Sweetening Brazil's economy

Fernando Reinach's research & funding expertise strengthen Brazil's sugarcane ethanol & agricultural markets

Fernando de Castro Reinach, research scientist, professor, and entrepreneur, has spearheaded the genome sequencing of bacteria affecting important Brazilian crops and launched some of Brazil's main biotech companies. With expertise in sugarcane and ethanol production, he has also become an important international spokesperson for bioenergy.

Compare the state of Brazilian bioenergy with that of the US.

The major difference between Brazil and the US is a geography issue. Brazil is in the tropics, and with the amount of sun and water we have access to, the amount of biomass we can produce per hectare will always be larger than the amount a country not in the tropics will be able to produce. We have a growing season that spans all months of the year.

Another issue is subsidies. Sugarcane and ethanol production have not been subsidized in Brazil since the early 80s. The cost of producing ethanol in the United States is already higher than in Brazil, and this doesn't incorporate subsidies: if agricultural subsidies are added to the cost, it becomes even higher. Today, the volume of ethanol produced in each country is similar.

Another difference is the maturity of the technology used. The genetics of sugarcane is still in its infancy; as a field of study, it's just beginning, and we are just starting to play with genetic modification of sugarcane to produce more biomass. Corn, the main ethanol source in the US, has been researched and developed for more than a century. Therefore gains in biomass productivity with corn in the foreseeable future will be smaller than with sugarcane.

Yet another difference relates to the process of collecting the biomass. Corn stover remains in the field after the crop is harvested, so there is an extra cost to collect and transport it for ethanol production. Sugarcane bagasse is a by-product of sugar, therefore the cellulosic biomass is already at the mill. (For non-corn biomass, switchgrass, and forest residue, the logistics and cost of gathering and transporting biomass will also have to be considered.) Beyond that, Brazil by now has amassed a long history of expertise in bioenergy; since the 1970s, we've been running cars on ethanol, and this is just starting in the US.

With your significant experience in both the science and funding sides of industrial biotechnology, what are your predictions for the growth of the international bioeconomy?

The bioeconomy will definitely evolve and grow. The questions are, at what pace, where (in terms of geography) and which will be the key products that will drive this evolution. Right now, it looks like fuels are the most important product that will move the bio-based economy into center stage. Later, there will be other products. The exact path will depend a lot on what investments are made into technology and where the markets will develop. I think the US is very well positioned, having a lot of capital from venture funds, private equity firms, and big companies who support this transition. Brazil has its advantages in terms of geography and bulk production capacity, but is disadvantaged in terms of developing new technology.

The first major wave we are now seeing in industrial biotechnology is ethanol and oils. Then we'll see plastics and other products than can be produced from ethanol penetrating the marketplace; so there will be an upward integration in the ethanol chain of synthesis. The third wave, which has already started in the US, will be the production of other small molecules that can be used by the chemical industry. These molecules in the future will be produced in plants.

For example, polyethylene can be produced from ethanol, and if the cost of ethanol is low enough, bio-based polyethylene will compete with polyethylene made from petroleum—but this will depend on both the cost of ethanol and of oil. The cost of these two products will determine how much of traditional chemical synthesis will be replaced by plant-based synthesis. As for that time frame, these new waves may take 5 to10 years to have a significant market share.

Has Brazil's acceptance of bioethanol, then, translated into consumer support for this second wave—creating, for example, a market for bioplastics?

Brazilians have a lot of knowledge about ethanol and how it has been successful in Brazil. But there is little understanding that there will be a new wave of green plastics and renewable materials. The general population is not well informed about these developments. There are lots of plastics and chemical companies that are looking into the possibility of producing plastics in Brazil, using Brazil-made ethanol. But the situation in Brazil is similar to the situation in other countries: there is a perceived risk in the costs of changing to bio-based platforms.

Production facilities that work with fossil fuels will primarily be driven by future prices of oil, and it is not yet clear how the oil market will evolve. Most people believe that ethanol will get cheaper as time goes by and that in the long term, oil will be more expensive. But the question for investors remains: What exactly will those costs be in 10 to 15 years? $55 a barrel? $110? This is a crucial issue, because of the huge capital expenditures required to shift to bio-based production. Companies obviously don't want to invest into bio-based production if oil prices will drop significantly in the future.

What technical challenges to bioethanol production is Brazil focusing on?

