Federal Energy R&D: Bioenergy Research Centers

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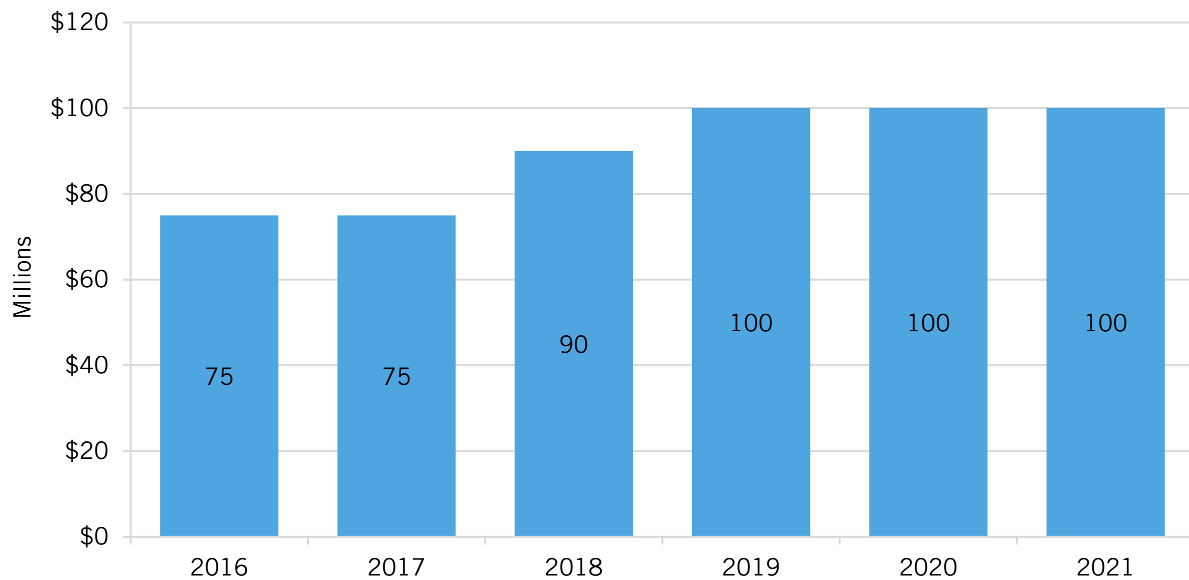
The Department of Energy's (DOE) Bioenergy Research Centers (BRCs) pursue fundamental research into microbial and plant biology as a basis for improving the extraction of energy from inedible plant biomass. BRC research topics include bioenergy crop production with minimal environmental impact, deconstruction techniques to efficiently break down and convert biomass into useful energy, and biotechnology approaches to sustainably produce advanced biofuels and bio-based products and materials.[1] BRCs also explore solutions to enhance carbon storage and sequestration in soil and increase plant nutrient uptake to reduce fertilizer consumption.[2]

Figure 1: *Energizing America* recommends doubling funding in clean energy research, including the basic energy science research conducted in the Office of Science, by FY 2026.[3]



What's at Stake

Biomass is versatile and can play a pivotal role in decarbonizing multiple sectors of the economy. It can be converted to transportation fuels, combusted for heat and power generation, gasified to produce hydrogen, and transformed into bioproducts such as bioplastics. The United States has the potential to produce 1 billion dry tons of nonfood biomass annually by 2030. That is enough to make approximately 50 billion gallons of biofuels (25 percent of U.S. transportation fuels), 50 billion pounds of high-value chemicals and products, and 7 billion kilowatt-hours (kWh) of electricity—enough to power 7 million homes.[4] Unlocking this potential will require addressing fundamental challenges that limit the sustainable and cost-competitive production and conversion of biomass into useful energy.

DOE's Office of Biological and Environmental Research (BER) funds four BRCs: 1) the Joint BioEnergy Institute (JBEI), 2) the Great Lakes Bioenergy Research Center (GLBRC), 3) the

Center for Bioenergy Innovation (CBI), and 4) the Center for Advanced Bioenergy and Bioproducts (CABBI). As of the end of FY 2019, these BRCs had produced 3,370 peer-reviewed publications, 715 invention disclosures, 510 patent applications, 244 licenses or options, 176 patents, and 19 company start-ups.[5] They facilitated knowledge sharing across multiple disciplines to make significant progress in the production of bioenergy and bioproducts.

CBI's research on switchgrass, for example, led to the identification of a number of genes that make plant cell walls resistant to deconstruction and conversion to biofuels. JBEI developed a new interference technique based on CRISPR (clustered regularly interspaced short palindromic repeats) to increase the production of isopentenol, an advanced biofuel that could serve as an alternative to gasoline. GLBRC engineered a strain of bacteria that is a precursor for developing valuable chemicals derived from lignin—a polymer found in plant biomass—to jump-start a bioplastics industry. And CABBI is using a "plants as factories" approach to produce biofuels, bioproducts, and high-value chemicals directly in plant stems.[6]

BRCs also support research to enhance carbon sequestration and nutrient uptake by plants and soil. GLBRC is conducting research on soil enzyme activities and characteristics that affect soil carbon sequestration and has found that soil on marginal lands unsuitable for growing food crops has the potential to sequester more carbon. CABBI has identified a number of genes for nitrogen transport in sugarcane that are now used as genomic targets for improving nitrogen uptake and use, which not only improves yields but also reduces demand for nitrogen-based fertilizers. Nitrogen fertilizers are carbon intensive to manufacture, and their use can result in the release of nitrous oxide, a potent greenhouse gas.[7]

