Energy Research Update:
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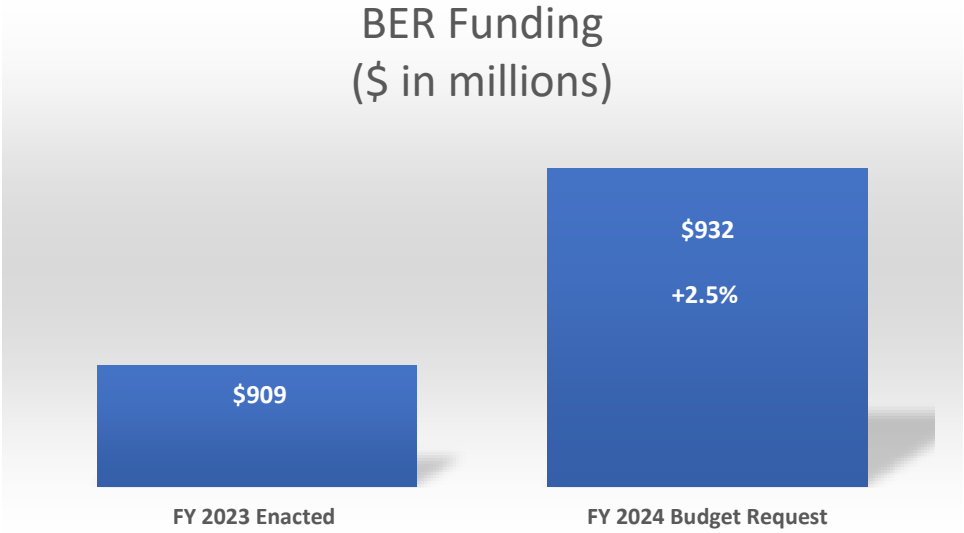
LEWIS–BURKE ASSOCIATES LLC

DOE Research and Funding Priorities for Biological, Climate and Environmental Sciences

This provides an update and advance intelligence on recent activities, emerging priorities, and future opportunities within the Department of Energy (DOE) Biological and Environmental Research (BER) program. This analysis is based on information from the virtual BER Advisory Committee (BERAC) meeting held on April 19-20, 2023, the FY 2024 President's budget request, and discussions with DOE program managers.

Funding Outlook

On March 9, DOE released its FY 2024 budget request and proposed $932 million for BER, a $23 million or modest 2.5 percent increase above the FY 2023 enacted level. Congress plans to start advancing FY 2024 appropriations bills in May but final funding will be contingent on the White House and Congress reaching agreement on a debt ceiling increase and top line funding for FY 2024 appropriations. Congress is expected to pass a Continuing Resolution at the end of the fiscal year on September 30 to avoid a government shutdown and maintain federal funding at FY 2023 enacted levels. This will give Congress additional time to try to finalize FY 2024 appropriations bills.



BER's FY 2024 priorities focus on advancing new initiatives and further expanding current activities, including:

- Supporting new **Energy Earthshot Research Centers and Research Foundations**, especially for the Carbon Negative and Industrial Heat Earthshots;
- BER's contribution to the **Accelerate Initiative**, currently being competed to support two-year awards for DOE National Lab-led teams to help commercialize emerging technologies with BER's investment focused on advancing integrated automated sensors that scale from laboratory fabricated ecosystems to field ecosystems and integrating in situ sensors, imaging, Omics analysis, and autonomous controls for continuous data acquisition and analysis;

- Increasing BER's contribution to the **Funding for Accelerated, Inclusive Research (FAIR)** and **Reaching a New Energy Sciences Workforce (RENEW)** initiatives to provide opportunities to enhance clean energy genome research at Minority Serving Institutions and in support of underserved and environmental justice communities;
- Increasing support ($118 million) for the four **Bioenergy Research Centers**, especially new research at each individual center such as higher yielding, more resilient bioenergy crops; broad-scale studies of the agronomics and economics of bioenergy crop production across large regions; optimized plant biomass construction and conversion processes; and microbial conversion technologies for aviation fuels; as well as 10 shared research projects between all four Bioenergy Research Centers to improve cooperation on major areas of bioenergy and biotechnology development.
- Adding **low dose radiation** research to the scope of the **Biopreparedness Research Virtual Environment (BRaVE)**, which provides cyber infrastructure, computational platforms, and next generation experimental research capabilities and workflows in a single portal and allows distributed networks of scientists to work together on multidisciplinary research priorities to address biopreparedness in response to future pandemics;
- Expanding the number of **Climate Resilience Centers** affiliated with HBCUs/MSIs/HSIs to accelerate basic climate system science towards equitable solutions and community engagement and establish a formal network to share information and coordinate activities across all centers;
- Supporting the **National Virtual Climate Laboratory (NVCL)**, managed by Argonne National Lab and launched in April 2023, to serve as a climate research information portal and enhance collaboration and engagement between HBCUs, MSIs, National Labs, climate resilience centers, and urban and rural public stakeholders; and
- Supporting the four **Urban Integrated Field Labs** focused on integrated natural-human urban systems to improve resilience to climate extremes using equitable solutions and located in the Chicago urban region, Baltimore urban region, the Texas gulf coast, and the Phoenix-Flagstaff corridor of Arizona.