We've been investing into "regular" breeding of sugarcane and in the biotechnology of sugarcane. Corn has been bred for decades to produce more grain—not more leaves or stalks. Until very recently, the best corn plant was thought to contain a huge amount of grain with as little as possible biomass (leaves, stalk); the only part used by industry was the grain. In the case of sugarcane, it has been bred to be very juicy, to have a lot of soluble sugars. Now the idea is to breed sugarcane for biomass (so-called fibercane)—to increase cellulose content without decreasing sugar content. This was never attempted before, because the greater the cellulose content, the more difficult it is to grind and crush the plant. We know that with new technologies that are being developed, we will be able to harness cellulose for ethanol production. We are therefore breeding sugarcane with an eye to increasing sucrose content, for use in regular sugar mills, but also for future cellulosic ethanol production.

We are also trying to breed sugarcane to grow in different environments within Brazil (for example, increasing drought- and disease-resistance). Nowadays, sugarcane can only grow in certain regions, which collectively represent only a small part of the agricultural land in Brazil. With new varieties of sugarcane, vast areas of new agricultural frontiers in Brazil that are now unused could be used to increase Brazil's ethanol production. The potential for expansion is very large.

What challenges do other regions face?

In the US, tariffs on imported ethanol are limiting the adoption of the technology and could harm the future adoption of new technologies. If corn-based ethanol production expands much further, that will affect the availability of corn for other uses, and corn prices would rise.

If the US were to drop or reduce tariffs on imported ethanol (which, I realize, would also be good for countries like Brazil that export ethanol), that would allow ethanol to compete with oil under more equal conditions, since the importation of oil is tariff-free into the US. In this way, it would boost the US bioeconomy and encourage the substitution of ethanol for some of US oil consumption. Since oil is such an important energy source, facilitated ethanol imports should increase energy security in the US. The reduction or elimination of ethanol import tariffs would probably be a smart decision for the US—probably not right now, because it is still building its internal ethanol production capacity, but rather, in a few years.

As for the cellulosic ethanol initiatives in the US, I foresee a potential problem, given the growth curve of corn ethanol. Most of us in the industry can see switchgrass and other cellulosic biomass being used for ethanol in the future. But if the demand for ethanol expands at a faster rate than that for new technologies to be deployed, the whole bioenergy program could come to halt, due to a strangulation of supply.

Ideally the US should grow its ethanol production smoothly, without a disruption due to limited corn supplies before cellulosic ethanol is developed. Otherwise you could have a grow-stop, grow-stop cycle: corn ethanol markets would grow until corn becomes too expensive, without having sufficient technological capacity to produce enough cellulosic ethanol to allow for a smooth transition between the two. Such hiccups are bad for the growth of the bioenergy economy. Difficult strategic decisions, such as how much to open markets, must therefore be considered.

Other countries face different challenges. Briefly, although China has a lot of land, it doesn't have enough water. It also faces huge challenges in terms of food production, so it's unlikely to be able to supply a lot of biomass for ethanol. But it will be a good market for Brazilian and other exported ethanol.

Africa faces the problem of having certain countries without the infrastructure to establish a large industrial sector, and as yet a lack of sufficient organization to effectively gather biomass for ethanol production. Huge plantations are needed to produce biofuels, and Africa does face significant political and general industrial development challenges. So a major challenge for Africa is an organizational one: for African society to organize itself to play a big role in the global ethanol market.

Also, while difficult to generalize, because Africa includes so many countries, availability of capital seems to be a potential problem. If an African country can build the right environment in which people can invest, then money will flow, from US, from Europe—so that the capital expenses of building biorefineries needn't come entirely from the African countries themselves. This is actually a challenge for all underdeveloped countries: how to protect sources of domestic revenues and how to manage the difficulties of building a good environment for capital inflow.

India, although it produces lots of sugarcane and has a huge potential for producing ethanol, has its agricultural industry organized into very small farms, with hundreds of small producers supplying sugarcane to single mills. It might then be very difficult to reduce costs, given the sheer scale of operations, for India to be competitive in world ethanol markets.

But there is lots of potential, especially in Africa and regions in the Pacific. In terms of effectively usable land area, water, and sun availability, I believe it will be difficult for many countries to compete with Brazil. On the other hand, Brazil does want other countries to produce ethanol at export-scale. Once ethanol becomes a global commodity, it will be important to have many producers, so that buyers don't feel dependent on one particular region for supply.

The future of the bioeconomy will depend on regions where there is a lot of sun for biomass production—the tropics. So the bioeconomy will be good for poorer countries, for achieving equality, and that's an attractive

Curriculum vitae
Fernando de Castro Reinach

Fernando Reinach has a long and established career in both science research (plant and medical) and entrepreneurship. He is a general partner of Votorantim Ventures, a venture capital fund of the Votorantim Group, one of Brazil's largest private conglomerates (with revenues of US$8 billion), as well as CEO of Brazilian genomics company, Alellyx. Reinach organized and was a coordinator of the Brazilian Genome project, an initiative by a number of institutions aimed at sequencing the genomes of *Xylella fastidiosa* and *Xanthomonas citri* bacteria.

