Biological and Environmental Research

Overview

The Biological and Environmental Research (BER) program's mission is to support transformative science and scientific user facilities to achieve a predictive understanding of complex biological, Earth, and environmental systems for clean energy and climate innovation. This fundamental research, conducted at universities, DOE national laboratories, and other research institutions across the country, focuses on organisms and ecosystems that can influence U.S. energy systems and advance understanding of the relationships between energy, the environment, and climate science, from local to global scales. BER's support of basic research will contribute to a future of stable, reliable, and resilient energy sources and infrastructures that, in turn, contributes to evidence-based and equitable climate solutions. Research within BER can be categorized into biological systems and Earth and environmental systems. Biological systems research seeks to characterize and predictively understand microbial and plant systems using advanced genomics coupled with integrated experimental, analysis, and modeling techniques. Fundamental genomics-based understanding of the function of these systems underpins the ability to design new innovative processes for clean energy production, including the sustainable development of biofuels and other bioproducts, as well as new carbon management practices. Characterization and understanding of microbial communities will lead to improved understanding of the functioning and improved designs of bioenergy systems, that in turn will provide cost-effective alternatives to fossil fuel and will be resilient to climate change and other environmental perturbations. Earth and environmental systems research seeks to characterize and understand the interdependence among the climate, environment, and energy systems, which includes studies of atmospheric physics and chemistry, ecosystem ecology and biogeochemistry, and development and validation of ultra-high resolution Earth system models of rapidly changing and/or extreme phenomena that impact, e.g. electric grid reliability and resilience. These models integrate dynamic information on the biosphere, atmosphere, terrestrial land masses, oceans, sea and land ice, subsurface, energy technologies, infrastructure, and other relevant human components. To promote world-class research in these areas, BER supports user facilities that use the latest technologies to provide new observations and analyses of atmospheric, biological, and biogeochemical processes. In addition, BER research utilizes advanced computational simulation, and data analytics (including Artificial Intelligence [AI] and Machine Learning [ML]) to enable scientific discovery and technological solutions for extreme phenomena that impact the Nation's energy systems. Engagement with the scientific community and the federally chartered BER Advisory Committee informs all BER activities.

Over the last three decades, BER's scientific impact has been transformative. Mapping the human genome through the U.S. supported international Human Genome Project that DOE initiated in 1990 ushered in a new era of modern biotechnology and genomics-based systems biology. Today, researchers in the BER Genomic Sciences activity and the Joint Genome Institute (JGI) are using powerful genomics-based tools for plant and microbial systems biology to pursue the early-stage research that will lead to the development of dedicated bioenergy crops and microbial systems to produce a wide variety of renewable fuels, chemicals and materials underpinning clean energy technologies for a more carbon- neutral bioeconomy.

Since the 1950s, BER and its predecessor organizations have been critical contributors to the fundamental scientific understanding of climate change, including atmospheric, land, ocean, environmental, and human systems. BER research reduces the greatest uncertainties in model predictions such as those involving clouds, aerosols, and carbon, and is incorporating new climate and energy infrastructure observations from initiatives such as Urban Integrated Field Laboratories (UIFLs) and is providing climate and environmental change information critical for the Nation's energy strategies. DOE research has made advances in increasing the reliability and predictive capabilities of climate models using AI/ML, access to DOE's fastest computers, and validation based on a diversity of observations and other data sources. BER initiatives such as UIFLs, CRCs, and core research activities broaden participation in the BER ecosystem to make it more representative of our nation. BER investments build capacity and help train a new energy workforce at emerging research institutions, underserved communities, and Historically Black Colleges and Universities (HBCUs), and Minority Serving Institutions (MSIs).

