ADVANCED BIOFUELS

Biofuels are an entrenched part of the nation's transportation policy. Most average Americans have grown accustomed to the notices at gas pumps announcing a 10% ethanol blend with gasoline. Many may have heard of biodiesel through news pieces and word of mouth reports of cars running on old restaurant oil. American biofuels use is poised to take a big step beyond these basic beginnings toward the adoption of advanced biofuels.

Today's conventional biofuels, or 1st generation biofuels, use sugars and starches in crops and oils from plants and animals to produce ethanol and biodiesel. Common examples of these 1st generation fuels include corn and sugarcane ethanol and biodiesel produced from vegetable oils and animal fats. Advanced biofuels do not use the food component of plants, but rather rely on new feedstocks. Cellulosic ethanol, a 2nd generation biofuel, uses inedible sugars that make up the structural material in stalks, grasses, woody biomass, and other non-crop sources to create ethanol. Together, these new sources provide a large and as yet mostly untapped potential to produce enormous energy and emissions reductions.

History

Biofuels are among the world's oldest and most reliable automotive fuel sources. The technology to create ethanol in the form of alcohol distillation existed long before the invention of the automobile. Consequently, many of the first auto manufacturers designed vehicles to make use of the powerful and readily available fuel source. Henry Ford designed his early vehicles, including the Model T, to run on ethanol. Rudolf Diesel, inventor of the eponymous engine, demonstrated his invention in 1900 with peanut oil as his chosen fuel.[1] These inventors and visionaries had every reason to plan for biofuels as their standard fuels. Much like the first-generation biofuels that we know today, biofuel producers used corn, vegetable oil, and other crops to produce a reliable and potent transportation fuel.

The advent of cheap, widely available gasoline brought the demise of biofuels as a primary transportation fuel source. By the 1920s, gasoline had established a complete dominance over the transportation fuel market.[2] Some companies briefly blended ethanol into gasoline to reduce knocking, but the innovation of

Getting to Know Biofuels: Definitions

Biomass: Biological material harvested from living or recently living organisms that serves as an energy source. Biomass encapsulates plant and animal matter of any source that can be converted into fuel and represents a sustainable, renewable feedstock.

Feedstock: The raw material used to produce a biofuel. Individual feedstocks vary between regions – corn is the most commonly available feedstock in the Midwest, whereas woody biomass is abundant in many parts of the Northeast and Mid-Atlantic.

Ethanol: A fuel made from alcohol produced from sugars and starches in plants. Ethanol typically comes from food crops, so it is a renewable resource. It burns cleaner than gasoline but has a lower energy density than gasoline. Corn is the most abundant feedstock for domestically produced ethanol, but other feedstocks commonly include sugarcane, wheat, rapeseed, and many more. Up to 85% ethanol can be used in Flexible Fuel Vehicles.

Biodiesel: A fuel made from fats and oils produced from plants or animals. The physical properties are similar to petroleum diesel, but like ethanol, biodiesel burns cleaner but has a lower energy density than diesel. Common feedstocks include vegetable oils (soy, rapeseed or palm), animal fats, and even grease from restaurants. Biodiesel is typically blended with petroleum diesel and at low percentages works in most standard diesel engines.

leaded gasoline soon put the brakes on the practice. During the Second World War, several belligerent governments experimented with biofuel use to replenish their exhausted gasoline supplies, but the interest faded immediately after the war, when regular gasoline supplies returned.

The gasoline crises of the 1970s spurred a renewed interest in biofuels and other alternative fuels. Not until the passage of several landmark energy laws more than a decade later, however, did biofuels get a push to become viable transportation fuel sources:[3]

- **The Energy Policy Act of 1992** set alternative fuel requirements for government fleets;
- **The Biomass Research and Development Act of 2000** created R&D funding and resources and coordinated national biofuels efforts;
- **The Energy Policy Act of 2005** created the National Renewable Fuel Standard (RFS), funded biofuel research and projects, and provided tax incentives for biofuel consumers and producers;
- **The Energy Independence and Security Act of 2007** set a more aggressive standard for biofuel use, incorporated advanced biofuels into the RFS, and expanded research and funding opportunities for biofuels projects.