See graphic below for funding breakdown by major program area.

FY 2024 President's Request

BER FY 2022 and Fy 2023 Appropriations and FY 2024 President's Request	FY 2022 Enacted	FY 2023 Enacted	FY 2024 President's Request
Genomic Science	$275,500	$328,685	$338,750
Biomolecular Characterization and Imaging Science	$45,000	$45,000	$45,750
Biological Systems Facilities & Infrastructure	$84,500	$90,000	$92,000
Total, Biological Systems Science	**$405,000**	**$463,685**	**$476,500**
Atmospheric System Research	$36,000	$36,000	$40,000
Environmental System Sciences	$114,000	$120,800	$137,000
Earth and Environmental Systems Modeling	$105,000	$115,500	$120,500
Earth and Environmental Systems Sciences Facilities and Infrastructure	$155,000	$172,700	$147,700
Total, Earth and Environmental Systems Sciences	**$410,000**	**$445,000**	**$445,200**
Subtotal BER	**$815,000**	**$908,685**	**$921,700**
EMSL Microbial Molecular Phenotyping Capability (M2PC) project	$0	$0	$10,000
Total, Biological and Environmental Research	**$815,000**	**$908,685**	**$931,700**
SBIR/STTR funding:			

Source: DOE Office of Science.

Planned FY 2024 Funding Opportunities

Crosscutting Programs

- **$200 million for Energy Earthshot Research Centers Lab Call (Spring 2024)**: DOE plans to release a second funding solicitation for new multi-investigator, multi-disciplinary centers to address the basic research challenges of the six existing Energy Earthshots in long duration storage, hydrogen, carbon negative technologies, geothermal, floating offshore wind, and industrial heat as well possibly one or two more Earthshots that may be announced before the end of the year. The National Lab-led teams with research university collaborators would focus on energy-relevant research with a scope and complexity beyond what is possible in standard single investigator or small group awards. Each center would be funded at $3 million to $5 million per year over four years. The most recent example is

is available here.

- **$75 million for Energy Earthshot Research Foundations (Spring 2024):** DOE plans to release a second solicitation, similar to the FY 2023 solicitation, to support small teams from research universities and national labs to advance key fundamental research challenges facing the six Energy Earthshots. This solicitation is designed for research universities since DOE national labs are not eligible to lead applications. Awards will range from $500,000 to $2 million each per year over three years.
- **$40 million for Funding to Accelerate Inclusive Research (FAIR) (January/February 2024):** DOE plans to release a second funding solicitation to build on FY 2023 to support research and infrastructure on clean energy, climate, and related topics at Minority Serving Institutions, including underserved and environmental justice regions. DOE would provide support to single Principal Investigators or small groups as well as for equipment and other infrastructure improvements. The majority of funds would directly support Minority Serving Institutions, but a portion would fund partnering institutions, such as research universities and national laboratories. This would complement the workforce development activities of the Reaching a New Energy Sciences Workforce (RENEW) initiative. Average award size will be $500,000 per year over three years.
- **$47 million for Reaching a New Energy Sciences Workforce (RENEW) (January/February 2024):** DOE plans to release a third solicitation, similar to prior years, to provide undergraduate and graduate training and research opportunities for students and academic institutions currently underrepresented in the Office of Science portfolio. This opportunity is primarily for non-R1 institutions of higher education and Minority Serving Institutions (MSIs) in partnership with DOE National Laboratories to access unique user facilities and science infrastructure. R1 institutions can be partners on multi-institutional collaborations. DOE views this initiative as part of a broader effort to advance a diverse, equitable, and inclusive research community. Each DOE Office of Science program office releases its own solicitation with a slightly different focus. New in FY 2024 will be a graduate fellowship program. Average award size is around $500,000 per year over three years.

