July 18, 2017

Mr. Samuel Wade
Branch Chief, Transportation Fuels
California Air Resources Board
P.O. Box 2815
Sacramento, CA 95812

Dear Mr. Wade,

The Biotechnology Innovation Organization (BIO) appreciates the opportunity to submit comments to the California Air Resources Board (CARB) on its recent public meeting on the "Low Carbon Fuel Standard: evaluation of alternative jet fuel inclusion," which took place on March 17, 2017.

BIO is the world's largest biotechnology organization with more than 1,000 members worldwide. Among its membership, BIO represents over 85 leading technology companies in the production of conventional and advanced biofuels and other sustainable solutions to energy and climate change challenges. BIO also represents the leaders in developing new crop technologies for food, feed, fiber, and fuel. BIO member companies represent many of the low carbon fuel producers that will supply the State of California with the fuels for LCFS credit and compliance.

**CARB Should Include Alternative Jet Fuel as an Additional Pathway to Generate Credits Under the LCFS**

BIO and its members strongly support California's efforts to reduce the carbon intensity of transportation fuels and believe that biofuels can and must contribute significantly to this important objective. Biofuels can help toward this goal not only by displacing petroleum-based ground transportation fuels, but also by displacing petroleum-based fuels needed for commercial and military airline transportation. To this end, BIO and its members agree with CARB's proposal to allow, on an opt-in basis, alternative jet fuel (AJF) as an additional pathway to generate credits under the Low Carbon Fuel Standard (LCFS).

This opt-in credit generation is the appropriate approach to helping to promote the development and use of AJF in California, and it is consistent with federal regulations governing these fuels. It will help facilitate and incentivize biofuel producers and airlines to produce and use AJF in the California market. This will, in turn, help California achieve its greenhouse gas emissions reduction goals under the LCFS. Moreover, allowing AJF to generate credit under the LCFS on an opt-in basis compliments and is consistent with federal

Renewable Fuel Standard (RFS) regulations that allow for Renewable Identification Number (RIN) generation for approved AJF pathways.

As both the CARB staff and National Renewable Energy Laboratory (NREL) presentations during the March 17, 2017 meeting highlighted, airlines are working hard to incorporate and use AJF in their daily operations and long-term planning. With the appropriate incentives, airlines are especially positioned to promote increasing production and use of AJF because of their ability to enter into long-term partnerships and significant off-take agreements with biofuel producers.[1]

**CARB Should Revise the Proposed Compliance Schedule for AJF Under the LCFS**

BIO and its members request that CARB staff adjust the proposed compliance schedule to instead establish a carbon intensity (CI) baseline for calculating AJF credits under the LCFS. Since CARB is not required to regulate the CI of jet fuels under the LCFS, it should not create a required compliance schedule for AJFs under the LCFS regulations. Instead, BIO and its members believe that the production and use of AJF would be more effectively incentivized through the use of an established CI baseline to calculate AJF credits. On this point, we echo the recommendations of A4A and the alternative jet fuel producers named in the April 27, 2017 letter to CARB from the Noyes Law Corporation.[2]

**CARB Should Ensure AJF That Can be Made From All Renewable Feedstocks May Generate Credits Under the LCFS**

Especially given the potential significance of LCFS compliant AJF to help achieve massive GHG reductions, BIO and its member companies urge CARB to ensure that AJF producers may receive credits by making the biofuel from *all* possible renewable feedstocks. Below, please find descriptions of some potential feedstocks that could be utilized to make biofuels that help reduce California's GHGs.

---

[1] *See* "Effect of Additional Incentives for Aviation Biofuel: Results from the Biomass Scenario Model," National Renewable Energy Laboratory, Mar. 17, 2017, available at https://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/031717nrel_presentation.pdf; *see also* "Low Carbon Fuel Standard: evaluation of alternaive jet fuel inclusion," California Air Resources Board staff presentation, Mar. 17, 2017, available at: https://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/031717presentation.pdf.