Year	1st Gen	2nd Gen	Total	% Cell.
		(GALLONS)		
2008	9.0	0	9.0	0
2009	10.5	.6	11.1	0
2010	12.0	.95	12.95	1
2011	12.6	1.35	13.95	2
2012	13.2	2.0	15.2	3
2013	13.8	2.75	16.55	6
2014	14.4	3.75	18.15	10
2015	15	5.5	20.5	15
2016	15	7.25	22.25	19
2017	15	9.0	24.0	23
2018	15	11.0	26.0	27
2019	15	13.0	28.0	30
2020	15	15.0	30.0	35
2021	15	18.0	33.0	41
2022	15	21.0	36.0	44

Present

The Renewable Fuel Standard (RFS) drives most biofuel use today. Passed in 2005, the RFS mandates blending a specified level of biofuels into gasoline at pumps throughout the country. The biofuels are separated into categories, including traditional ethanol sources, biomass-based diesel, cellulosic ethanol, and advanced ethanol. Each category is given a specific production mandate for each year through 2022. Increases in the near future will be delivered by traditional ethanol and biodiesel, but cellulosic ethanol is due to deliver the highest quantity of biofuel by 2022 at 16 billion gallons.

Biofuels use extends beyond conventional ethanol blends at gasoline pumps. Many consumers are turning to Flexible Fuel Vehicles (FFVs) to take advantage of the lower costs of biofuels and to reduce their exposure to gasoline's price volatility. FFVs constitute the single largest Alternative Fuel market, with over half a million vehicles sold each year.[4] FFV sales have doubled since the creation of the RFS, and large automakers are at the center of the trend. The available number of FFVs has also doubled since the implementation of the RFS to nearly 70 commercially available models. The "Big Three" U.S. automakers are out in front of the FFV competition, accounting for nearly 80% of the market,[5] though many consumers are not aware that their vehicles are FFVs.

FFVs are inexpensive to produce, costing manufacturers only about $150 above the cost of a gasoline-only model. Auto manufacturers generally do not pass this cost to the customer as a separate itemized cost, nor does the addition of flex fuel capability hinder a vehicle's performance. Conversion kits are also available to consumers at less than $1000 and can be installed easily by the consumer or a mechanic.[6]

Sowing the Seeds: Biofuel Incentives

Advanced biofuels are promoted by individual states through subsidies, market incentives, or preferential policies. Many states in the Northeast and Mid-Atlantic offer some combination of the following incentives:[7]

- **Production Tax Credits:** Producers of ethanol, biodiesel, and cellulosic ethanol are eligible to receive tax credits, paid either incrementally or as total awards. Rates and awards vary by state, with some states focusing on advanced biofuels.

	Production Tax Credits & Grants	Research & Development Funding	Tax Reductions & Exemptions	Acquisition Requirement
Maine	●			
New Hampshire				●
Vermont	●			
Massachusetts			●	
Rhode Island			●	
Connecticut	●			
New York	●		●	●
New Jersey				●
Pennsylvania				●
Delaware				●
Maryland	●	●		●
Washington, DC				●
West Virginia				
Virginia	●	●	●	

- **Research & Development Funding:** Grants and loans are available for the research, development, and commercialization of biofuels, with some states focusing on advanced biofuels.
- **Tax Exemption:** Certain biofuels are granted reductions or exemptions when used as transportation fuels.
- **Federal Tax Credit:** Cellulosic ethanol producers are eligible for a federal tax credit of over $1 for every gallon of ethanol produced. This tax credit will expire at the end of the year unless Congress votes to renew it.

Potential to Grow

Since the passage of the RFS in 2005, ethanol production in the United States has more than tripled. Production capacity has increased so rapidly that the United States has overtaken Brazil to become the world's largest biofuel producer.[8] The U.S. corn ethanol industry has already built enough production capacity to nearly satisfy the entire 15 billion gallon conventional biofuel level called for in 2015 by the RFS.

