GLOBAL PRODUCTION OF SECOND GENERATION BIOFUELS: *TRENDS AND INFLUENCES*

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Executive Summary

For more than a century, fossil fuels have been the primary source of a wide array of products including fuels, lubricants, chemicals, waxes, pharmaceuticals and asphalt. In recent decades, questions about the impacts of fossil fuel reliance have led to research into alternative feedstocks for the sustainable production of those products, and liquid fuels in particular. A key objective has been to use feedstocks from renewable sources to produce biofuels that can be blended with petroleum-based fuels, combusted in existing internal combustion or flexible fuel engines, and distributed through existing infrastructure. Given that electricity can power short-distance vehicle travel, particular attention has been directed toward bio-derived jet fuel and fuels used in long distance transport.

This report summarizes the growth of second-generation biofuel facilities since Dovetail's 2009 report[1] and some of the policies that drive that growth. It also briefly discusses biofuel mandates and second-generation biorefinery development in various world regions.

Second generation biorefineries are operating in all regions of the world (Figure 1), bringing far more favorable energy balances to biofuels production than have been previously realized. Substantial displacement of a significant portion of fossil-based liquid fuels has been demonstrated to be a realistic possibility. However, in the face of low petroleum prices, continuing policy support and investment in research and development will be needed to allow biofuels to reach their full potential.

Introduction

Serious modern-day efforts to displace use of gasoline with biofuels in the United States began following the oil embargo of 1973. The Energy Tax Act of 1978 created tax credits for producers of ethanol, initiating a series of federal actions to incentivize ethanol production that have continued to the present. Goals were twofold: to make the U.S. less vulnerable to fossil fuel supply disruptions, and to help American farmers combat low corn prices. The Renewable Fuel Standard (RFS), which established benchmarks for volumes of renewable fuel production, was established under the Energy Policy Act of 2005. The Energy Independence and Security Act of 2007 further increased RFS program targets, establishing a 36 billion gallon (136 billion liter) target for total biofuels by 2022, a quantity sufficient to displace 16-17% of U.S. crude oil in that year.[2]

In 2015, the U.S. produced an estimated 14.7 billion gallons (56 billion liters) of ethanol, and 1.3 billion gallons (4.8 billion liters) of biodiesel. Ethanol production alone was equivalent to 527 million barrels of crude oil, or 31% of U.S. crude oil imports. Ethanol production was estimated to impact 40 percent of U.S. corn production and to account for 26% of U.S. harvested cropland.

Even as the biofuels program was being established, it was recognized that the energy balance in corn-based ethanol production was quite modest, yielding only a 28% gain in delivered energy relative to fossil energy input. Consequently, a key aspect of biofuels development has involved support for research aimed at development of high energy balance second generation fuels.

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[1] *Biofuels/Biorefinery Development Report Card*, available at:

[2] USDA Economic Research Service (2010)

First generation biofuels helped to demonstrate the potential for large-scale production, distribution, and use of plant-based fuels. However, in view of the fact that such fuels were and continue to be made from corn and soybeans, first generation processes have also raised a number of concerns regarding land use choices, food vs. fuel issues, and environmental impacts of vast-scale corn and soybean production.

Raw materials for second generation lignocellulosic biofuel production are quite different, and in the case of ethanol include corn stalks rather than corn itself, wood, and a range of non-food biomass. Production processes can also yield a wider range of useful end products.

Second-generation biofuels began to be produced at full commercial scale in 2015. Currently, 67 second-generation biofuel facilities operate around the world (Figure 1), with over one-third of these operating at commercial scale. As of 2015, 35% of the commercial installed capacity for production of second generation ethanol worldwide was located in the U.S.

Figure 1
Global Biorefineries

Legend:
Blue markers display operational biorefineries.
Yellow markers display biorefineries in development.
Red markers display biorefinery developments that have been suspended.