[2] See Letter to CARB from A4A, April 28, 2017, available at https://www.arb.ca.gov/fuels/lcfs/workshops/04282017_a4a.pdf; see also, letter to CARB from Alternative Jet Fuel Producers, April 27, 2017, available at: https://www.arb.ca.gov/fuels/lcfs/workshops/04272017_ajfproducers.pdf.

Woody Biomass

Worldwide, wood is the largest source of biomass for energy and also has applications for the production of biofuel, including liquid transportation fuels. Wood can be converted into fuel in solid, liquid, and gaseous forms and can supplement or replace any other energy source.

Woody biomass is derived from timber, urban wood waste, trimmings, and construction debris etc. After tree harvesting, woody biomass is commonly chopped, chipped, or pelletized in a preprocessing step and transported to conversion and power generation facilities. It is then converted into fuel, heat, or energy via thermochemical or biochemical processes, such as gasification, biogasification, or pyrolysis.[3]

While the southern U.S. produces more wood products than any other region of the country due to its forestry, thinning, and harvesting activities, other parts of the country also have strong and vibrant forest industries. The transportation and processing infrastructure that has developed around woody biomass makes it a competitive and viable feedstock for biofuel production.

A major factor in the economic feasibility of woody biomass is the ease with which sugar can be released from the feedstock without excessive processing. To process woody biomass into fuel, it must be treated in order to release the sugars that are bound up in the plant's cell walls. Once the sugars are released, a variety of biofuels can be generated, including liquid fuels. Some of today's short rotation species, including Eucalyptus and Poplus species, have produced exceptional yields that can easily release cellulose for bioprocessing to aviation turbine fuels or middle distillates.

Several studies have suggested that woody biomass is one of the lowest cost biomaterials available today on a Btu-to-pound ratio, compared to both fossil fuels and other materials.

By planting purpose grown hardwoods as biomass crops, a sustainable supply of high quality wood for conversion to sugars can be assured, and the versatility of trees and variety of species make trees a crop that can easily be grown in much of the United States. The ability of airlines to sign long term fuel contracts also represents the best chances we have today for landowners generally and timber (forestry) landowners, specifically to recognize the potential of purpose grown trees. Numerous DOE, USDA and state forestry reports point to the strong yield from sustainable forestry for biofuels.

---

[3] C. Staudhammer et al., *Wood to Energy: Using Southern Interface Fuels for Bioenergy*, The United States Forest Service, GTR-132, (2011). *available at* http://www.srs.fs.fed.us/pubs/gtr/gtr_srs132.pdf.

Grasses as Dedicated Energy Crops

BIO's membership includes several leading biomass crop developers, who are well-positioned to provide large-acreage plantings of biomass crops for biofuel production. These developers have invested heavily in research and breeding over the last several years to demonstrate the productivity of energy grasses – including miscanthus, switchgrass and sorghum –in trials and small commercial facilities throughout the United States. These grasses are highly productive, and several can yield 10+ dry tons per acre per year. Many are perennial grasses, and yield productive stands many years from a single planting. On the supply chain and logistics side, thousands of acres have been harvested under demonstration regimes using both conventional and newly developed harvesting equipment. These biomass crops are ready for deployment -- what the industry currently needs are firm offtake agreements to support commercial-scale seed production, grower adoption of these crops, and ramp up of the supply chain for large-scale delivery of biomass for conversion to biofuels.

Among the leading energy crops being tested at pilot and demonstration scale in the U.S. are switchgrass, miscanthus, sugar cane, energy cane, and arundo donax. All of these feedstocks have different agronomy profiles (soil and water requirements, productivity, fertility regimes, etc.) and they show promise in certain environments. In the southernmost regions of the U.S., typically around the Gulf Coast and in Florida, sugar cane and energy canes have been tested. Switchgrass and miscanthus have been tested extensively from the Gulf Coast to the Great Lakes regions and both show great promise in the temperate climates.

