

# Sustainable Aviation Biofuels Workgroup

Report to Washington State Legislature

January 26, 2018

The goal of the Sustainable Aviation Biofuels Workgroup (SABW) was to facilitate conversation among parties from state and federal government, the aviation industry, academic and national laboratory research organizations, and biomass feedstock producers to advance the development of a sustainable aviation biofuels industry in Washington.

The SABW was chaired by Senator Andy Billig and supported by Washington State University.

This report, prepared in 2017, is intended to be a final update from the SABW. It builds on the more comprehensive reports to the legislature from December 2012<sup>1</sup> and December 2013.<sup>2</sup>

During 2015 and 2016, the Sustainable Aviation Biofuels Workgroup conducted two meetings, the first on November 13, 2015 and the second on October 4, 2016, at WSU's Seattle office. Both meetings were attended by about 15 workgroup participants and guests. Thirty-one individuals constitute the workgroup, but individual schedules precluded full participation in the meetings.

The two meetings were structured to include a series of presentations and discussions about paths forward to advance the growth of the aviation biofuels industry in Washington.

Presentations were heard from:

- Biofuel industry representatives
- Research projects
- Government/non-profit organizations

## **Biofuel Industry Overview**

In June, 2016, the National Science and Technology Council published its "Federal Alternative Jet Fuels Research and Development Strategy."<sup>3</sup> While this document describes the various public policy and research activities that are being undertaken, the SABW focused on what could be done in Washington State to accelerate the development of the alternative jet fuel industry. A summary of existing developments follows.

Several biofuel companies with aviation biofuel off-take agreements and State of Washington connections exist. Among these are:

- AltAir, in whom the State invested \$2 million in federal stimulus funds. The company subsequently moved the focus of its operations from Washington to California with fuel being produced in Los Angeles and delivered to Los Angeles International Airport (LAX) in an agreement with United Airlines and others.<sup>4</sup>
- The Northwest Advanced Renewables Alliance's partner GEVO has an off-take agreement with Lufthansa.<sup>5</sup> At present, its fuel is produced in Texas and Minnesota, with no known plans for a production facility in Washington. It was the GEVO facility in Texas that converted the isobutanol produced from Washington forest residues into biojet fuel for the Alaska Airlines demonstration flight in November, 2016 as part of the NARA project.

---

<sup>1</sup> [www.climatesolutions.org/sites/default/files/uploads/pdf/aviation\\_biofuels\\_work\\_group\\_2012\\_update\\_1.pdf](http://www.climatesolutions.org/sites/default/files/uploads/pdf/aviation_biofuels_work_group_2012_update_1.pdf)

<sup>2</sup> no longer posted on-line, but available upon request

<sup>3</sup> [www.caafi.org/files/Federal\\_Alternative\\_Jet\\_Fuels\\_Research\\_and\\_Development\\_Strategy.pdf](http://www.caafi.org/files/Federal_Alternative_Jet_Fuels_Research_and_Development_Strategy.pdf)

<sup>4</sup> [www.united.com/web/en-US/content/company/globalcitizenship/environment/alternative-fuels.aspx](http://www.united.com/web/en-US/content/company/globalcitizenship/environment/alternative-fuels.aspx)

<sup>5</sup> [www.biofuelsdigest.com/bdigest/2016/09/08/gevo-lufthansa-rock-markets-with-renewable-jet-fuel-deal/](http://www.biofuelsdigest.com/bdigest/2016/09/08/gevo-lufthansa-rock-markets-with-renewable-jet-fuel-deal/)

Other companies with a presence in Washington, but without fuel off-take agreements with US-based carriers include:

- Renewable Energy Group, which is considering an investment in renewable diesel in Washington state.
- Mercurius Biorefining is developing its novel REACH (Renewable Acid hydrolysis Condensation Hydrotreating) process, which converts cellulosic biomass to hydrocarbons in the renewable diesel, aviation, and marine fuel ranges. Valuable by-products include bio-char and a bio-plastic monomer.<sup>6</sup>
- Neste, a Finnish company that converts vegetable oil into aviation biofuel, has been in discussions with Boeing<sup>7</sup> and the Port of Seattle as the Port works to enable the uploading of aviation biofuel to all aircraft at Sea-Tac Airport.