Map produced by Dovetail Partners. For the full scale, interactive map, visit:
http://www.dovetailinc.org/programs/responsible_materials/maps/global_biorefineries

In 2015, 144 million tons of biomass (primarily corn) were used within the U.S. to produce biofuels, which supplied 5% of domestic transportation fuel needs[3]. However, the volume of biomass potentially available for production is far greater. For example, based on a 2011 estimate of potential sustainable biomass production in the U.S. of 1.1-1.6 billion dry tons annually[4], it was determined that biomass could supply a quantity of biofuels equivalent to total domestic transportation fuel needs in 2012. While use of all or even most available biomass for

[3] Energy Information Administration (2016)
[4] U.S. Department of Energy (2011)

this purpose is not a realistic possibility, it is nonetheless clear that bioenergy potential is far greater than present production levels. [5]

Overview of Biofuel Production

First generation starch and sugar-based biofuels are dominantly refined from vegetable oil and corn sugar. In the U.S., corn is the dominant feedstock. Increasingly, corn planted for biofuels is being genetically modified to enhance production of biofuels. Even though a number of states require a minimum ethanol mix in fuels (thus "fueling" the market), the low price of fossil fuels makes it difficult to operate biorefineries profitably using first generation methods. Moreover, the industry continues to face questions regarding environmental performance, including life cycle energy consumption, water use, and the environmental impacts of large-scale corn production and use.

Second generation cellulosic biofuels can be derived from almost any ligno-cellulosic material including corn stover and bagasse, non-food crops such as woody biomass, switchgrass and Jatropha seeds, or from municipal solid waste. The end products can be ethanol, biodiesel, aviation fuel, or any one of a wide array of industrial biochemicals. Dovetail Partners' *Bioenergy Update: A Biofuels/ Biorefinery Development Report Card*[1] revealed that as of 2009, there were several pilot and demonstration second generation biofuel facilities in North America, Europe, Brazil, and Asia. However, commercial production of second generation biofuels was not available anywhere in the world at that time.

Now, commercial production of second-generation biofuels is a reality. Several facilities began operation in 2014 and 2015. In October 2015, DuPont opened the world's largest cellulosic ethanol plant in Nevada, Iowa. The biorefinery runs on corn stover and can produce 30 million gallons of ethanol per year. While a step forward, this recent development occurred at about the same time that several large biofuel producers, including Abengoa, BP, and DuPont, either closed plants or suspended projects.

Overview of Cellulosic Biofuel Production

There are three primary ways to make cellulosic biofuels: chemical, biochemical and thermochemical. The biochemical conversion of cellulose to ethanol happens in three steps, pretreatment, hydrolysis, and fermentation. Pretreatment weakens the plant wall, then acid or enzymatic hydrolysis separates the cellulose into sugars, and lastly fermentation converts the sugars into ethanol. In order to produce biodiesel, cellulose needs to undergo thermochemical processes, such as pyrolysis or gasification (Figure 2, following page).

Production and use of second generation biofuels results in far greater displacement of fossil fuels than do first generation fuels, and emissions of carbon dioxide equivalents are significantly lower as well. Whereas the fossil energy input per unit of first generation ethanol is 0.78 million British thermal units (Btu) of fossil energy for each 1 million Btu of ethanol delivered[6], production of second generation ethanol yields 4.4-6.6 energy units for every energy unit in[7], meaning that the fossil energy input per each 1 million Btu of second generation cellulosic ethanol is only about 0.15-0.23 million Btu.

