DOE to award $118M to 17 projects to accelerate domestic biofuel production (https://www.greencarcongress.com/2023/01/20230127-doe.html)

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The US Department of Energy (DOE) will award (https://www.energy.gov/articles/us-department-energy-awards-118-million-accelerate-domestic-biofuel-production) some $118 million in funding for 17 projects to accelerate the production of sustainable biofuels. Made from widely available domestic feedstocks and advanced refining technologies, energy-dense biofuels provide a pathway for low-carbon fuels that can lower greenhouse gas emissions throughout the transportation sector and accelerate the bioeconomy.

Financing for novel biorefinery process systems can be a barrier to commercializing advanced biofuels, and this funding will reduce technological uncertainties and enable industry deployment.

The projects also support the US Sustainable Aviation Fuel Grand Challenge goal of enabling the production of three billion gallons of sustainable aviation fuel annually by 2030 and 35 billion gallons annually by 2050.

The selections, which are subject to final award negotiations and additional eligibility vetting, will be administered by DOE's Bioenergy Technologies Office (BETO). Over the past two years, DOE has invested more than $500 million in bioenergy and biorefinery research and development through BETO.

Award amounts range from $500,000 to $80 million, with most receiving at least $2 million. The 17 selected projects fall into four areas:

1. Pre-Pilot Scale-Up of Integrated Biorefineries,
2. Pilot Scale-Up of Integrated Biorefineries,
3. Demonstration Scale-Up of Integrated Biorefineries, and
4. Gen-1 Corn Ethanol Emission Reduction.

Topic Area 1: Pre-Pilot Scale-Up of Integrated Biorefineries

Algenesis Corporation, "Pre-Pilot Scale Production of Algae-based Jet Fuel and Polyurethane Monomers", $4,987,974. The goal of the project is to continue to develop a circular carbon economy that replaces the petroleum-based chemicals in consumer products with algae-derived and biodegradable polymers. Under this project, Algenesis will demonstrate a scaled supply process for generating polyurethane monomers at sufficient quantity to produce a line of prototype consumer products with our corporate partners.

It will valorize the economic production of algae-based biofuels and de-risk the mass manufacturing of algae-based polyurethanes, and associated consumer products. To accomplish this, the company proposes to: 1) Develop a refining process that utilizes differential precipitation (winterization) of crude algae oil, derived from biomass grown utilizing direct air capture, to separate saturated and unsaturated fatty acids; 2) Chemical processing of the recovered fatty acids into biofuels (saturated FA) and polyurethane precursors (unsaturatedFA); and 3) Production of ASTM certified renewable jet fuels and finished polyurethane products that meet industrial standards, from these precursors.

Captis Aire LLC, "Renewable Blending Components to Enable 100% Sustainable Aviation Fuel (SAF)", $2,000,000. This project will demonstrate the conversion of gaseous carbon wood wastes (terpenes) to renewable Terpenes SAF blending components. Captis will blend these with fuels from previously ASTM-approved SAF production pathways, for example Hydroprocessed Esters and Fatty Acids Synthetic Paraffinic Kerosene (HEFA-SPK), to provide fully formulated, backwards compatible, 100% SAF, also termed 'drop-in' SAF.

Currently, SAF is typically blended with fossil fuels. This diminishes the sustainability of the resulting fuel. This issue has motivated R&D toward the development of the fully formulated, drop-in Terpenes SAF. This approach enables 100% SAF for the three most technically mature SAF pathways, termed "Leader Pathways". The SAF blends are expected to meet not only minimum ASTM specification requirements, but also density requirements. Hundreds of millions of gallons of drop-in 100% SAF will be unlocked.

Comstock Inc., "Production of Renewable Diesel, Sustainable Aviation Fuel, Gasoline, and Marine Fuel from Lignocellulosic Biomass at Dramatically Improved Yield, Efficiency, and Cost", $2,000,000. Comstock proposes to build a pre-pilot scale system to demonstrate a novel new pathway to convert its biointermediates from forestry residues and other forms of lignocellulosic biomass into renewable diesel, sustainable aviation fuel, gasoline, and marine fuel at dramatically improved yield, efficiency, and cost.