Highlights of the FY 2025 Request

The FY 2025 Request of $945.2 million is an increase of $36.5 million over the FY 2023 Enacted level. BER will enhance its research on climate science with a new initiative focused on a high resolution prediction capability based on the interdependence of climate change with realistic scenarios of U.S. deployments in energy innovations, enhanced UIFLs and the network of climate centers, affiliated with emerging research institutions, underserved communities, and HBCU and

MSI; expanded investments in AI approaches for improving Earth and environmental system predictability; and continuing Earthshots research that focuses on science at the nexus of clean energy production and climate change. BER will enhance its systems biology research by continuing the Energy Earthshot Research Centers (EERCs) and expanding Earthshot research activities to bring together multi-disciplinary teams addressing innovative clean energy production and carbon management practices. These efforts will seek to rapidly remove barriers hampering the translation of basic science into technological solutions and speed development of new innovations in biotechnology, including development of sensor technologies to enable the translation of laboratory-scale results, such as in fabricated ecosystems, to broader-scale field ecosystems. BER will continue the Established Program to Stimulate Competitive Research (EPSCoR) and enhance investments in Reaching a New Energy Sciences Workforce (RENEW) and Funding for Accelerated, Inclusive Research (FAIR) initiative to build stronger programs with underserved communities and emerging research institutions as well as HBCUs and MSIs, including investing in a more diverse and inclusive workforce.

Research

- Within Genomic Sciences, the Biological Research Centers (BRCs) will provide new research both individually and through shared research themes, underpinning clean energy innovations and production of fuels, chemicals, and other products from sustainable biomass resources. The EERCs will continue efforts with a specific focus on translational research that lowers risks and speeds adoption of basic research results to industry for a broader, more carbon-neutral bioeconomy. The Biopreparedness Research Virtual Environment (BRaVE) will add additional functionality to its collaborative cyber infrastructure allowing distributed networks of scientists to work on multidisciplinary research priorities and/or national emergency challenges. The BRaVE effort includes enhanced low dose radiation research. Computational Biosciences efforts will support advanced computing to deploy a flexible multi-tier data and computational management architecture for microbiome system dynamics and behavior. Research in Biomolecular Characterization and Imaging Science will develop multi-modal and quantum information science (QIS)-enabled techniques to understand biological processes.
- BER will expand FAIR, which encompasses all BER activities, to provide focused investment on enhancing biological and environmental research and capacity building increasing the participation and engagement with groups in clean energy and climate research at emerging research institutions, underserved communities, and HBCUs and MSIs.
- Earth and Environmental Systems Sciences research will focus on improving the representation of physical, biogeochemical, and human processes to enhance the predictability of climate, Earth, and environmental systems. Environmental System Science will integrate physical and hydrobiogeochemical sciences to provide scale-aware predictive understanding of above- and below-surface terrestrial ecosystems. Atmospheric System Research will investigate cloud-aerosol-precipitation interactions, including urban and forested regions. Modeling research, in particular the DOE Exascale Energy Earth System Model (E3SM), will expand and continue activities to utilize advanced software and AI/ML for running on future DOE computer architectures. Exascale research activities will continue to build from the completed Exascale Computing Project (ECP), broadening software development for advanced computing and sustainability across current and future computing platforms. The Data Management effort will enhance data archiving and management capabilities, including use of AI research for environmental field data.
- RENEW, which encompasses all BER activities, expands targeted efforts, including a RENEW graduate fellowship to increase inclusion of emerging research institutions, underserved communities, and HBCUs, MSIs within BER research to broaden participation and advance equity and inclusion in SC-sponsored research.

Facility Operations

- The JGI will expand providing genome sequence data and analysis techniques for a wide variety of plants and microbial communities. ARM will continue new observations to advance Earth System models and atmospheric research, and to complement ARM's field observations of cloud-aerosol interactions, will initiate the Drizzle, Aerosol, and Cloud Observation (DRACO) chamber project with other project cost (OPC) funding to complement ARM's field observations of cloud-aerosol interactions. EMSL will provide analytical and imaging capabilities in support of BER's biological, environmental, and climate science priorities, and will embark on development of a capability for microbial molecular phenotyping.

Projects

- The BER FY 2025 Request includes $19.0 million to continue the Microbial Molecular Phenotyping Capability (M2PC) project at the Pacific Northwest National Laboratory.