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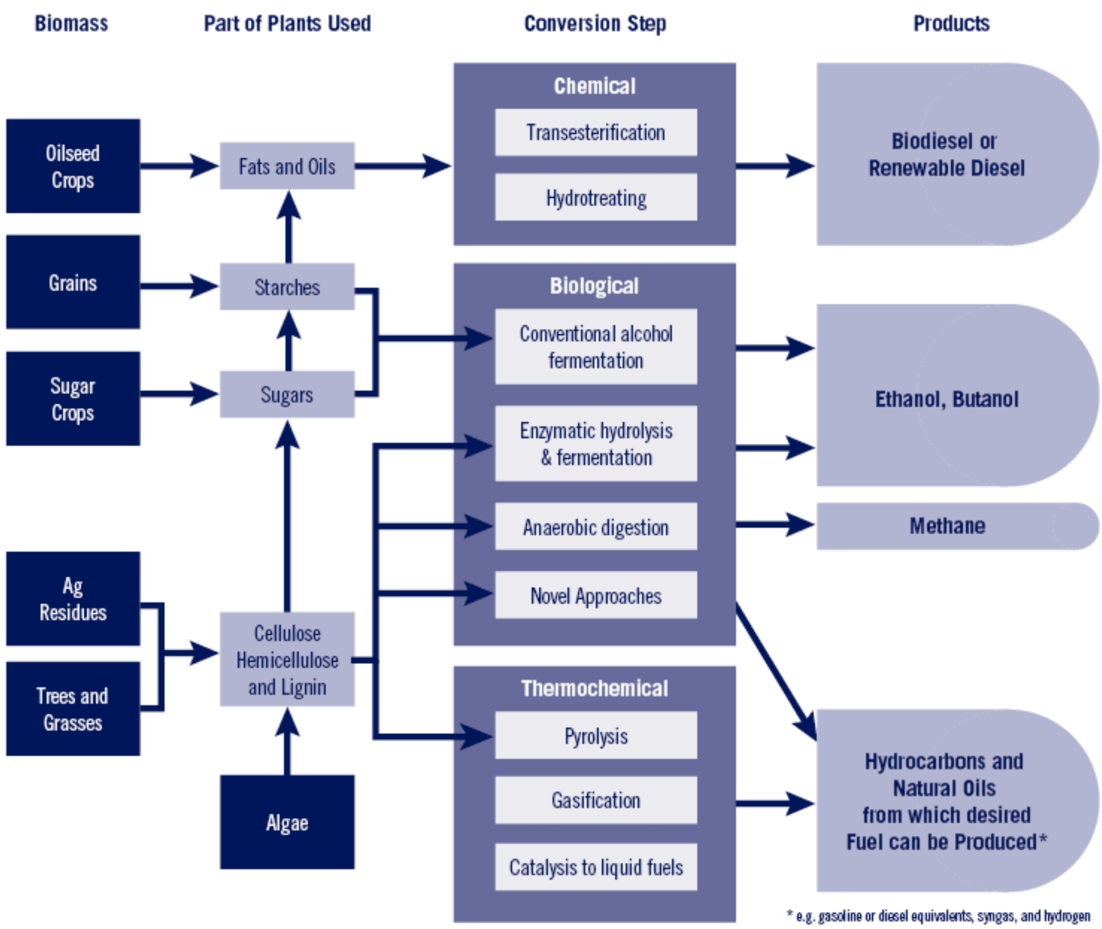
[5] Globally, it is estimated that total annual biomass production on earth is over 200 billion metric tons of organic dry matter, of which about 46% is aquatic vegetation. Field et al. (1998)

[6] Wang (2007)

[7] Sims et al. (2008)

Because of fossil energy displacement, the use of ethanol also reduces greenhouse gas (GHG) emissions per unit of energy produced. On a per-gallon basis, Department of Energy (DOE) modeling shows that corn ethanol reduces GHG emissions by 18% to 28% in comparison to gasoline, while cellulosic ethanol offers an 87% reduction.[8]

Figure 2
First and Second Generation Biofuel Pathways



Source: Pena and Sheehan (2007). Figure and additional information available from the Center for Climate and Energy Solutions (http://www.c2es.org/node/5995)

Production of biofuels has helped boost rural economies since cellulosic biofuel production facilities are generally located in rural areas where feedstocks are abundant. Bioenergy supports an estimated 2.5 million direct and indirect jobs globally, and 427,000 jobs in the United States. Of the jobs in the U.S, about 228,000 are related to ethanol, 49,000 to biodiesel, and 152,000 to solid biomass (not including traditional firewood).[9] Commercialization of second generation fuels is expected to set the stage for further growth. However, implementation of a new technology brings new challenges.