Achievements

- Top 0.1% biomedical researchers in Latin America, Top 2.5% biomedical researchers worldwide, 1981-1999 (Science Citation Index)
- (2003) Co-founded CanaVialis, world's largest breeder of sugarcane, which focuses on the breeding of sugarcane for new growing regions and with higher productivity.
- (2002) Co-founded Alellyx, now the largest sugarcane and eucalyptus biotech company; focuses on genetics and molecular biology of sugarcane, eucalyptus, and citrus.
- (2000) Published full sequence of *Xylella fastidiosa* (citrus pest bacterium)
- (1999) Co-founded .comDominio data center and Internet hosting service
- (1991) Becomes youngest full professor at University of São Paolo
- (1990) Co-founded Genomic Engenharia Molecular, one of the first Brazilian companies to perform DNA and paternity tests (now one of the country's largest such testing companies)

Degrees and honors

- 1984 PhD, Cornell University Medical College; awarded "Best thesis"
- 1984–1986 Postdoctoral fellow with Ludwig Institute for Cancer Research, Medical Research Council Center, Cambridge, UK
- 1990–1997 Biotechnology research fellow, Rockefeller Foundation
- 1997–2003 Research scholar, Howard Hughes Medical Institute
- 1997 Member, Brazilian Academy of Sciences
- 1999 Secretary of Science, Federal Government of Brazil
- 1999 President CTNBio (Technical Commission on Biosafety)
- 2002 National Order of Scientific Merit

potential for future development. When you look at previous waves of development, almost none is constrained by geographic factors, in terms of being region-dependent in global geography, but the biobased economy is very much geography-dependent (although technical developments, such as genetic engineering, can be used to develop plant varieties that can partially meet these challenges). Companies like Intel or other chipmakers, for example, will simply go where the best engineers are, where production costs are low, and where materials are cheap. They don't care if it's sunny, cloudy, if there's not enough irrigation-water supply. But now there is a sector of the economy where basic geographical factors become very important; so it has to be taken into consideration where one is going to deploy investments. This is a new reality from which countries can benefit a lot, if they're smart.

Describe the role of the Brazilian government in establishing the country's ethanol industry.

In the 1970s, we had an energy program somewhat similar to what the US is doing today. We had subsidies for ethanol production, as well as mandatory production of and subsidies for ethanol cars. By the 1980s, there were both ethanol and gasoline cars; this was before flex fuel technology was developed and adopted in Brazil. And gasoline stations were mandated to distribute both 100% ethanol and gasoline. With the introduction of flex fuel cars, the deployment of ethanol will be simpler. In theory, the distributors can mix a percentage of ethanol with gasoline, meaning that storage tanks at gas stations need not be doubled. This should make it easier for the US to adopt ethanol. In Brazil, we had to duplicate all the infrastructure.

Brazil has now captured a large share of global exports of ethanol. The problem for us is that internal consumption is growing very fast, and therefore part of the future growth will be taken by our internal markets. So the dilemma is how to supply the global market without sacrificing the internal market. Our share of the world market will depend on the speed with which Brazil can increase its production. For that we will need, on one hand, an expansion of the number of mills, and on the other hand, new technologies. That is why we have invested in the development of fibercane: a high-sugar, high-cellulose sugarcane variety.

Today there is a lot of foreign interest in Brazilian ethanol—from investors who want to produce ethanol in Brazil, those interested in acquiring existing facilities, or funding "green field" projects. There are also a lot of opportunities in developing new ethanol production technologies. And since bagasse is probably the cheapest biomass available in large-scale volumes, Brazil stands to be the best place to develop cellulosic ethanol. We have seen a lot of interest in developing such projects in Brazil and perhaps moving some of these projects into the US at some point in the future.

How do you see emerging industrial biotechnologies affecting ethanol production?

Cellulosic ethanol will be the most important development—using those sugars that are still largely trapped within cellulose. One major challenge will be the production of cellulose-degrading enzymes within the plant itself, but that's a long way off. In the short term, enzymes produced by microorganisms will still be important. Probably the large enzyme companies, like Novozymes and Genencor, will play a dominant role. There are many start-up and small companies that lag behind the larger enzyme producers, but they have a promising future, especially those companies that are working on discovery of new cellulases from different environments. The companies that will be able to engineer novel enzymes back into plants will be making a very significant contribution. Again, there will be many waves of biotechnology in the industrial sphere.