U.S. DEPARTMENT OF
ENERGY

Office of
ENERGY EFFICIENCY & RENEWABLE ENERGY

Benefits of Biofuel Production and Use Series—Spotlight on Colorado

Congressional staff members smell different biofuel products during a tour of the Integrated Biorefinery Research Facility at the National Renewable Energy Laboratory (NREL). *Photo credit: NREL.*

The U.S. Department of Energy's (DOE's) Bionergy Technologies Office (BETO) enables the development of novel technologies that can be used to establish Colorado as one of the leaders in the bioeconomy. Colorado can leverage its existing, abundant biomass resources to produce biofuels and high-value products.

Setting the Stage for Biofuels

Colorado's biomass resources offer a sustainable strategy to stimulate economic growth, improve U.S. energy security, reduce harmful emissions, and create new jobs.

- **Economy**

  Colorado spent $7.4 billion on petroleum for transportation in 2015. Investments in Colorado biofuels help keep a larger portion of those dollars within the state to stimulate economic development and add to jobs in the state's bioenergy and biobased products industries.

- **Energy**

  Colorado's transportation sector consumed 75.4 million barrels of petroleum in 2015—about 60% of its total production (126 million barrels). Colorado embodies the "all-of-the-above" strategy by developing its abundant conventional and renewable energy resources. Locally produced biobased fuels and products support this strategy.

- **Environment**

  In 2014, fossil fuels' use by Colorado's transportation sector released 28 million metric tons of carbon dioxide. On a life-cycle basis, advanced biofuels can reduce harmful emissions by >50% compared to petroleum—helping to reduce environmental impacts.

- **Feedstocks**

  Colorado has 6.7 million dry tons of annual biomass resources potential that can be sustainably utilized to produce advanced biofuels and high-value products. Utilization of municipal solid waste, energy crops, and algae can all contribute to the bioeconomy and the production of biofuels and products.

Bringing Technology to Market

Strategic policies and investments help bridge the gap between promising research and large-scale production of advanced biofuels.

- The Bioscience Discovery Evaluation Grant Program aids in the growth of the bioscience industry in Colorado. Since 2007, the program has helped to establish 45 new Colorado companies that commercialize biofuels and other bioscience technologies.

- Since 2006, BETO has awarded more than $556 million to national laboratory, university, and industrial partners in Colorado to research, develop, and demonstrate sustainable biobased fuels and products. Of this total, the **National Renewable Energy Laboratory (NREL)** received $522 million in DOE funds. NREL is also developing technologies and helping prepare a new-generation workforce to enable the commercialization of drop-in biofuels. NREL's algae research and development (R&D) is distributed across the entire value chain, from production strain identification to biofuel and bioproducts upgrading.

Renewable Bioenergy Program at NREL

Colorado is home to NREL, which is developing technologies to sustainably convert non-food biomass resources to fuels, chemicals, and materials. Its research facilities include the following:

- **Integrated Biorefinery Research Facility** enables researchers and industry partners to develop and test novel biochemical processes for producing biobased fuels and products.

- **Thermochemical Users Facility** enables the testing and development of reactors, filters, catalysts, and other thermochemical conversion-unit operations at a minimal industrially relevant scale.

- **Energy Systems Integration Facility** enables high-performance computing and collaborators to accelerate the integration of renewable energy and energy efficiency technologies.

Why Colorado?

- **State Mandate**

  Colorado's Renewable Energy Standard requires investor-owned

electric utilities to provide 30% of electricity sold from renewable energy sources by 2020, with 3% coming from distributed generation.[1]

- **Innovative Research**

  NREL's national leadership in innovative research supports growth of the bioeconomy in Colorado. NREL has over 300 licensable, patented technologies, and in 2016, it had 259 new and 749 total active technology partnership agreements.

- **Jobs and Economy**

  In 2013, the state's biobased products industry contributed 11,500 direct jobs (21,800 total jobs) and $635 million in direct value ($1.53 billion in total value). In 2015, Colorado's ethanol industry generated about 140 direct jobs and 2,780 total jobs.[2]

DOE has supported the Colorado Center for Biorefining and Bioproducts (C2B2)—a cooperative research and educational center combining the work of Colorado universities and NREL—as well as individual projects from the University of Colorado, Colorado School of Mines, and Colorado State University. DOE seeks to accelerate promising biofuel and biotechnologies research towards a point where industry can take these forward to market. ■

BETO Projects in Colorado

Organization	Colorado State University	Colorado School of Mines	NREL		University of Colorado & C2B2	PACE, Colorado School of Mines[3]
Project	Develop computational models to build more efficient biomass cookstoves	Improve biomass yields with high-throughput directed evolution of marine microalgae and phototrophic consortia	Advance production of cost-competitive, high-performance carbon fiber material from non-food-based feedstocks	Valorize biogas: develop of a biogas-to-muconic acid bioprocess	Develop rapid solar-thermal chemical reactor systems for the conversion of biomass	Enhance overall algal biofuels sustainability by maximizing carbon dioxide, nutrient, and water recovery and recycling, as well as biopower cogeneration
Location	Fort Collins	Golden	Golden	Golden	Boulder	Multiple
Stage	R&D and lab testing	R&D and lab testing	R&D	R&D	R&D	R&D
Primary product	Clean biomass cookstoves	Process improvement	Renewable carbon-fiber-based materials	Muconic acid (a key building block for producing biofuel and bioproducts)	Synthesis gas	Fuels and high-value coproducts from algae
Feedstock	Multiple woody crops (e.g., fir, coconut, wood pellets)	Algae	Acrylonitrile produced from lignocellulosic biomass-derived sugars	Biogas substrates (microorganisms convert methane to muconic acid	Multiple (e.g., grass, sorghum, corn stalks and leaves, wood waste, and algae)	Algae

[1] The Eagle Valley Clean Energy (EVCE) biomass plant in Gypsum is Colorado's first commercial-scale woody biomass plant, which burns waste gathered from surrounding forests and consumes trees culled as part of efforts to fight pine beetle infestations.

[2] Based on NREL's Jobs and Economic Development Impact (JEDI) model job estimates, which are full-time equivalent employees per year.

[3] Producing Algae and Co-Products for Energy (PACE) consortium, led by Colorado School of Mines, is collaborating with Los Alamos National Laboratory, Reliance Industries Limited, Genifuel Corporation, and others.

For more information on Colorado's energy portfolio and the economic and environmental benefits of biofuels, visit:

Colorado state profile and energy estimates
Colorado Energy Office
U.S. petroleum consumption by sector – 2015
U.S. petroleum expenditures by sector – 2015
State carbon dioxide emissions – 2014
2016 Billion-Ton Report state biomass resources download tool
U.S. Department of Agriculture analysis on economic impact of U.S. biobased products industry
U.S. ethanol capacity and production by states (2016)

For more information on Colorado clean energy initiatives and DOE partnerships, visit:

Colorado energy policy
BETO funding opportunities
About DOE-BETO
BETO biogas research
NREL technology partnerships
NREL bioenergy research
NREL projects
NREL Thermochemical Users Facility
NREL Integrated Biorefinery Research Facility

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For more information, visit
energy.gov/eere/bioenergy

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