One challenge involves capital costs. Since cellulosic ethanol production is more complex than first generation processes, and in any case has only recently reached commercialization,

[8] Wang (2007)
[9] International Renewable Energy Association (2016)

investment requirements are significantly greater than for than corn-starch or sugarcane-based ethanol. The recent construction cost of a cellulosic ethanol plant with an annual capacity of 30 million gallons, totaled $225 million. In contrast, the investment required for a corn ethanol plant that produces 40 million gallons per year is about $80 million.[10] Furthermore, lenders are hesitant to invest in this sector since the conversion technology has not been proven to be economically viable without subsidy. As a result of lack of financial support, several large-scale cellulosic ethanol plants have closed in recent years. Another challenge for second generation biofuel production is that it shares the same market with fossil fuels, the price of which has reached record lows in the past year.

As of early fall 2015, 67 biorefineries worldwide were producing second generation ethanol, biodiesel, or aviation biofuel. Over a third of these (24) were operating on commercial scale (Table 1). North America has the most commercial second generation plants (9).

Table 1
Number of Operating Second Generation Biorefineries in the World

Region	**Pilot**	**Demonstration**	**Commercial**	**Total**
Africa	5	0	3	**8**
Asia-Oceania	6	5	4	**15**
Europe	7	7	5	**19**
North America	5	6	9	**20**
South America	1	1	3	**5**
Total	**24**	**19**	**24**	**67**

Source: Compilation by Que Nguyen. Dovetail Partners.

Africa

Africa's biofuel producers can benefit substantially from exporting to the EU and the US since most African countries receive preferential trade access to these two markets under the Everything but Arms Initiative (EBA), provisional Economic Partnership Agreements (EPAs), and the African Growth and Opportunity Act. Under these trade agreements, Africa can export duty-free and quota-free ethanol and biodiesel to the EU and the US.

Opportunities for biofuels are also abundant in Africa's domestic markets. Growth in demand for transport fuels has been estimated at more than 5% per year in sub-Saharan African countries (Mitchell 2011). Household cooking fuels are another potential market. There are currently 10 African countries that have biofuel mandates or planned biofuel targets (Table 2). Due to increases in population and income, as well as deforestation near urban areas, biofuels made from agricultural crops are viewed as having potential to supplement charcoal and basic wood fuels.

The main feedstock for first and second generation biorefineries in Africa is sugarcane. There are currently eight operating second generation biorefineries in Africa, and two of these are producing cellulosic ethanol at relatively large scale. Other second generation facilities are small-scale biodiesel plants that use Jatropha seeds as feedstock. Growing Jatropha as fuel stock has remained a controversial topic. Jatropha can be grown easily on marginal and arid lands that are unsuitable for agriculture. However, to provide high yields, Jatropha needs water, nutrients, and fertile soils, which means that Jatropha competes for the same fertile land as food crops.

[10] Bracmort (2015)

Therefore, growing Jatropha for biodiesel has led to food vs. fuel concerns. There are also concerns that forests may be replaced by Jatropha plantations.

Table 2
Current Biofuel Policies in Africa*

Country	Current Mandate	Planned Target
Angola	E10	
Ethiopia	E5	E20
Kenya	E10 (in Kisumu)	
Malawi	E10	
Mauritius		E5 (implementation date not firm)
Mozambique	E10	
Nigeria	E10 voluntary std.	E10
South Africa	E2, B5	
Sudan	E5	
Zambia		Considering E10, B5
Zimbabwe	E5 (up to E15 as energy crop production allows)	E20

**Numbers after "E" refer to percent biofuel in blend with gasoline.*
Source: Biofuels Digest (2016)

Asia-Oceania

Biofuel production activities in Asia and Oceania are concentrated in Australia, China, India, Thailand, and the Philippines. Indonesia and Malaysia are also major players, with fuels in these countries produced almost exclusively from oil palm. Throughout this region, 11 countries have approved blending mandates (Table 3). There are currently 13 operating second generation biorefineries in this region, four of which are producing on commercial scale. These 13 plants mostly produce cellulosic ethanol. There are also 11 plants that are in the planning or construction phase.