Climate, Earth and Environmental Sciences

- **$10 million for Environmental Systems Science (November 2023):** An annual call that focuses on research to advance an integrated, robust, and scale-aware predictive understanding of terrestrial systems and their interdependent microbial, biogeochemical, ecological, hydrological, and physical processes. A recent priority has been on ecosystems and watersheds. See prior solicitation for most recent topic areas.
- **$15 million for Atmospheric Systems Research (October/November 2023):** An annual funding call that focused on research on key cloud, aerosol, precipitation, and radiative transfer processes that affect the Earth's radiative balance and hydrological cycle. See prior solicitation for most recent topic areas.
- **$5 million for Climate Resilience Centers (December 2023):** DOE plans to release a second solicitation, similar to FY 2023, to add at least five additional Climate Resilience Centers in FY 2024. The goal of these centers is to extend DOE climate science, capabilities, and research by supporting HBCUs, non-R1 MSIs, and emerging research institutions to address regional resilience needs and impacts on natural, socioeconomic, and/or built systems and their intersections. Each center would be funded up to $1 million over three years.
- **NO NEW FUNDING OPPORTUNITY in FY 2024: Urban Integrated Field Laboratories**: For FY 2024, BER does not plan to release a new solicitation. Instead, BER will prioritize funding (an additional $1 million for a total of $24 million) for the second or third year of investment of the existing four centers. The centers will continue outreach activities and promote best practices in collaboration with the established Climate Resilience Centers.

Biological Sciences

- **$10 million for Systems Biology of Bioenergy Relevant Microbes to Enable Production of Next-Generation Biofuels and Bioproducts (January 2024):** The focus is on advancing genomic science for energy applications. DOE is likely to support research that advances the development of promising new model organisms, microbial functional capabilities, and biosynthetic pathways relevant to biofuels and bioproducts production and research into the metabolic pathways that can achieve synthetic polymer deconstruction and conversion to recycled monomers. The focus will likely be similar to the prior solicitation.

Future BER Research Priorities

The following recent workshop reports, Executive Orders, and White House guidance is driving future BER investments:

- **FY 2024 Biden Administration Research and Development Priorities:** FY 2024 crosscutting priorities that impact BER were laid out in the annual federal agencies research and development priorities memo. The most relevant include:
  - Tackling climate change with
    - Climate science
    - Innovation in clean energy technologies and infrastructure
    - Climate adaptation and resilience
    - Nature-based climate solutions for mitigation and adaptation
    - Greenhouse gas monitoring
  - Advancing national security and technology competitiveness including
    - Critical and emerging technologies, especially AI and quantum information science
  - Preparing for and preventing pandemics
  - Innovating for equity
    - Innovative funding mechanism and programs
  - Cultivating Equitable Stem Education
- **Executive Order on Advancing Biotechnology and Biomanufacturing for Sustainable, Safe, and Secure American Bioeconomy (EO 14081).** The goal of the EO was to accelerate biotechnology innovation and grow America's bioeconomy across industry sectors, including health, agriculture, and energy. DOE was specifically tasked with advancing biotechnology, biomanufacturing, bioenergy, and biobased products to address climate change, including by sequestering carbon and reducing greenhouse gas emissions.
- **Bold Goals for U.S. Biotechnology and Biomanufacturing:** In March 2023, the White House Office of Science and Technology Policy published a report with research priorities based on input from key federal science agencies, including DOE. DOE, primarily through BER, is responsible for advancing ten goals for climate change solutions and will influence future budget requests (see graphic from the report). More specific research priorities to advance each of these 10 goals is further defined in DOE Roadmaps and workshop report, including:
  - Transportation and Stationary Fuels:
    - Billion-Ton Report
    - Sustainable Aviation Fuel Grand Challenge Roadmap

Theme 1: Transportation and Stationary Fuels

Goal 1.1: Expand Feedstock Availability – In 20 years, collect and process 1.2 billion metric tons of conversion-ready, purpose-grown plants and waste-derived feedstocks and utilize >60 million metric tons of exhaust gas CO_2 suitable for conversion to fuels and products, while minimizing emissions, water use, habitat conversion, and other sustainability challenges.

Goal 1.2: Produce Sustainable Aviation Fuel (SAF) – In 7 years, produce 3 billion gallons of SAF with at least 50% (stretch 70%) reduction in GHG lifecycle emissions relative to conventional aviation fuels, with production rising to 35 billion gallons in 2050.