Box 1: An Innovation Agenda to Accelerate Biological Solutions for Climate

The Information Technology and Innovation Foundation's (ITIF) September 2020 report "Gene Editing for the Climate: Biological Solutions for Curbing Greenhouse Gas Emissions" examines promising opportunities for gene editing to mitigate emissions from agriculture and other sectors, and to capture carbon from the atmosphere. Gene editing could enhance the efficiency of photosynthesis, reduce methane emissions from cows and rice paddies, optimize biofuel crops, and solve many other climate challenges. Though not explicitly directed at the BRCs, these recommendations may be useful as DOE develops its research agenda:

- Governments should increase investment in research and development (R&D) for gene-edited solutions for climate change several-fold, especially in nitrogen fixation, improved photosynthesis, genetics of root architecture, methods for measuring soil carbon content, livestock breeding and improved management of ruminant microbiomes, and microbial and algal systems for carbon capture, utilization, and storage (CCUS) in powerplants and industrial facilities. DOE should expand its research into artificial photosynthesis to produce fuels from sunlight.[8]
- Governments should increase investment and R&D funding for CRISPR, a powerful technology for editing genomes.[9]

- The White House Office of Science and Technology Policy (OSTP) should develop and oversee a national strategy to improve interagency coordination in gene-edited climate solutions. OSTP's 2019 Bioeconomy Initiative would provide a good initial building block.
- Federal agencies that invest in gene-editing R&D should work with the Realizing Increased Photosynthetic Efficiency (RIPE) Project to create a worldwide climate-solutions initiative in collaboration with philanthropic and industrial partners.

Bioenergy Research Centers

BER funds four bioenergy research centers:[10]

- **Center for Advanced Bioenergy and Bioproducts (CABBI),** led by the University of Illinois at Urbana-Champaign, develops efficient ways to grow bioenergy crops and convert biomass into valuable chemicals. It uses a "plants as factories" approach to produce fuels and chemicals in plant stems and an automated foundry to convert biomass into valuable chemicals that are economically and ecologically sustainable through recent advances in agronomics, genomics, and synthetic and computational biology.[11]
- **Center for Bioenergy Innovation (CBI),** led by Oak Ridge National Laboratory, explores a host of new technologies to produce bio-based products and advanced biofuels from biomass and lignin residues. Using genetic technology and bioengineering, CBI is developing high-yielding feedstock plants that optimize water and nutrient use. CBI also explores methods for both producing advanced biofuels that can be blended with existing transportation fuels and developing high-value biproducts from lignin waste.[12]
- **Great Lakes Bioenergy Research Center (GLBRC),** led by the University of Wisconsin-Madison in partnership with Michigan State University, focuses on engineering bioenergy crops to increase their environmental and economic value, generating multiple products from plant biomass, and understanding and optimizing the field-to-product pipeline. GLBRC identifies and engineers new biomass conversion microbes to make bioplastics that could potentially replace petroleum-based plastics.[13] GLBRC continues to conduct studies on growing energy crops on nonagricultural land to eliminate land-use competition between food production and biofuels.
- **Joint BioEnergy Research Institute (JBEI),** led by the Lawrence Berkeley National Laboratory, develops innovative technologies to produce clean, sustainable, and carbon-neutral biofuels and bioproducts. JBEI engineers microbes to convert sugar into "drop-in" advanced biofuels compatible with existing fueling infrastructure and vehicles across a range of transportation modes. JBEI also harnesses solar energy in biomass sources such as grasses and other inedible plants.[14]

Further Reading

- Val Giddings, Robert Rozansky, and David M. Hart, "Gene Editing for the Climate: Biological Solutions for Curbing Greenhouse Emissions" (Information Technology and Innovation Foundation, September 2020), https://itif.org/publications/2020/09/14/gene-editing-climate-biological-solutions-curbing-greenhouse-emissions.
- 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.

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ENDNOTES

1. DOE, FY 2021 Congressional Budget Request Volume 4, 161.
2. DOE, FY 2017 Congressional Budget Request Volume 4, 119.
3. Ibid.
4. DOE, "FY 2021 Congressional Budget Justification" Volume 3 Part 1, 45–46.
5. DOE, "Bioenergy Research Centers 2020 Program Update" (DOE/SC–0201, February 2020), https://genomicscience.energy.gov/centers/BRC_Booklet_2020LR.pdf.
6. DOE, FY 2021 Congressional Budget Request Volume 4, 156.
7. Ibid.
8. Val Giddings, Robert Rozansky, and David M. Harte, "Gene Editing for the Climate: Biological Solutions for Curbing Greenhouse Emissions" (Information Technology and Innovation Foundation, September 2020), https://itif.org/publications/2020/09/14/gene-editing-climate-biological-solutions-curbing-greenhouse-emissions.
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11. Center for Advanced Bioenergy and Bioproducts Innovation (CABBI), accessed April 16, 2021, https://cabbi.bio/about/.
12. Center for Bioenergy (CBI), accessed April 16, 2021, https://cbi.ornl.gov/about.
13. Great Lakes Bioenergy Research Center (GLBRC), accessed April 16, 2021, https://www.glbrc.org/research/highlights.
14. Joint BioEnergy Institute, accessed April 16, 2021, https://www.jbei.org/research/.