Table 3
Current Biofuel Policies in Asia-Oceania*

Country	Current Mandate	Planned Target
Australia	In New South Wales: ethanol accounts for 3.1% of transport fuels sales despite an E6 mandate.	
China	E10 (fully covers 6 provinces and 27 cities in 5 additional provinces)	10% biofuels in transport fuels as a national standard being pushed by various interests. As yet, no commitment from government to do so.
Fiji	E10, B5 voluntary standard	
India	E5	20% biofuels in transport fuels by 2017
Indonesia	E3, B10	
Malaysia	B7	
Philippines	E10, B5	
South Korea	B2.5	B3 by end of 2018
Taiwan	B1	E3 contemplated, but no deadline set for adoption.
Thailand	B5	
Vietnam	E5	

**Numbers after "E" refer to percent biofuel in blend with gasoline. "B" refers to biodiesel.*
Source: Biofuels Digest (2016)

Australia

In 2015, Australia's total biofuel production was 330 million liters, including 265 million liters of ethanol (70 million gallons) and 65 million liters of biodiesel (17 million gallons).[11] Neither New South Wales (NSW) nor Queensland require a specific ethanol blending ratio, but target to have a certain percentage of transport fuels sales come from biofuels (Table 3). These states allow unblended fuels in the market to accommodate vehicles that cannot run on ethanol. In NSW, ethanol sales constitute 4% of regular gasoline sales, instead of 6% as targeted, due to the small price difference between E10 and regular fuels.

It was announced in 2016 that Queensland will invest almost $20 million Australian dollars (approximately US$15.1 million), to become an Asia-Pacific hub for biofutures industries (Queensland Government 2016). This is a part of Queensland Biofutures 10-Year Roadmap and Action Plan. The state hopes to attract more international investors, taking advantage of its favorable climate, skilled workforce, well-developed supply chains, proximity to Southeast Asia, and strong agricultural and research and development sectors.

The advanced biofuels sector in Australia is supported by the Australian Renewable Energy Agency (ARENA). The agency has provided over $25 million Australian dollars (approximately US$18.9 million) to advanced biofuel projects. Australia's largest second generation biorefinery was scheduled to begin commercial-scale operation in late 2016, but has been sidelined related to a land clearing controversy.

China

In 2014, China approved a National Climate Change Plan (NCCP) which sets a target of 130 billion liters (34 billion gallons) of biofuel production by 2020. The current reality is far from that target. The final tally of domestic ethanol production for 2016 is predicted to be only 3.15 billion liters (less than 1 billion gallons). Another 0.90 billion liters (0.24 billion gallons) are imported. Biodiesel production for 2016 is expected to reach 1.14 billion liters (0.3 billion gallons).[12]

Counter to goals set under the NCCP, earlier central government actions would appear to discourage biofuels production. For instance, the government ceased its support for grain-based ethanol in 2010 due to increased prices of domestic and imported grain. And, because Chinese leaders did not want to sacrifice food security for biofuel production, all subsidies for grain-based ethanol were removed. In addition, in the same year that the NCCP was approved (2014), a value added tax rebate of 17% was terminated, and a 5% consumption tax for grain-based ethanol production was imposed.

Adding to the difficulties of China's biofuels industry, many small scale biodiesel plants have been suspended due to limited supply of waste cooking oil and a lack of government support for biodiesel.[13] There is no national or regional mandate for biodiesel use. Furthermore, state-owned oil companies do not allow the sales of biodiesel in their stations. Biodiesel distribution is mostly limited to private gas stations located in small cities or in the countryside. Yet another problem is that China's second generation ethanol market is dominated by state-owned companies as they are given preferential access to capital by the government.[14] In contrast, private companies,

[11] Farrel (2015)
[12] Anderson-Sprecher (2015)
[13] Ibid
[14] Ibid

which conceivably could react more aggressively to growing market opportunities, cannot receive government incentives or subsidies.

Collection of biomass for use in biofuel production is also problematic. Limited numbers of producers face a significant challenge in collecting and transporting feedstock from scattered small-scale farms.

There are two operating second generation biorefineries in China that produce cellulosic ethanol on a commercial scale, and one that produces cellulosic ethanol on a demonstration scale. Two other commercial projects are in planning or construction phase.