Still other companies developing or already producing aviation biofuels, but without a Washington connection include:

- Amyris, with its partner Total, the European oil producer, is marketing farnesene as a single molecule fuel for aviation biojet and diesel.<sup>8</sup>
- SG Preston has an off-take agreement with Jet Blue and Qantas, and is producing 120 million gallons per year of renewable jet and diesel from plant oils at their Ohio facility.<sup>9</sup>

### **Biofuel Industry Presentations at SABW Meetings**

A significant funding competition was undertaken by the USDA, USDOE, and USDOD to accelerate the deployment of alternative biojet fuel production facilities by providing matching capital grants and feedstock subsidies. Two of the three winning companies in the 2014 Defense Title III competition are Red Rock Biofuels and Fulcrum Bioenergy.<sup>10</sup> The SABW invited Red Rock Biofuels to present at the 2015 meeting and Fulcrum Bioenergy at the 2016 meeting. These two companies are establishing aviation biofuel production facilities in Oregon and Nevada, respectively.

Highlights of the presentations follow.

#### **Red Rock Biofuels**

- In late 2015, Red Rock Biofuels was acquired by Joule Unlimited. Both firms were financed by Flagship Ventures, and the merger improved Red Rock's access to near-term financing. Construction on their plant in Lakeview, Oregon is set to begin in 2017.
- Red Rock projects their plant will produce 15 million gallons of fuel annually from 140,000 dry tons of biomass. Offtake agreements for 3 million gallons per year are already in place with FedEx and Southwest Airlines.
- Primary feedstock will be biomass residuals from harvest and forest health treatments, though their Fischer-Tropsch process can also handle organics derived from municipal solid waste. Natural gas can also be used, especially if there are interruptions in biomass feedstock supplies.
- Their production pathway, which results in synthetic paraffinic kerosene, was the first certified aviation biofuel. A maximum 50/50 blend with jet fuel was approved in 2009.
- Red Rock is focusing on jet fuel instead of other distillates such as renewable diesel due to market demands (e.g. long-term offtake agreements).

---

<sup>6</sup> [www.mercuriusbiofuels.com/Technology.html](http://www.mercuriusbiofuels.com/Technology.html)

<sup>7</sup> [www.neste.com/en/neste-and-boeing-lead-industry-commercialization-renewable-aviation-fuels](http://www.neste.com/en/neste-and-boeing-lead-industry-commercialization-renewable-aviation-fuels)

<sup>8</sup> [bit.ly/2CPNsY9](http://bit.ly/2CPNsY9)

<sup>9</sup> [sgpreston.com/news-detail/18](http://sgpreston.com/news-detail/18)

<sup>10</sup> [www.biofuelsdigest.com/bdigest/2014/09/19/breaking-news-us-navy-doe-usda-award-210m-for-3-biorefineries-and-mil-spec-fuels/](http://www.biofuelsdigest.com/bdigest/2014/09/19/breaking-news-us-navy-doe-usda-award-210m-for-3-biorefineries-and-mil-spec-fuels/)

- Red Rock’s “sweet spot” for feedstock costs is approximately \$50 per bone dry ton. Their production operating expense, not including capital debt service, is roughly \$1.50-1.65/gallon.
- They will be selling offtake agreements into various markets based upon highest value under fuel incentive programs, which initially means shipping product to Oakland due to California’s low-carbon fuel standard (LCFS). The California Air Resources Board is in the process of including alternative jet fuels under the state’s LCFS, and the ability for aviation to opt-in to Oregon’s similar Clean Fuels program has been recommended as well.
- They would very much like the ban on Renewable Identification Numbers (RINs) used to track compliance with the federal Renewable Fuel Standard for biofuels produced from woody biomass harvested from federal lands to be lifted. Rep. Walden of Oregon has been a leader on this issue in recent years. The Congressional Biomass Caucus includes four representatives from the Northwest: Rep. McMorris-Rodgers from Washington, and Reps. DeFazio, Walden and Schrader from Oregon.

### **Fulcrum Bioenergy**

- Fulcrum Bioenergy converts municipal solid waste (MSW) into jet and other fuels and co-products. The company has a partnership with Waste Management Inc., a minority owner in Fulcrum, for feedstock and takeoff agreements with United Airlines, Cathay Pacific, and the US Air Force. Additional partners are Abengoa US, Abengoa, Tesoro, Waste Connections Inc., Abell Foundation, and Barrick.
- Fulcrum Bioenergy uses state-of-the-art sorting technology to separate MSW into a variety of marketable recyclables and feedstock for conversion into a synthesis gas by steam reforming gasification. The synthesis gas is then converted to fuel via Fischer-Tropsch technology. The company claims operating costs, not considering capital debt service, of less than \$1 per gallon, and a standardized design it hopes to replicate in numerous locations, including western Washington. When all plants are built, the company envisions 300 million gallons per year of production with carbon emissions reduced more than 80%.
- The company’s first plant (Sierra Biofuels) is being built in Reno, Nevada. The MSW handling and sorting portion is already under construction. The biorefinery is being built as a turn-key plant engineered to produce 11 million gallons per year of fuel. Completion by Abengoa US, with some input from Abengoa (the international parent of Abengoa US) is scheduled for 2020. Abengoa’s efforts to restructure their US subsidiaries under Chapter 11 and 15 bankruptcy proceedings has complicated Sierra’s development plans.
- The Sierra Biofuels plant is the beneficiary of a \$105 million loan guarantee from USDA and a \$70 million grant from the Defense Production Act, for a total of about 80% of the plant’s capital cost.

