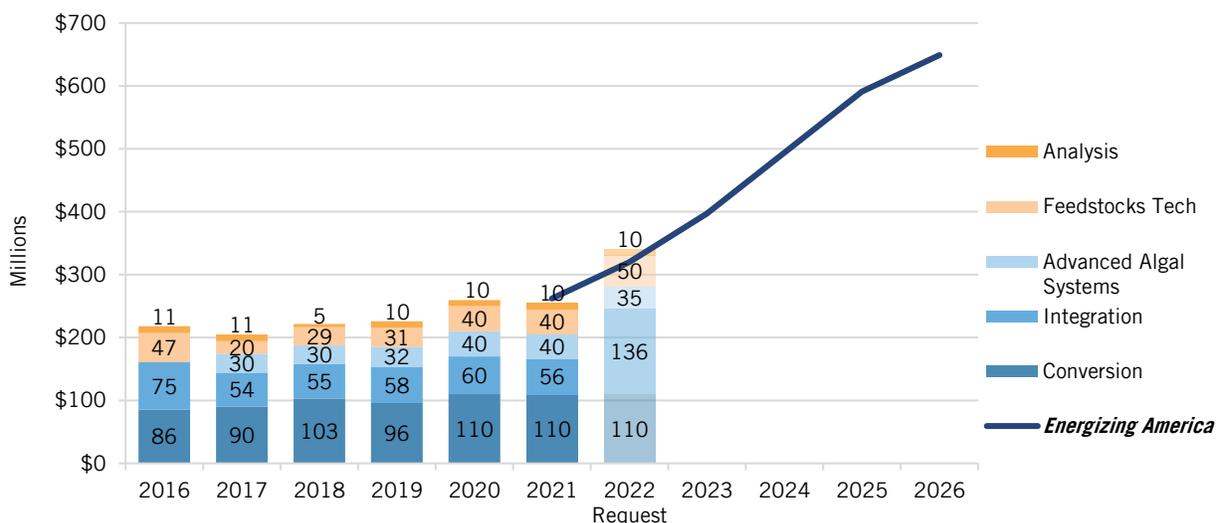


Federal Energy RD&D: Bioenergy Technologies

BY COLIN CUNLIFF AND LINH NGUYEN | JUNE 2021

The Department of Energy’s (DOE) Bioenergy Technologies Office (BETO) focuses on research, development, and demonstration (RD&D) to develop sustainable bioenergy technologies capable of producing price-competitive biofuels from nonfood sources of biomass such as wastes and agricultural residues, and energy crops such as switchgrass and algae. The program’s primary RD&D focus is on creating “drop-in” biofuels that are compatible with both existing fueling infrastructure and vehicles across a range of transportation modes, including renewable gasoline, diesel, and jet fuels. Transportation is the largest greenhouse gas-emitting sector in the United States, having surpassed electric power in 2016.¹

Figure 1: *Energizing America* recommends ramping up funding by 150 percent by FY 2026.²



What’s at Stake

The United States has the potential to sustainably produce 1 billion dry tons of nonfood biomass resources by 2030 without disrupting agricultural markets for food and animal feed.³ This feedstock could be converted into approximately 50 billion gallons of biofuels (25 percent of U.S. transportation fuels), 50 billion pounds of high-value chemicals and products, and 75 billion kilowatt-hours (kWh) of electricity—enough to power 7 million homes—each year.⁴ In addition, enough algae, which grows quickly and consumes waste, could be harvested to provide another 5 billion gallons per year (BGY)—about 20 percent of the current domestic jet-fuel market—by 2030, and 20 BGY in the long run.⁵ A number of other bioenergy pathways, combined with carbon sequestration technologies, offer the potential to remove carbon dioxide from the atmosphere, resulting in carbon-neutral or even carbon-negative bioproducts.⁶

Each of the bioenergy production and conversion targets within BETO was chosen to create new technology options that are more efficient than, and at least as affordable as, conventional

technology. Achieving these targets would both improve transportation-energy affordability and take the United States one step closer to reaching its national goals in energy security, economic growth, and environmental stewardship.