Europe

EU

The Renewable Energy Directive (RED) of 2009, a part of the EU Energy and Climate Change Package (CCP), lays out an overall policy for the production and promotion of renewable energy in the EU. Under the RED, by 2020, at least 20% of the EU's total energy needs and at least 10% of its transport fuels must come from renewable sources (Table 4). In April 2015, the European Parliament approved a new directive known as the Indirect Land Use Change Directive, which specifies how member countries can meet the target of 10% renewables in transport fuels.[15]

Table 4

Current Biofuels Policies in Europe*

Country	**Current Mandate**	**Planned Target**
28 EU countries	5.75% biofuels in transport fuels.	By 2020: • 10% biofuels in transport fuels; • Maximum of 7% first generation biofuels in transport fuels; • 0.5% advanced fuels in transport fuels (non-binding target).
• Italy		By 2018: Minimum of 0.6% advanced fuels in transport fuels; By 2022: Minimum of 1.0% advanced fuels in transport fuels.
Norway	B3.5	
Ukraine		E5

**Numbers after "B" refer to percent biodiesel in blend with diesel fuel.*

Source: Biofuel Digest (2016)

The directive, which is considered a revision to the RED, caps the amount of first generation biofuels in the transport sector at 7%. It also sets out a non-binding target of 0.5% advanced biofuels in transport fuels by 2020. Advanced biofuels include both second and third generation biofuels (third generation fuels include those from algae). Member countries are expected to include these targets in their national legislation by mid-2017. Italy appears to be ahead of the game as it announced in 2014 that by 2018, transport fuels in Italy must contain 0.6% advanced biofuels, and 1% by 2022.

There are currently 19 operating second generation biorefineries within the EU, 17 of which are producing cellulosic ethanol. Four of the 17 cellulosic ethanol plants are on commercial scale (the others are pilot and demonstration projects). The world's first commercial cellulosic ethanol biorefinery, built by Beta Renewables, was opened in 2013 in Crescentino, Italy. The refinery runs on rice straw, wheat straw, and *Arundo donax* (giant reed), and has a full capacity of 75

[15] Flach et al. (2015)

million liters/year (nearly 20 million gallons per year). There are also nine second generation biofuel projects in planning or construction phase in Europe.

The UK and Brexit

In June, 2016, the United Kingdom voted to leave the European Union. It is predicted that Brexit could cause slight changes to biofuel production in the UK. Before the referendum, industry experts had already forecast that it was unlikely that the UK would meet targets set out in the EU RED directive, requiring 10% biofuels in transport by 2020.

In 2015, only 3.2% of road fuels consumed in the UK were biofuels (Lane 2016). The UK's Low Carbon Vehicles Partnership proposed that replacing E5 with E10 would be the only way for the UK to meet the RED target, although it was recognized that 9% of vehicles might not be compatible with E10. Withdrawing from the EU might allow the UK to pursue more lenient renewable energy policies in the transportation sector.

There is only one operating cellulosic ethanol plant in the UK. The plant in Surrey, owned by TMO Renewables, has been operating on a demonstration scale since 2008. Another second generation biofuel project is the Green Sky Project by British Airways, which sought to convert London's municipal solid waste to 60 million liters annually (16 million gallons) of aviation biofuel. However, the project was suspended at the beginning of 2016 due a lack of government support, low crude oil prices, and investor hesitation.

North and Central America

Biofuels are on the radar screens of most North and Central American governments. As indicated in Table 5, the U.S., Canada, and Mexico all are pursuing renewable fuel initiatives, as are a number of Central and South American countries.

Table 5
Current Biofuel Policies in North and Central America

Country	**Current Mandate**	**Planned Target**
Canada	E5, RD2 (renewable diesel)	
Costa Rica	E7, B20	
Mexico	E2 (in Guadalajara)	E2 blending mandate under consideration for Mexico City and Monterrey
Panama	E10	
United States	Renewable Fuel Standard	Renewable Fuel Standard

Source: Biofuel Digest (2016)