Biological and Environmental Research
Funding

(dollars in thousands)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Biological and Environmental Research				
Genomic Science	328,685	298,935	316,420	-12,265
Biomolecular Characterization and Imaging Science	45,000	45,750	43,910	-1,090
Biological Systems Facilities & Infrastructure	90,000	85,550	93,565	+3,565
Total, Biological Systems Science	**463,685**	**430,235**	**453,895**	**-9,790**
Atmospheric System Research	36,000	38,584	35,750	-250
Environmental System Sciences	120,800	123,000	155,020	+34,220
Earth and Environmental Systems Modeling	115,500	108,000	114,610	-890
Earth and Environmental Systems Sciences Facilities and Infrastructure	172,700	135,825	166,950	-5,750
Total, Earth and Environmental Systems Sciences	**445,000**	**405,409**	**472,330**	**+27,330**
Subtotal, Biological and Environmental Research	**908,685**	**835,644**	**926,225**	**+17,540**
Construction				
24-SC-31 Microbial Molecular Phenotyping Capability (M2PC), PNNL	–	–	19,000	+19,000
Subtotal, Construction	**–**	**–**	**19,000**	**+19,000**
Total, Biological and Environmental Research	**908,685**	**835,644**	**945,225**	**+36,540**

SBIR/STTR funding:
- FY 2023 Enacted: SBIR $21,327,000 and STTR $2,999,000
- FY 2024 Annualized CR: SBIR $20,319,000 and STTR $2,857,000
- FY 2025 Request: SBIR $21,999,000 and STTR $3,094,000

Biological and Environmental Research
Explanation of Major Changes

(dollars in thousands)

	FY 2025 Request vs FY 2023 Enacted
Biological Systems Science This activity ramps down efforts in secure biosystems design and microbial research on biofuels to prioritize early-stage science to understand mechanisms controlling the interplay of microbes and plants in soil systems for clean energy and carbon management initiatives. The BRCs will jointly provide new research underpinning bioenergy and bioproducts production from sustainable biomass through individual and multi-BRC collaborative efforts. The EERCs will continue and Science Foundations for Energy Earthshot research will be enhanced to continue to remove barriers to translating basic science innovations into clean energy and carbon management solutions. FAIR is enhanced and includes both clean energy and climate research at emerging research institutions, underserved communities, and HBCU and MSIs. Emerging technology capabilities to scale results from laboratory fabricated ecosystems to field ecosystems will be developed using integrated sensor networks, complementing efforts to understand processes governing soil-microbe-plant interactions controlling carbon turnover. Biotechnology to transform advanced manufacturing and accelerate innovations in emerging technologies will shift to other priority basic research supporting a growing bioeconomy. The initial pilot project to develop the scope of biopreparedness research scope BRaVE is completed while efforts in low dose radiation research are enhanced. New bioimaging, measurement, and characterization approaches including integrative platforms will continue at reduced levels. QIS research continues. JGI continues plant transformation research.	**-$9,790**
Earth and Environmental Systems Sciences The climate science initiative will advance an innovative capability able to evaluate risks to environmental, infrastructure, and human activities across America's rural landscapes based on multi-model-data fusion and response to climate extremes. Research continues to support increasingly higher-resolution Earth system modeling using exascale-class computers, focused on DOE missions for energy and infrastructure resilience and security. The enhanced investments in AI will accelerate high-resolution predictive capabilities across the DOE climate model-data-experiment enterprise. Environmental System Science will increase support of the Urban IFLs providing new data for informing climate and Earth system models. The support for the Energy Earthshot research activities will continue. RENEW increases by including additional emerging research institutions, underserved communities, and HBCU and MSIs within BER research to broaden participation and advance equity and inclusion in Office of Science-sponsored research, including through a RENEW graduate fellowship. The network of climate resilience centers that focuses on local to regional ecological and atmospheric risks and responses, is expanded. Using observations from the ARM facility, Atmospheric System Research will focus activities to advance knowledge and improve model representations of Earth's energy balance, critical to inform the design of climate-hardened energy infrastructures. ARM will continue operations at long-term sites, continue the mobile unit deployment in Tasmania, Australia, and initiate a mobile unit deployment in Baltimore, Maryland. A cloud chamber project effort will be initiated to inform cloud-aerosol processes based on ARM's field observations. EMSL will focus on biological and environmental molecular science and new technologies for microbial molecular phenotyping. Data management activities will enhance applying AI and ML to environmental field data.	**+$27,330**
Construction Design activities will continue for the Microbial Molecular Phenotyping Capability (M2PC) at the Pacific Northwest National Laboratory.	**+$19,000**
Total, Biological and Environmental Research	**+$36,540**