### **Conclusions and Challenges from Industrial Presentations:**

1. Low-cost feedstock, such as municipal solid waste or diseased trees, is important to the economic bottom line of these companies. However, MSW comes with an inherent challenge, the sourcing of reliable volumes in Washington due to the distributed nature of hauling contracts with private entities.
2. Stable government incentives and associated policies, both federal and state, are essential to stand up initial production facilities.
3. Off-take agreements and other forms of financial support from the airlines (such as joint venture investment) are important to complete the financial base.

## **Research Project Presentations**

During 2015 and 2016, the SABW also received updates and final presentations from the two large USDA-funded advanced biofuels research consortia based in Washington State, Advanced Hardwood Biofuels Northwest (AHB) and Northwest Advanced Renewables Alliance (NARA). These efforts continue to be led by the University of Washington and Washington State University, respectively. Both projects dealt extensively with feedstock and conversion supply chains, sustainability analyses, educational programming, and extension public outreach.

### **Advanced Hardwood Biofuels Northwest (AHB)<sup>11</sup>**

AHB is focused on laying the foundation for a renewable biofuels and bio-based chemical industry. High-value chemicals, such as acetic acid, ethyl acetate, ethylene and cellulosic ethanol, which are produced during the first stages of their targeted biorefining process, can be used to make an array of bioproducts, including paints and plastics.

The longer-term goal is to develop poplar-based biofuels including jet, diesel and gasoline fuels that can supplement fossil fuels. These biofuels will be certified to run in conventional car, truck, and aircraft engines and will be 100% compatible with existing infrastructure.

In 2016, AHB completed its five years of initial funding and entered a final-year, no-cost extension. The poplar partner, Greenwood Resources, has sold its 13,000-acre plantation in Boardman, Oregon to an agricultural consortium and dairy. The irrigated poplars were doing quite well at this location, as are non-irrigated plantations in other areas of the Northwest and California. All are producing about 10 tons of biomass per acre after the third year of growth. Harvesting costs are a significant expense, but a coppice harvesting technique has reduced the expense.

Feedstock studies included isoprene emissions, soil and water quality sensitivities, and determination of tree sterility. One conclusion is that it will be economically difficult to grow poplars on irrigated land, particularly if competing with more valuable agricultural crops. However, integration with wastewater and stormwater management systems offers promising future opportunities.

Industrial partner ZeaChem is going through changes in leadership, but the Boardman plant is running. The product focus is lactic rather than acetic acid.

Conversion take-away is that large facilities are needed to produce fuels economically, but large facilities will find it difficult to source feedstock only from poplar plantations. Early, smaller facilities should focus on producing higher value biochemicals.

### **Northwest Advanced Renewables Alliance (NARA)<sup>12</sup>**

NARA is focused on sustainable production of jet fuel and other valuable co-products from post-harvest forest residues and forest health treatments, i.e., tree-tops, limbs, and other forms of low-value biomass. The NARA team consists of 33 member organizations from universities, tribes, private companies, federal laboratories, and non-profit organizations. The project has completed its initial five-year funding period and is in a one-year, no-cost extension period during which final documentation will be completed.

---

<sup>11</sup> [hardwoodbiofuels.org](http://hardwoodbiofuels.org)

<sup>12</sup> [nararenewables.org](http://nararenewables.org)

A culmination of the project was the demonstration flight by Alaska Airlines on November 14, 2016 from Sea-Tac International Airport to Reagan National Airport in Washington, D.C. The flight was fueled by a 20% blend of biojet fuel produced by NARA participants. The demonstration flight documented the feasibility of using forest harvest residues converted to sugar by a USDA Forest Products Laboratory process (SPORL), with final conversion to isobutanol and then isoparaffinic kerosene (biojet) using technology provided by NARA-partner Gevo. This demonstration flight was the first to use a biojet fuel made from lignocellulosic (woody) feedstock. The flight attracted significant media attention and was met in DC by the Secretary of Agriculture, Tom Vilsack.

The project supply chain converts one metric ton of forest harvest residues into 190 liters of biojet fuel and substantial quantities of valuable coproducts such as lignosulfates, activated carbon, epoxies, and plastics.

Detailed regional supply analyses were produced for four areas of the Pacific Northwest.