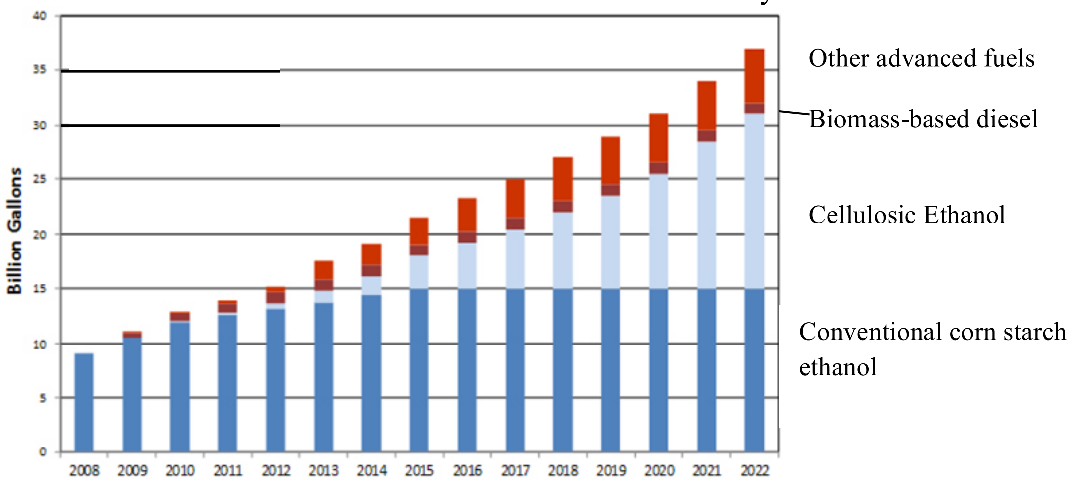
USA

The statute that currently regulates biofuel production in the U.S. is the Renewable Fuel Standard (RFS). It was established under the Energy Policy Act of 2005 and expanded under the Energy Independence and Security Act of 2007. By 2022 the RFS requires 36 billion gallons of biofuels in transport fuels, of which 21 billion gallons must be advanced biofuels (Figure 3). Advanced biofuels, including cellulosic biofuel, biomass-based diesel and other advanced fuels, must have a life cycle greenhouse gas emissions reduction of 50%. The RFS also caps the production of conventional biofuel (e.g. corn-based ethanol) at 15 billion gallons per year.

To achieve these goals, the Environmental Protection Agency (EPA) sets out annual targets. In May 2016, the EPA released proposed targets for 2017 and 2018. For 2017, 4 billion of 18.8 billion gallons of renewable transport fuels are to come from advanced fuels.

For every year since 2010, EPA has lowered the target volume for cellulosic ethanol production, from the amount specified in the statute down to the volume expected to be available for that year. This inconsistency has negatively affected investors' confidence in this sector (Bracmort 2015). Moreover, each year's targets are supposed to be finalized by November 30 of the previous year but this deadline has not been consistently met. Such uncertainties can delay investments and planning for the biofuel and petroleum industries.

Figure 3
Renewable Fuel Standard Volumes by Year



Source: Alterative Biofuels Data Center

The Department of Energy (DOE) recently reported[16] that the United States has the future potential to produce at least one billion dry tons of biomass resources (composed of agricultural, forestry, waste, and algal materials) on an annual basis without adversely affecting the environment. Report authors indicate that this amount of biomass could be used to produce enough biofuel, biopower, and bioproducts to displace approximately 30% of 2005 U.S. petroleum consumption without negatively affecting the production of food or other agricultural products.

There are 14 operating cellulosic ethanol plants in the U.S., 9 of which are producing at commercial scale (Table 6). Although the total capacity of these 14 facilities is approximately 104 million gallons per year, production for all of 2015 only reached 2.2 million gallons of cellulosic ethanol, much lower than EPA's 2015 target of 120 million gallons. Production numbers for 2016 are predicted to be significantly greater (Rapier 2016).

[16] U.S. Department of Energy (2016). 2016 Billion-Ton Report: Advancing Domestic Resources for a Thriving Bioeconomy. July. (https://energy.gov/eere/bioenergy/2016-billion-ton-report)

Table 6
Operating Cellulosic Ethanol Plants in the U.S.