Basic and Applied R&D Coordination
BER research underpins the needs of DOE's energy and environmental missions and is coordinated through internal DOE mechanisms, and more broadly through the National Science and Technology Council (NSTC) and other committees of the Office of Science and Technology Policy (OSTP). BER research includes biological, Earth and environmental systems investments in theoretical, experimental, predictive modeling research, and science supporting renewable energy alternatives. Basic research on genomics, microbes and plants provides fundamental knowledge that can be used to develop new bioenergy crops and improved biofuel and bioproduct production processes that enable a more sustainable bioeconomy. Basic research on atmospheric and ecological processes is used to advance predictive capabilities and assess risks and resilience of energy systems. Coordination with other federal agencies on priority bioeconomy science needs, occurs through the Biomass Research and Development Board, a Congressionally mandated interagency group created by the Biomass Research and Development Act of 2000, as amended by the Energy Policy Act of 2005 and the Agricultural Act of 2014. Coordination of BER's climate, environment, geospatial, and Arctic investments occur within the NSTC Committee on Environment, most notably through the US Global Change Research Program. Coordination with OSTP and other federal agencies on short-term weather, seasonal, and short-term climate forecasts is conducted under the Interagency Council for Advancing Meteorological Services (ICAMS), chartered by OSTP in 2020 as part of the U.S. Weather Act of 2017. Furthermore, BER coordinates with DOE's applied energy offices through regular joint DOE working groups, program manager meetings, by participating in their internal program reviews and in joint principal investigator meetings and technical workshops.

BER supports some interagency projects to manage databases (such as the Protein Data Bank) through interagency awards and funding for complementary community resources (such as beamlines and cryo-electron microscopy), mostly with NIH and NSF. BER is a member of the advisory committee for DoD's BioMADE project researching synthetic biology applications.

All climate systems research activities within BER are dedicated to advancing predictive capabilities that inform the design and deployment of DOE's applied programs. The centerpiece of BER's modeling investments is the Energy Exascale Earth System Model, that has evolved to become the world's highest resolution Earth system model able to run on exascale computers, facilitating the scientific community in developing and testing system-level scientific concepts on the smallest scales. Other agencies, e.g., NOAA, NASA, the Navy, and NSF, are following developments in E3SM via both USGCRP and ICAMS. The Intelligence Community has demonstrated significant interest in E3SM, as a platform to incorporate their data to address national security problems. The E3SM research is tightly coordinated with BER's large scale experimental activities and has strong links to DOE applied programs and DOE Office of Policy.

Program Accomplishments
Notable accomplishments in *Biological Systems Science* include:

- *Improved molecular understanding of an enzyme with the fastest known rate of CO_2 fixation.* Advanced analysis techniques at SLAC enabled mechanistic understanding of a reductive carboxylase enzyme that facilitates new engineered techniques for this enzyme to capture CO_2 more efficiently and effectively from the air for conversion to products such as fuels and chemicals currently produced from petroleum.
- *Biologically engineered yeast that produces chemical bioproducts, making biofuel production more economical*. A yeast strain engineered at the Joint BioEnergy Institute produces triacetic acid lactone (TAL), a valuable co-product, from lignocellulose, potentially making combined production of biofuels and bioproducts more economically feasible.
- *New possibilities for bioprocessing of plant biomass and biomanufacturing - evidence of lignin degradation with no oxygen needed.* Researchers in association with JGI recently demonstrated conclusively that fungi can degrade lignin anaerobically (i.e., with no oxygen), a process not previously thought to be possible.
- *Understanding the role of plant exudates that influence soil microbiome communities associated with bioenergy crops.* Through advanced genomics techniques, researchers at Oak Ridge National Laboratory identified two microorganisms that are dependent on salicin, a plant exudate, potentially leading to mechanisms that can alter microbiome activity for beneficial plant growth.