Comstock's proposed pre-pilot scale system will validate best-in-class renewable fuel yields exceeding 80 gallons per dry ton (on a gasoline gallon equivalent basis), carbon efficiencies exceeding 40%, and a minimum fuel selling price of less than $2.65 per GGE, with lifecycle emissions reductions exceeding 80% over petroleum.

Global Algae Innovations, "Algae Direct Air Capture Scale-up to Multi-Acre Raceways", $3,600,000. In this project, the recently developed technology for algae cultivation solely on carbon dioxide supplied through direct-air-capture will be scaled to a 12-acre raceway with a 50,000 gallons per year biofuel intermediate production rate. With this approach, carbon dioxide is directly absorbed from the atmosphere into the open raceways so that no separate carbon dioxide concentrating or distribution system. Direct air capture of carbon dioxide is a key technology that not only reduces the cost of algae biofuel production, but greatly increases the volume of algae biofuel that can be produced by enabling algae farms to be located anywhere.

This technology will be scaled a validated through the integrated cultivation and harvesting with full media recycle in a new cultivation facility located in Shandon, CA. The advanced cultivation will be operated for 12 months to demonstrate the efficacy of the process and generate key performance parameters to validate the projected minimum fuel selling price of $2.50/gallon with over 80% reduction in greenhouse gas emissions.

MicroBio Engineering Inc., "Attached Algae Flow Ways for Biofuels Production Utilizing Air-CO_2", $3,978,199. This project will develop and demonstrate, at the pre-pilot scale , an innovative microalgae biomass and biofuels production process using air-CO_2 and Attached Algae Flow Ways (AAFW). Tthis project will cultivate selected filamentous algal species to maximize 1) biomass production, 2) air-CO_2 utilization, 3) biofuel yields, and 4) nutrients (N and P) recovery.

The project will demonstrate 12,500 GGE algae biofuels production potential on air-CO_2 at an operating facility.

Research Triangle Institute, "A Corn Stover Pyrolysis Pathway for Sustainable Aviation Fuel", $2,000,000. RTI International and partners at POET Research, Inc. and the National High Magnetic Field Laboratory (the MagLab) at Florida State University (FSU) will leverage existing capabilities to develop and demonstrate an integrated process to convert preprocessed corn stover into SAF through a catalytic fast pyrolysis (CFP), biocrude intermediate upgrading pathway.

The integrated technology consists of a novel corn stover preprocessing step to remove alkali and alkaline earth metals, corn stover CFP, biocrude hydroprocessing, and distillation for SAF recovery.

University of California Riverside, "Scale-up Demonstration of Hybrid Catalytic Biorefining of Biomass to Sustainable Aviation and Marine Fuels", $2,000,000. This project aims to build and demonstrate a scaled-up CELF (co-solvent enhanced lignocellulosic fractionation) pretreatment and lignin fractionation operation within the hybrid catalytic biorefining (HCB) architecture capable of processing at least 0.5 dry ton equivalents of hardwood biomass per day (0.5 TPD) to produce high-quality lignin intermediates suitable for the production of renewable jet fuels and marine fuels.

A primary objective of this project is to also demonstrate the reliable and continuous on-stream operation of 100 h while collecting critical operational data over 500 h cumulative to inform larger future scale-up demonstration projects. The pre-pilot will also feature a custom-made solvent recovery system to recover and re-use the solvent and fractionate the CELF lignin simultaneously into low and high MW cuts. The project will be underpinned by technoeconomic and lifecycle analysis simulations that will aid in optimizing process configurations for reducing carbon intensity and operating costs.

University of Utah, "Entrained-Flow Biomass Gasification with Syngas Fermentation for Production of Sustainable Aviation Fuels" $2,000,000. This project will scale up and demonstrate that biomass can be efficiently processed in a pressurized entrained-flow gasifier to produce syngas suitable for production of sustainable aviation fuels (SAF).