Sustainability was of paramount importance in the project. Feedstock sustainability was documented through various studies with NARA partner Weyerhaeuser, along with participating university researchers. Long-term forest plots, detailed analysis of forest soil health, and basic genetics and genomics of Douglas fir were part of the NARA project. There are sufficient forest harvest residuals to meet up to 50% of the Pacific Northwest's biojet fuel needs in perpetuity.

Lifecycle analysis of the overall supply chain from forest through use of the biojet confirmed that it more than meets the 60% reduction in lifecycle greenhouse gas emissions required by the Federal government in order to be compliant with the Renewable Fuels Standard for cellulosic biofuels.

Over 35,000 people – including students from kindergarten through graduate school, plus many members of the general public and teaching profession – learned about sustainable production of jet fuel from forest harvest residues by an extensive team of educators.

Detailed reports and educational materials are available on the NARA website and are archived at WSU's library archive site.<sup>13</sup>

### **Conclusions from Research Presentations:**

These two projects have produced an enormous amount of information about the potential for producing jet fuel from Pacific Northwest woody feedstocks. Common conclusions include:

1. The path to economically viable biojet fuel from woody feedstocks requires development and marketing of valuable co-products.
2. Environmentally sustainable supply chains in the Pacific Northwest can provide feedstock for up to 50% of the region's aviation fuel needs without negatively impacting forest ecosystem functions.
3. Economic impacts to rural forested communities will be significant, partially replacing job losses resulting from closure of forest product mills.
4. To expedite the development of the biojet industry, action on state-level policies and incentives similar to those in California and Oregon will be required.

---

<sup>13</sup> [research.libraries.wsu.edu/xmlui/handle/2376/5309](http://research.libraries.wsu.edu/xmlui/handle/2376/5309)

## **Port of Seattle Report on Biojet Fuel Infrastructure**<sup>14</sup>

A study jointly funded by the Port of Seattle, Boeing and Alaska Airlines examined the distribution chain for delivery of 50 million gallons per year of neat biofuels (prior to mixing with fossil jet) to Sea-Tac Airport. Various means of transport were analyzed, including rail, road, and barge. The study considered initial and long-term buildout of the infrastructure, including what properties would need to be acquired.

Relevant findings include:

- The Olympic Pipeline, which transports fuel south from refineries in Whatcom and Skagit counties, is heavily scheduled, and bringing in a blended product will be difficult.
- Olympic's Renton station is one potential focal point as it is the origin of a spur that only carries jet fuel to Sea-Tac Airport.
- Another spur exists from Renton to Harbor Island in Seattle. The study considered interim reversal of flows to facilitate barging biojet to Harbor Island and then using the pipeline to send it to Sea-Tac Airport. Initial analysis indicates this is probably too expensive.
- Possible blending sites are at the refineries in the north, at Sea-Tac Airport's tank farm, or in Renton.

### **Observations:**

This study communicates a serious commitment by the Port and its partners to moving forward quickly on the vision of providing biojet fuel to all aircraft fueling at Sea-Tac Airport. This effort should be seen positively by biojet producers looking to locate in Washington.

### **Concluding Comments and Observations**

The meetings of the SABW have facilitated continuing discussion among the various interested parties in Washington.

Looking forward, the SABW found that significant, stable state-level policies and incentives are vital to the future of the aviation biofuels industry. As noted in the policy recommendations from SABW's 2013 Update, these include aligning tax incentives to support the industry, continued funding of research and development efforts, public sector procurement requirements (especially for co-products resulting from biorefining), and a willingness to engage in the public-private partnerships necessary to attract capital investment.

Most importantly, the state should consider adopting fuel content requirements such as a low-carbon fuel standard to drive adequate market demand. It is obvious that policies in California have put that state at the forefront of biojet fuel production for commercial airlines. Los Angeles International Airport has biojet provided by AltAir, a company with its roots in Seattle, from a production facility in the Los Angeles near to the airport. The feedstock is reclaimed vegetable oil and animal oils. The two companies that spoke with the SABW during these two years are both targeting distribution into California. All have reported that the incentives provided by California are critical in business decisions to stand-up the facilities.

The SABW has completed its tenure as defined by the Washington Legislature. While it is hoped that the networking will continue, there is no state sponsorship of this effort at this time.

As a final note, the working group greatly appreciates the leadership of Sen. Billig, without whom the SABW would never have existed.

---

<sup>14</sup> [www.portseattle.org/Environmental/Documents/Aviation\\_Biofuel\\_Infrastructure\\_Report\\_Condensed.pdf](http://www.portseattle.org/Environmental/Documents/Aviation_Biofuel_Infrastructure_Report_Condensed.pdf)