The Energy Act of 2020 provides the first reauthorization of DOE's Sustainable Transportation program—which includes BETO, the Vehicle Technologies Office, and the Hydrogen and Fuel Cell Technologies Office—in over a decade. The bill authorizes \$830 million for FY 2021, \$855 million for FY 2022, and \$880 million for FY 2023 for Sustainable Transportation—although it does not specify the amount to be allocated to each office.⁷

Figure 1 shows historical DOE investment in bioenergy technologies RD&D by subprogram, for fiscal years 2016 through 2021, and the FY 2022 budget request. The blue line shows recommended funding levels from the *Energizing America* report (see box 1). Because bioenergy plays such an important role in addressing many harder-to-abate transportation and industrial sectors, *Energizing America* recommends a fast ramp-up to 150 percent above FY 2020 levels over the next five years.

Box 1: An Innovation Agenda for Bioenergy Technologies

The *Energizing America* report co-authored by the Information Technology and Innovation Foundation (ITIF) and Columbia University's Center on Global Energy Policy offers several recommendations to accelerate innovation in bioenergy technologies. Similarly, ITIF's September 2020 report "Gene Editing for the Climate: Biological Solutions for Curbing Greenhouse Gas Emissions" makes recommendations to DOE and Congress:

- Congress should ramp up investment in bioenergy and biomanufacturing RD&D by 150 percent over the next five years.⁸ This increase is needed to make up for historical underinvestment and help scale promising bio-technologies from the lab to commercial scale.
- Congress and DOE should create a permanent research program to develop negative emissions technologies such as bioenergy with carbon capture and storage (BECCS).⁹
- Congress should allow farmers and state and local governments to take advantage of the Section 45Q tax credit for carbon capture projects that use gene-edited technologies.¹⁰ The 45Q tax credit could complement DOE's BECCS programs by expanding the market for BECCS technologies.
- DOE and the United States Department of Agriculture (USDA) Biofuels program should support the development of drop-in fuels for aviation, shipping, and other hard-to-electrify transportation sectors.¹¹
- DOE should expand its recent initiative to support research into gene-editing tools that improve cellulosic biomass processing to make switchgrass, sorghum, and even trees become economical materials for biofuels production. There is also considerable potential for gene-edited improvements in harnessing algae to produce energy-dense compounds such as butanol.¹²

Bioenergy Technologies RD&D Subprograms

RD&D in the Bioenergy program is distributed across these five subprograms:¹³

- **Feedstock Technologies** develops and improves strategies, technologies, and systems to provide consistent quality feedstock to biorefineries, while focusing on supply and logistics challenges to support further development of advanced biofuels. The Feedstock subprogram funds the Feedstock Conversion Interface Consortium (FCIC), a group of eight national laboratories focused on feedstock handling, preprocessing, and conversion opportunities in order to reduce the sales price of biofuel.
- **Advanced Algal Systems** supports RD&D of algal-biomass production and logistics systems, with a focus on improving capabilities to predict, breed, and select the best-performing algal strains, harvest algae at high-throughputs, and extract and convert algal biomass components into fuels.
- **Conversion Technologies** focuses on converting biomass feedstocks into “drop-in” hydrocarbon transportation fuels and coproduced bioproducts and explores both biological and thermochemical conversion pathways.
- **System Development and Integration** works to scale up integrated biorefinery systems and focuses on both the development, testing, and verification of biorefinery processes, and the identification of new market opportunities for bioproducts.
- **Data, Modeling, and Analysis** provides quantitative evaluations to inform BETO decisions regarding the future direction and scope of its RD&D portfolio.

Key Elements of the FY 2022 Budget Proposal¹⁴

The budget proposal seeks \$340 million for the Bioenergy program, a 33 percent boost from FY 2021 enacted levels. Some highlights include:

- **A 144 percent increase in System Development and Integration**, including a \$77.5 million increase in funding to scale up RD&D for biofuel production, with a focus on aviation fuels and waste-to-energy technologies.
- **A 13 percent reduction in Advanced Algal Systems**, including a \$5 million reduction in funding for research on direct air capture technologies. Direct air capture (DAC) technologies remove carbon dioxide directly from the atmosphere, offering the potential for carbon-neutral or even carbon-negative applications. Algal bioenergy systems often use carbon dioxide as a feedstock. In FY 2020, DOE issued a new competitive funding opportunity to integrate DAC technologies with algal bioproduct systems, with the goal of reducing both algae biomass production costs and net carbon emissions.
- **A 25 percent increase in Feedstock Technologies**, including increased funding for national laboratory research and development (R&D) activities focused on soil carbon sequestration, bioenergy with carbon sequestration (BECCS), and other sustainable agriculture technologies; continued funding for competitive research to reduce the costs of feedstock logistics; continued funding for the Feedstock-Conversion Interface