Expected outcomes include (1) showing that liquifying lignocellulosic biomass and sorted municipal solid waste by pyrolytic liquefaction enables it to be pumped and fed to a high-pressure gasifier, (2) demonstrating that conversion in an entrained-flow gasifier achieves more than 98% conversion of carbon to syngas, (3) proving that the syngas has negligible tar and soot and is suitable for fermentation to ethanol, and (4) verifying that SAF production via entrained-

flow gasification with syngas fermentation can achieve a fuel selling price cost-competitive with petroleum-based fuels, with greater than 50% conversion of biogenic carbon to fuel, and GHG reductions of at least 70% relative to petroleum-based equivalents.

Viridos, Inc., "Pre-pilot Integrated Sustainable Aviation Fuels Algae Biorefinery", $2,000,000. This project will deliver a demonstrated scalable, deployment-ready oil-extraction system focused on creating a low carbon-intensity pathway to algae-based sustainable aviation fuels (SAF). The envisioned system will be developed to support production of at least 0.5 dry ton per day algal biomass at Viridos' California Advanced Algal Facility (CAAF), in Calipatria, CA, and processing and extracting oil using NREL's pilot plants to meet the equivalent target of at least 35 gallons of upgrading-ready oils.

Viridos, formerly Synthetic Genomics, is a leader in the field of synthetic biology and innovative algae farming.

Topic Area 2: Pilot Scale-Up of Integrated Biorefineries

LanzaTech, Inc., "RESTORE: Replenishing EcoSystems by Transforming Residues to Energy", $1,640,286. LanzaTech proposes to pilot an integrated field-deployable, zero-discharge, biorefinery concept for distributed production of ethanol—as feedstock for larger LanzaJet alcohol-to-jet SAF facilities—and biochar for soil amendment. One target application is processing residues and small-bore trees removed by the US Forest Service (USFS) to reduce wildfire risk. Pacific Northwest National Laboratory (PNNL) will assess ecosystem services impacts at the watershed level and Roundtable on Sustainable Biomaterials (RSB) will advise on requirements for sustainability certification.

The pilot will consist of a low cost, easy to operate, air blown gasifier coupled with LanzaTech's second generation bioreactor (2GBR). The ethanol will be converted to sustainable aviation fuel at LanzaJet's Freedom Pines Fuels facility, in Soperton, Georgia. USDA's Agricultural Research Laboratory (ARS) in Corvallis, Oregon will assess biochar quality for soil uses, including returning carbon to forest.

MicroBio Engineering Inc., "Scale-up of Hydrothermal Liquefaction with Supercritical Water Oxidation in an Integrated Biorefinery", $579,673. This project will integrate hydrothermal liquefaction (HTL) with supercritical water oxidation (SCWO) technologies in an innovative integrated HTL-SCWO biorefinery approach, in which municipal wastewater sludges are converted to biocrude oil, to be upgraded to sustainable marine, diesel and aviation fuels. Co-products recovered from the process include phosphorus fertilizers and reclaimed water free of recalcitrant organic contaminants such as PFAS (per- and polyfluoroalkyl substances), microplastics and residual toxic organics generated in the HTL process. The SCWO process requires no catalysts and generates heat that can be recovered for use in HTL process, reducing greenhouse gas emissions by over 70% compared to fossil fuels.

In the HTL process the wastewater sludge (at approximately 20% solids and 80% water) is fed into the reactor heated to near 350 °C at about 250 atmospheres pressure, with the resulting products separated by filtration and decantation after cooling into the crude oil, water, solids and gaseous phases. The recovered oil phase contains about 50% of the initial organic carbon and near two-thirds of the energy content of the sludge feed.

Topic Area 3: Demonstration Scale-Up of Integrated Biorefineries

Alder Fuels, LLC, "Decarbonizing the Skies – Sustainable Aviation Fuel from Alder Biocrude Oil", $2,000,000. Alder Fuel's approach to scaling SAF integrates commercial fast pyrolysis technology into existing refinery infrastructure. Alder builds upon decades of technical learning within the pyrolysis community to separate highly reactive components in fast pyrolysis oil that plug hydrotreaters into an aqueous phase and convert the remaining organic components into hydrocarbons. This enables downstream distillate hydroprocessing using commercial sulfided, base-metal catalysts as practiced today to process fats, oils, grease (FOG) and petroleum. Alder biocrude can be co-hydroprocessed with esters and fatty acids (HEFA) to deliver SAF with exceptional energy density, reduced sooting tendency, and polymer seal swell.