Goal 1.3: Develop Other Strategic Fuels – In 20 years, develop technologies to replace 50% (>15 billion gallons) of maritime fuel, off-road vehicle fuel, and rail fuel with low net GHG emission fuels.

Theme 2: Chemicals and Materials

Goal 2.1: Develop Low-Carbon-Intensity Chemicals and Materials – In 5 years, produce >20 commercially viable bioproducts with >70% reduced lifecycle GHG emissions over current production practices.

Goal 2.2: Spur a Circular Economy for Materials – In 20 years, demonstrate and deploy cost-effective and sustainable routes to convert bio-based feedstocks into recyclable-by-design polymers that can displace >90% of today's plastics and other commercial polymers at scale.

Theme 3: Climate-Focused Agricultural Systems and Plants

Goal 3.1: Develop Measurement Tools for Robust Feedstock Production Systems – In 5 years, develop new tools for measurement of carbon and nutrient fluxes in agricultural and bioeconomy feedstock systems that contribute to a national framework.

Goal 3.2: Engineer Better Feedstock Plants – In 5 years, engineer plants and manipulate plant microbiomes to produce drought tolerant feedstocks capable of growing on underutilized land with >20% improvement in nitrogen and phosphorus use efficiency.

Goal 3.3: Engineer Circular Food Protein Production Systems – In 5 years, demonstrate viable pathways to produce protein for food consumption including from biomass, waste, and CO_2 that achieve >50% lifecycle GHG emissions reduction and cost parity relative to current production methods.

Theme 4: Carbon Dioxide Removal

Goal 4.1: Develop Landscape-Scale Biotechnology Solutions – In 10 years, develop technologies to expand implementation of landscape-scale soil carbon sequestration and management techniques on tens of millions of acres, increasing soil health and drought resilience and supporting U.S. climate targets.

Goal 4.2: Enable Biomass with Carbon Removal and Storage (BiCRS) – In 9 years, demonstrate durable, scalable biomass CO_2 removal for <$100/net metric ton, on a path to enabling gigaton-scale removal.

    - Chemicals and Materials
        - Industrial Decarbonization Roadmap
        - Strategy for Plastics Innovation
    - Climate-Focused Agricultural Systems and Plants
        - Bioenergy's Role in Soil Carbon Storage Workshop
        - Designing for Deep Decarbonization: Accelerating the U.S. Bioeconomy
    - CO2 Removal
        - Negative Emissions Technologies and Reliable Sequestration
- **Genomes to Structure and Function Workshop Report:** A new report with recommendations on how to open up more opportunities for researchers to combine genomic, functional, and structural approaches to address important biological questions and to advance biosystems design capabilities for BER science. Recommendations are in three broad areas: Science, such as improvements in predictive design and imaging chemical exchanges between microbes and plants; Technology Development, such as automation and miniaturization of high throughput data generation; and User Facility Integration, such as better data integration and access and standardized experimental workflows.
- **Artificial Intelligence/Machine Learning for BioEnergy Research (AMBER):** In April 2023, DOE published this workshop report focused on opportunities to integrated AI/ML with automated experimentation, genomics, biosystems design, and bioprocessing to revolutionize bioenergy research. The primary recommendations focused on high-quality data, AI/ML algorithms, and laboratory automation. The AI/ML focus was on applications of AI/ML for biosystems design including enzymes, plants and microbes, microbiomes, and bioprocess development.
- **Planned for mid-September 2023: Overcoming Barriers in Plant Transformation: A Focus on Bioenergy Crops:** DOE is still defining the workshop goals and questions but the Workshop Chair has been announced and will be Dr. Wayne Parrott from the University of Georgia.
- **Executive Order on Environmental Justice:** In April, President Biden released a second EO on environmental justice. The EO directed every federal government to incorporate environmental justice into its mission. In its FY 2024 Budget Request, DOE elevated environmental justice as a crosscutting priority area across its programs, including those within the Office of Science. BER's support of basic research is intended to contribute to a future of stable, reliable, and resilient energy sources and infrastructure using evidence-based solutions with a focus on environmental justice.
- **Unified Data Framework:** BER is soliciting input from interested parties on strategies to further integrate and strengthen BER's data infrastructure in support of BER research. Input would cover major research areas including atmospheric science; earth and environmental system modeling; environmental science; bioenergy and bioproducts; and plant and microbial genomics.