Consortium (FCIC); continued funding for R&D on harvest logistics and quality assurance, biomass densification, and biomass analytic;

- **No change in total funding for Conversion Technologies R&D**, including funding increases for bio-processing R&D, catalyst R&D, and co-products R&D, and a funding decrease of \$26.5 million for deconstruction and synthesis R&D, an area that has been a focus in prior years.
- **No change in the Data, Modeling, and Analysis subprogram.**

Further Reading

- Varun Sivaram et al., *Energizing America: A Roadmap to Launch a National Energy Innovation Mission* (ITIF and Columbia University SIPA Center on Global Energy Policy, 2020), <http://www2.itif.org/2020-energizing-america.pdf>.
- L. Val Giddings et al., “Gene Editing for the Climate: Biological Solutions for Curbing Greenhouse Emissions” (Information Technology and Innovation Foundation, September 2020), <http://www2.itif.org/2020-gene-edited-climate-solutions.pdf>.

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ENDNOTES

1. U.S. Department of Energy (DOE), “FY 2021 Congressional Budget Justification,” Volume 3 Part 1, (DOE/CF-0163, February 2020), 45–46, <https://www.energy.gov/sites/prod/files/2020/02/f72/doe-fy2021-budget-volume-3-part-1.pdf>.
2. Varun Sivaram et al., *Energizing America: A Roadmap to Launch a National Energy Innovation Mission* (ITIF and Columbia University SIPA Center on Global Energy Policy, 2020), 116, <https://itif.org/publications/2020/09/15/energizing-america-roadmap-launch-national-energy-innovation-mission>.
3. DOE, “U.S. Billion-Ton Report,” Volume 1 (Washington, D.C.: DOE, July 2016), https://energy.gov/sites/prod/files/2016/12/f34/2016_billion_ton_report_12.2.16_0.pdf.
4. DOE, “FY 2021 Congressional Budget Justification” Volume 3 Part 1, 45–46.
5. Hui Xu et al., “Assessment of algal biofuel resource potential in the United States with consideration of regional water stress” (Elsevier, November 2018), <https://doi.org/10.1016/j.algal.2018.11.002>; Johnathan Holladay, Zia Abdullah, and Josh Heyne, “Sustainable Aviation Fuel” (Pacific Northwest National Laboratory, August 2019), <https://www.pnnl.gov/sites/default/files/media/file/Sustainable%20Aviation%20Fuel.pdf>.
6. Daniel L. Sanchez et al., “Chapter 5: Hybrid Biological and Engineered Solutions,” in *Building a New Carbon Economy: An Innovation Plan* (Carbon180 and the New Carbon Economy Consortium), <https://carbon180.org/s/ccr02innovationplanFNL.pdf>; Colin Cunliff, “An Innovation Agenda for Deep Decarbonization: Bridging Gaps in the Federal Energy RD&D Portfolio” (ITIF, November 2018), 40–43, <http://www2.itif.org/2018-innovation-agenda-decarbonization.pdf>.
7. Consolidated Appropriations Act, 2021, Division Z, Sec. 9009, <https://rules.house.gov/sites/democrats.rules.house.gov/files/BILLS-116HR133SA-RCP-116-68.pdf>.
8. Varun Sivaram et al., *Energizing America*, 116.
9. Ibid, 71.
10. L. Val Giddings et al., “Gene Editing for the Climate: Biological Solutions for Curbing Greenhouse Emissions” (Information Technology and Innovation Foundation, September 2020), <http://www2.itif.org/2020-gene-edited-climate-solutions.pdf>.
11. Varun Sivaram et al., *Energizing America*, 62.
12. L. Val Giddings et al., “Gene Editing for the Climate: Biological Solutions for Curbing Greenhouse Emissions,” 10-11.
13. DOE, “FY 2021 Congressional Budget Justification” Volume 3 Part 1, 52–66.
14. DOE, “FY 2022 Congressional Budget Justification” Volume 3 Part 1, 303, (DOE Chief Financial Officer DOE/CF-0173, June 2021), 237-258, <https://www.energy.gov/sites/default/files/2021-06/doe-fy2022-budget-volume-3.1-v2.pdf>.