Production of cellulosic ethanol, however, is developing more slowly than was anticipated by the Renewable Fuel Standard.[9] Many advanced biofuel plants are nearly ready to begin production, but producers will still need to overcome a few barriers before achieving complete commercialization:[10]

- **High Production Costs:** Current 1st generation biofuels are less expensive than the anticipated costs of 2nd generation biofuels. As advanced biofuels processing becomes more streamlined and the economies of scale are reduced, advanced biofuel prices will decline sharply.
- **Logistics:** Presently, 2nd generation biofuels do not have streamlined paths to markets. As the process for creating cellulosic ethanol is improved, supply chains will grow and adapt to create an efficient delivery method.
- **Agricultural & Forestry Adoption:** Waste materials and corn stover have been the most popular feedstocks for the first advanced biofuels plants, though the most cost-effective feedstocks vary depending upon the region. Producers must determine the best feedstock and secure access to feedstock sources before production can begin.
- **Investments:** Return on investment has been minimal because cellulosic ethanol production is lagging behind anticipated production. Once commercialization begins in the near future, investors will be able to confidently back cellulosic ethanol ventures.

Know Your Fuels

E10/E15: The "E" refers to ethanol and the number denotes the percentage of ethanol blended with gasoline, e.g., E10 is 10% ethanol. Higher ethanol concentrations offer fuel savings and reduced GHG emissions, but can also have adverse effects on automobiles that are not designed for high ethanol concentrations, such as FFVs. E10 is the standard blend available at fueling stations, though experiments have begun on E15 in order to comply with rising RFS standards.

E85: A blend of up to 85% ethanol with gasoline. E85 is a standard fuel for Flex Fuel Vehicles, but is recommended only for vehicles designed specifically for high ethanol concentrations. The lower cost of E85 helps offset the reduced range that drivers experience in comparison to gasoline. E85 is a clean, high-performing Alternative Fuel.

B20: A popular blend of 20% biodiesel to 80% petroleum diesel that can be used in specially designed vehicles.

To locate E85 or B20 stations, go to: http://www.afdc.energy.gov/afdc/locator/stations/

And yet despite these challenges, there is great potential for the success of advanced biofuels in the transportation market. The RFS has created a market for advanced biofuels and has already succeeded in developing the traditional biofuels market. Because consumers have already accepted biofuel blending with gasoline, producers of advanced biofuels won't have to overcome a skeptical consumer base, though consumer preferences may change once the current 10% blend is surpassed. And perhaps most importantly in the current economy, the development and commercialization of advanced biofuels can create jobs and sustain the American transportation sector. Though 2nd generation biofuels production is currently stuck in neutral, the potential is enormous once production shifts into gear.

Food for Thought

At the outset of the RFS, full life-cycle analyses concluded that corn ethanol provided a definite GHG reduction of approximately 20%, with some variance among studies[11]. However, when Indirect Land Use Change (ILUC) is included in the life-cycle analysis, the emissions reduction benefits are less clear. ILUC occurs when crops are switched towards biofuel production, thereby reducing the total amount of available food. Food shortages are overcome by converting forest into agricultural land, which often results in new emissions and less sequestration of

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carbon, particularly in tropical areas with inexpensive, accessible forest land. In this way, ILUC can reduce or perhaps even eliminate the emissions benefits of using renewable crops as transportation fuel. Of course, as quantifying this effect requires modeling the whole global agricultural system, the results vary depending on the models and assumptions.[12]

Advanced biofuels largely circumvent the ILUC problem by using non-crop feedstocks. By using energy crops, waste material from food crops, and waste, advanced biofuels do not create the same need for land as have traditional biofuels. Some land will still be needed for energy crops. Energy crops contain more energy per acre, however, and therefore probably drive less indirect land use change. Many advanced biofuel feedstocks also can be grown on marginal lands, thereby reducing displacement of food production.[13]

Endnotes

1. http://www.afdc.energy.gov/fuels/electricity_infrastructure.html
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3. http://www.fuel-testers.com/ethanol_fuel_history.html
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11. http://www.afdc.energy.gov/vehicles/flexible_fuel_emissions.html
12. IEA, "Sustainable Production of 2nd Generation Biofuels: Potential and Perspectives in Major Economies and Developing Countries." February 2012. Page 85.
13. Ibid.

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