G bioethanol and certain more expensive oil sources,[2] particularly at locations where 2G operations can piggyback on existing 1G infrastructure, such as sugarcane bagasse feedstock or corn stover at 1G plants that already process sugarcane and corn, respectively. On a marginal-cost basis, 2G is already structurally more attractive than 1G because its running costs[3] are lower.

However, there are two important risks: feedstock security (which can be addressed through forward contracts) and technology. Building new commercial-scale plants will encourage simplification and standardization, while also leading to scale efficiencies that reduce capital expenditures. As with the development of wind farms, leading players should eventually be able to offer investors turnkey operations. Government support could improve the business case substantially for some 2G plants, and there are precedents for this: Germany helped build initial capacity for solar power, as the United States did for the 1G industry.

Management

The biofuels industry is not all that young; it is time for it to improve the way it is managed, in several ways.

Capabilities for industrialization

Small companies have been at the industry's forefront over the past decade, but they lack the capabilities, infrastructure, and capital for industrial-scale 2G. Attracted by its potential, bigger firms began to get involved, but some have left in recent years for strategic reasons. There's a case that firms should collaborate to maximize their chances of success, but a handful of players will probably take the lead to create competitive technical solutions. The challenge will then be significant because although these companies could own a viable technical solution within a piece of the value chain, they may lack the competencies, people, infrastructure, and capital to scale up a worldwide industry deploying 50 to 100 projects a year. New types of players will have to engage.

What's next. To build the industry, big players, such as contractors or downstream specialists, should create partnerships or acquire firms with specialized value-chain expertise to scale up project deployments. For an analogy, consider how the oil industry creates complex, project-centered value chains in its exploration and extraction projects.

Value-chain integration

Critical gaps persist in the industry's value chain—whose players now have fragmented capabilities—so that each 2G capital project gets a unique, inefficient, and expensive solution. Furthermore, the downstream distribution network is not yet geared for takeoff, because of technological and logistical barriers. Distribution pumps at fuel retailers, for example, are not equipped for flexible blending.

What's next. To establish a bankable turnkey solution, leading players should create and coordinate teams comprising feedstock suppliers, government agencies, technology owners, and investors. By collaborating, these partners can structure complex 2G projects from beginning to end and collectively assemble all the capabilities needed to complete them.

One such project is in the works in the Malaysian province of Sarawak. A consortium of local companies, international partners, and the government plans to invest in a new biomass hub, and a 2G plant is scheduled to open in coming years—the first in Southeast Asia. The Hock Lee Group, based in Malaysia, will grant access to the biomass and operates a local network of petrol stations. Biochemtex (based in Italy) will provide expertise in running large capital-investment projects; its subsidiary, Beta Renewables, will contribute conversion know-how. Another firm will offer enzyme technology. The hope is that by using by-products from the area's palm-oil plantations and other feedstock, these efforts will create new, high-value industries in the region.

Market

The major issues here have to do with getting some breathing space while the market matures.

Demand

In the medium term, as installed 2G capacities increase, producers of 2G biofuels or biochemicals may not find buyers for all their output. In the short term, if oil prices stay low, 2G will have difficulty competing on price; that, in turn, affects the industry's long-term prospects by discouraging sustained commitment. It's also important to remember that competing renewable-energy paths to ethanol, such as gasification, are being developed.

What's next. One possibility is that 2G biofuels could move down the cost curve and eventually compete with fossil fuels on price at the gas station. Other emerging industries have overcome similar cost disadvantages; for example, Germany instituted public policies to give consumers incentives to adopt solar power.

One area of significant potential 2G demand that isn't fuel related would be providing building-block inputs for both bulk and higher-value chemicals, such as butadiene, butanol, and lactic acid. Global chemical companies investing in the sector hope to create opportunities for biorefineries that could produce an array of biobased chemicals providing diversification to adapt at the changing price points that the spot market would offer.

This is already happening with 1G technologies: BioAmber and Mitsui, for example, have invested in a 30,000-ton-a-year Ontario plant to produce succinic acid through bioroutes. Many companies are becoming serious about making their products and processes sustainable and renewable. Initiatives to source plastic more sustainably in the consumer industry, for example, have created an uptick in demand on the biobased-chemical side.

Stable and supportive regulation

Government support—blending mandates and outlays on industry R&D,[4] especially in the United States—has started to create a market for 2G products. But progress has been halting. In part, this is a result of the sluggish buildup of 2G biofuels production; the US Energy Policy Act, in 2005, created mandates, but the industry failed to deliver. No government has taken a bold position promoting 2G fuels or biomass conversion. While the United States has created mandates in the form of Renewable Fuel Standards, these are not binding on ethanol blenders.

What's next. Without stable regulatory support, investors do not see a prospect of strong medium-term demand. That discourages them from committing funds, and without such investments 2G will be hard pressed to scale up. Industry players need to speak with a clear and united voice to explain why public support would be worthwhile.

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Given the need for energy and chemicals that are not derived from fossil fuels, as well as the benefits of renewables—reducing pollution and diversifying domestic energy sources—there's a case for developing 2G bioconversion into a full-fledged industry.

How big a piece of the renewables pie is 2G likely to capture? This will depend on two things: the speed of adoption and whether 2G can address the seven enablers discussed above and improve relative to alternative fuels. The future is unknown. What is clear, however, is that even after the problems of the past decade, the 2G industry now has an opportunity to industrialize its technology—and thus to improve its chances of success. ■

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1 This estimate is based on a second-generation (2G) plant with a nominal 2,000-ton biomass-processing capacity. In the United States, a standard round bale of stover weighs about 600 kilograms (1,322 pounds). Thus, 8 bales fit on a standard five-ton flatbed truck or up to 36 bales on a trailer—90 to 400 truck movements a day, depending on the size of the vehicle.

2 This estimate is based on McKinsey modeling and best estimates for respective conversion costs by input parameter and the estimated evolution of input-factor costs.

3 Running costs refer to the cost per gallon once an investment is made. Depreciation, for example, is not included.

4 A blending mandate defines the required share of first- and second-generation bioethanol in a fuel.

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