The goal of Phase One is to complete the engineering design work to establish the first Alder Fuel's demonstration facility in the southeastern US, which will be rated to process 120 dry metric tonnes per day (MTD) of forest residuals and produce 3 million gallons per year (MGPY) of liquid hydrocarbon biofuel. Critically, 2 MGPY will be sustainable aviation fuel (SAF). Success at the demonstration scale will enable Alder Fuels to rapidly scale to commercial levels and produce SAF with more than a 70% reduction in the carbon intensity and minimum fuel selling price below $4/gallon.

AVAPCO LLC, "AVAP Biorefinery: Enabling Net Zero", $80,000,000. The proposed project will construct and operate a 1.2 million gallon per year equivalent fully integrated biomass to cellulosic Sustainable Aviation Fuel (SAF) and renewable diesel demonstration plant. Valuable co-products will include second generation (2G) cellulosic sugars for conversion to biochemicals and a nanocellulose rubber masterbatch, the Nanocellulose Dispersion Composite (NDC), for the tire and rubber goods industries.

The project would be Phase 2 of AVAPCO's "ABBA: Advanced Biofuels and Bioproducts with AVAP" project awarded for Phase 1 (Design Phase) under the DOE's 2016 FOA: Project Development for Pilot and Demonstration Scale Manufacturing of Biofuels, Bioproducts, and Biopower. Project partners include Petron Scientech, Byogy Renewables, Birla Carbon, and Clark Atlanta University.

Topic Area 4: Gen-1 Corn Ethanol Emission Reduction

Green Plains, "Emissions Reduction Technologies for Green Plains Biorefineries" $500,000. This project will validate three different technology platforms at Green Plains facilities, in a means to reduce their life cycle GHG emissions from Scope 1, Scope 2, and Scope 3 emissions. The technologies include on site renewable synthesis gas production (Scope 1), wind and solar generation/utilization (Scope 2), and reduction of farm-level emissions utilizing advanced crop management practices and reduced fertilizer use (Scope 3).

Lincolnway Energy LLC, "Reduced Carbon Intensity Ethanol via Biogas from Stillage & Other Feedstocks", $453,000. This project will evaluate the feasibility of deploying biogas (anaerobic digestion) technology using various forms of stillage and/or corn stover in a site-specific design to provide an integrated analysis to scale-up biogas technology with corn-ethanol production. The project design and learnings can be applied across the entire US corn ethanol industry upon successful commercialization of this technology, as well as future ethanol derivatives such as sustainable aviation fuels (SAF).

Marquis, Inc, "Carbon Refining: Corn Ethanol 2.0", $8,547,047. Marquis will host, commission, and operate a LanzaTech skid-mounted gas fermentation pilot plant at its Hennepin, IL biorefinery, sourcing CO_2 from operations and low CI H_2 to produce low CI ethanol at >70% GHG emissions relative to petroleum-based alternatives. This collaboration can lower the CI and increase ethanol yield by 50% without additional land and/or fertilizers of 1G ethanol biorefineries.

RenewCO2 Inc, "Integrated Electrocatalytic Conversion of CO_2 from Bio-Ethanol Emissions into Carbon-Negative Chemicals", $499,953. The objective of the project is to conduct a feasibility study for converting waste CO_2 from bioethanol production to a value-added plastics monomer with RenewCO2's electrochemical process to (i) reduce the carbon footprint of the biofuel by more than 70% compared with gasoline and (ii) achieve a cost-competitive Minimum Fuel selling Price (MFSP).

The proposed integrated system will be based on a Generation 1 Corn Ethanol Plant and will utilize the current CO_2 waste gas as a feedstock for the production of monoethylene glycol (MEG) via RenewCO2's electrochemical process. Further, a techno-economic analysis and lifecycle GHG benefit analysis will validate the projections using real-world processes and provide a representative sample of replicable cases to catalyze widespread adoption.

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