Name	Location	Feedstock	Scale	Year Operations Began	Capacity (mil gal)
American Process	Alpena, MI	Wood chips	Commercial	2012	0.95
	Thomaston, GA	Wood chips	Commercial	2013	N/A
Calgren Renewable Fuels	Pixley, CA	Cow manure	Commercial	2015	N/A
DuPont	Nevada, IO	Corn stover	Commercial	2015	30
Gulf Coast Energy	Livingston, AL	Wood waste	Pilot	2009	20
Indian River Bioenergy Center	Vero Beach, FL	Municipal solid waste	Commercial	2013	8
LanzaTech	Soperton, GA	Wood waste	Pilot	2014	0.09
Pacific Ethanol	Stockton, CA	Corn kernel fiber	Commercial	2015	0.75
Project LIBERTY (POET)	Emmetsburg, IA	Corn stover, corn cobs, leaves, husk, stalk	Commercial	2014	20
Quad-County	Galva, IA	Corn kernel fiber, corn	Commercial	2014	2
Renmatix	Rome, NY	Wood chips, tall grasses, corn stover, bagasse	Demonstration	2008	N/A
Summit Natural Energy	Cornelius, OR	Food processing and agricultural waste	Pilot	2009	N/A
Tyton Biofuels	Raeford, NC	Tobacco waste	Pilot	2010	15
ZeaChem	Boardman, OR	Wood	Demonstration	2013	0.25

Source: Que Nguyen, Dovetail Partners

South America

There are a number of countries in South America that have established mandates or targets for renewable fuels (Table 7). The majority of biorefineries in South America are first generation plants utilizing sugarcane and soybean feedstocks. The cellulosic ethanol sector has great potential in South America because it can take advantage of sugarcane residues. However, there are only four operating cellulosic ethanol biorefineries in South America, all of which are located in Brazil. Three of them are producing on a commercial scale (Table 8) while the other is a demonstration plant.

Table 7
Current Biofuel Policies in South America

Country	Current Mandate	Planned Target
Argentina	E5, B10	
Brazil	E27 and B7	Considering B10 and E27.5
Colombia	E8	Considering E10
Chile	E5, B5 (voluntary)	E5 and B5 no set date
Ecuador	B5	E10 by 2018, B10 no set date
Paraguay	E25, B1	E27.5 under consideration
Peru	E7.8, B2	B5 no set date
Uruguay	B2, E5 (voluntary)	

Source: Biofuel Digest (2016)

Brazil

In March 2015, an increase in ethanol blend in gasoline from 25 to 27% was approved. Ethanol fuel production for 2016 is predicted to reach 28.15 billion liters (nearly 7.5 billion gallons), 1.3 billion liters (0.34 billion gallons) more than in 2015. There are approximately 360 ethanol plants in Brazil. In 2016, total biodiesel production is predicted to be 4.11 billion liters (about 1.09 billion gallons), about the same as in 2015. There are 56 biodiesel plants in Brazil as of 2015. Most of these plants use soybeans, animal fat, or cotton seeds as feedstocks. Cellulosic ethanol production was expected to total 6 billion gallons in 2016, a three-fold increase over the previous year; 2017 production is forecast to reach 8 billion gallons.[17]

Table 8
List of Operating Cellulosic Ethanol Plants in Brazil

Name	Location	Feedstock	Scale	Status
Bioflex 1 (GranBio)	Alagoas	Bagasse, straw	Commercial	Operating since 2014
Dedini	Sao Paulo	Bagasse	Demonstration	Operating since 2002
Iogen	Sao Paulo	Bagasse	Commercial	Operating since 2015
Raizen	Sao Paulo	Bagasse	Commercial	Operating since 2015

Source: Que Nguyen, Dovetail Partners

Bottom Line

Second generation biorefineries are operating in all regions of the world, bringing far more favorable energy balances to biofuels production than have been previously realized. Substantial displacement of a significant portion of fossil-based liquid fuels has been demonstrated to be a realistic possibility. However, in the face of low petroleum prices, continuing policy support and investment in research and development will be needed to allow biofuels to reach their full potential.

[17] Barros (2016)

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