The feasibility of commercial scale-up and economics of commercial production currently varies by crop. Switchgrass and now miscanthus can be propagated via seed, which greatly simplifies and reduces the time and cost to establish large, commercial-scale acres. Miscanthus and other perennial grasses require low inputs and little or no nitrogen, providing attractive economics and further reducing fossil fuel consumption in the biofuel production cycle.

Between the two crops, miscanthus currently is demonstrating higher yields than switchgrass in most production environments, which translates into better production economics. Other crops, such as Arundo and energy cane (and some miscanthus varieties) have to be propagated vegetatively either as stem cuttings, tissue culture multiplication, or rhizomes. While these methods have been tested extensively in the United States and abroad, they limit the speed of commercial ramp-up and the total number of biomass acres that can be established, and increase its cost.

In sum, many of the seeded perennial grasses currently being developed by BIO members will be ready for planting at the scale of thousands of acres over the next several years. All that is needed is financing and offtake agreements to provide the necessary signal for such production. And the economics of the winning energy grass systems are expected to be competitive with other biomass feedstock sources—namely agricultural residues and wood—and can be a source of economic development and stimulus in rural agricultural regions throughout many parts of the U.S.

Algae-based Biofuels

Algae and some cyanobacteria (also known as blue green algae) function both as a feedstock and a production organism. Algal biomass has great potential as a plentiful and economic advanced drop-in feedstock, with many significant benefits. For instance, algae has a short growing cycle and can be grown quickly and in large quantities using land and water unsuitable for plant or food production; it may even be grown quickly in salt water in the desert.

Algae-derived biofuels can be made from autotrophic or heterotrophic algae. Autotrophic algae rely directly on photosynthesis to grow. They convert sunlight and carbon dioxide into organic carbon that can be converted into high quality oil. Heterotrophic algae can grow in the dark by ingesting organic molecules (molecules that contain carbon) present in their aquatic environment. They can convert carbohydrate feedstock derived from domestic, renewable, sustainable, next generation feedstocks into high quality oil. Both types of algae can result in oils that can be refined into gasoline, diesel and jet fuel with molecular structures similar to traditional petroleum. In fact, they can yield renewable equivalents to JP-5, JP-8, and F-76 fuels that fully comply with DOD's emerging specifications for these fuels (HRJ-5, HRJ-8 and HRD-76).

Municipal Solid Waste

Urban waste is a source of feedstock for biofuel production. Components of urban waste include municipal solid waste (MSW) and construction and demolition debris (C&D). However, only a portion of this urban waste contains cellulosic materials that can be used for the production of biofuels. Thus, within the MSW stream, only paper/paperboard, wood, yard trimmings and food scraps can be used for biofuels production, and within the C&D stream, only woody materials can be used in biofuels production.

The EPA has acknowledged that this material offers a potentially reliable, abundant and inexpensive source of feedstock for renewable fuel production which, if used, could reduce the volume of discarded materials sent to landfills and could help achieve both the GHG emissions reductions and energy independence goals of the Energy Independence and Security Act of 2007 as well as the GHG reduction goals of the LCFS. Urban waste that is diverted from landfills for biofuels production will save valuable landfill space for other materials and reduce the production of methane gas associated with the biogenic decomposition of these materials.

Certain existing biofuels technologies are able to recover and use the moisture in MSW with high moisture content, such as food waste, thereby resulting in a water neutral state or water positive state. Additionally, residue resulting from conversion of the MSW feedstock can have valuable uses, such as daily cover or compost materials.

First Generation Feedstocks

The biofuel feedstocks that are most widely utilized in the United States at this time are corn grain and soybeans. As summarized below, these feedstocks have made significant contributions toward lowering cumulative GHG emissions and helping to displace major quantities of imported petroleum in a sustainable and economic manner. As such, it is clear that such feedstocks should continue to be utilized as California and the nation strives to meet its energy needs in a more sustainable manner.

*i. Corn*

In the U.S., the primary feedstock for bioethanol has been corn grain, a renewable resource with a demonstrated record of meeting transportation needs, while reducing GHG emissions. In addition to this GHG benefit, domestic corn ethanol significantly improves the local economies in which it is produced. This is especially critical in rural America, which would otherwise be even more adversely impacted by the global economic slowdown. By contrast, imported fuels (like sugarcane-based ethanol from Brazil) contribute to the U.S. trade deficit and produce no domestic jobs.

Since the RFS was adopted by Congress in 2005, biofuels have displaced nearly 2.5 billion barrels of oil in U.S. transportation. The United States has reduced greenhouse gas emissions by 752.33 million metric tons of CO2, compared to a scenario without the RFS in place. That reduction is the equivalent of taking 158.4 million cars off the road over the past 12 years. Unlike many other biofuels, corn grain ethanol results in the production of a valuable feed co-product: distillers dried grains (DDGs). The amount of DDGs produced is significant, about 17.4 lb/bushel, or more than 44 million short tons annually from 2014 to 2017.[4] While most of this material was used domestically as feed, 11 million short tons were exported each year, directly contributing to the overall balance of trade story.

[4] http://www.extension.iastate.edu/agdm/crops/outlook/dgsbalancesheet.pdf

The U.S. supply of corn grain has grown exponentially since the early 1930's, with annual production remaining above 13.6 billion bushels for the past 5 years (2013-2017). This represents a more than 500% increase from the 2.3 billion bushels produced on about the same land area in 1939. The compound annual growth rate in U.S. average corn yields is now 2.37%, which exceeds the current rate of world population growth (1.13%).[5] This excess supply has made it possible for the U.S. to utilize corn grain as a means to launch a sustainable biofuel business. Continued gains in corn grain are expected, based on better seed germplasm, continued biotech-based innovations, and more widespread adoption of advanced agronomic practices, such as precision agriculture. Another major new opportunity is to increase utilization of corn stover and corn fiber (see below), either as a feedstock for cellulosic ethanol, renewable energy generation, or as a feed supplement.

*ii. Soybeans*

Soybeans are by far the main source of vegetable oil production in the U.S. and likewise, biodiesel production. They represent more than 71% of U.S. biodiesel – with total U.S. production exceeding 1.5 billion gallons in 2016. Canola oil is the third largest biodiesel feedstock in the northern U.S., representing 13% of U.S. biodiesel in 2016. Corn oil is the second largest source of U.S. biodiesel, representing about 15%.[6]

Soybean yields continue to increase in the U.S. Just as in corn, these advances are coming through advanced breeding, biotechnology, and improved agronomic practices. The compound annual growth rate in U.S. average soybean yields is now 1.29%, somewhat less than in corn, but still outpacing the rate of global population growth. This means that soybeans should continue to represent a sustainable biodiesel feedstock in the future.

**The LCFS Should Reflect the Path to Economic Viability of Advanced Drop-in Biofuels**

Technology that allows the production of drop-in biofuels to be widely distributed could significantly improve the economic viability of the whole process. In reviewing economic viability of biofuels, there is a variance in net production cost by location and that is a result of the cost of feedstock transportation. Therefore, if the harvesting, processing, and conversion of cellulosic feedstocks can be accomplished within a few miles of each other the economics will be dramatically improved.

Several technologies moving to commercialization are producing breakthroughs in biotechnology of production organisms to utilize well-established feedstock sources and processing equipment for production of advanced drop-in biofuels offering a rapid path to

[5] USDA Feed Grains Database: https://www.ers.usda.gov/data-products/feed-grains-database/
[6] https://www.eia.gov/biofuels/biodiesel/production/table3.pdf

economic viability. Industrial biotechnology is also rapidly advancing production of advanced drop-in biofuels from next generation feedstocks, such as cellulosic biomass, MSW and algae. These next generation feedstocks have the potential to provide greatly enhanced supply of economically sustainable advanced drop-in biofuels that would help achieve the GHG reduction targets under the LCFS.

Thank you for considering these comments.

Sincerely,

Brent Erickson
Executive Vice President
Industrial and Environmental Section