- *Candidate genes identified in Camelina that control oilseed traits.* A collection of 222 Camelina sativa plants were re-sequenced in a collaboration among JGI, Hudson Alpha, and Arizona Genomics Institute. Genome wide association studies identified genes controlling seed size, fatty acid composition, and flowering time, providing tools for development of higher yielding bioenergy crops that require minimal fertilizer input.
- *Development of a modified CRISPR-CAS system for precise genome editing within a microbial community.* Species-specific, phage-based methods were developed to deliver CRISPR-CAS based genome editing machinery to targeted microbes, demonstrating a way to modify specific microbes within a mixed community for enhanced biotechnologies.

Notable accomplishments in *Earth and Environmental Systems Sciences* include:

- *Building the next generation of climate models – the first to run on the exascale Frontier computer, placing the U.S. as the global leader in high resolution prediction science.* BER scientists developed a 3 km resolution climate prediction capability that allows for unprecedented scientific analyses of extreme events on local scales needed for energy, such as the electrical grid and urban energy systems, and other stakeholder applications. As a testament from the international scientific community of the innovations achieved with E3SM to set the global standard for modeling and prediction, the DOE developer team recently won the first-ever Association for Computing Machinery (ACM) Gordon Bell Prize for Climate Modelling at the International Conference for High Performance Computing, Networking, Storage and Analysis (SC23) in Denver on November 16, 2023.
- *Improving weather and climate predictions using machine learning.* A newly designed machine learning algorithm, applied to cloud radar data from the Atmospheric Radiation Measurement User Facility, discovered more drizzle (i.e., fine particle precipitation) in marine stratus clouds than previous observing systems had detected, critical for improved accuracy of local to regional scale climate models. Drizzle dynamics exert significant control of the radiative properties of low warm clouds, influencing the rates of regional to global climate change.
- *Understanding and modeling changes in precipitation associated with urbanization and irrigation.* Effects of large-scale urbanization and irrigation on summer precipitation in the mid-Atlantic region indicated that urbanization suppresses precipitation, while irrigation enhances most precipitation types. This study reveals the effects of human activities on regional rainfall distribution.
- *Environmental impacts assessed with molecular characterization of wildfire smoke.* An ultra high-resolution, custom-built instrument at the DOE Environmental Molecular Sciences Laboratory User Facility was used to characterize organophosphorus compounds in wildfire smoke, and subsequently identify the severity of wildfire burns on landscapes and the impacts of wildfires on adjacent aquatic systems.
- *Observing increased nutrient availability from ecosystem warming.* The SPRUCE warming and CO_2 enrichment experiment in Minnesota has shown that whole-ecosystem warming has exponentially increased nutrient availability throughout the soil profile. Peatlands hold a large amount of global soil carbon storage and increased nutrient availability will impact this storage.

Biological and Environmental Research
Biological Systems Science

Description
The Biological Systems Science subprogram integrates advanced genomics research with computation and user facility capabilities for basic science on plant and microbial systems relevant to national priorities and DOE's mission in renewable energy and innovation in biotechnology underpinning novel clean energy, carbon management and biotechnology solutions needed to address the climate crisis.

Genomic Science
The Genomic Science activity supports basic research in foundational genomics, bioenergy, environmental genomics, and computational bioscience to reveal the fundamental principles that drive biological systems and enable the design of new biosystems relevant to DOE missions in renewable energy to discover the breakthroughs that will propel the Nation towards a more carbon neutral bioeconomy.

Foundational Genomics supports basic research on discovery and manipulation of genome structural, regulatory, and epigenetic controls to understand genotype to phenotype translations in microbes and plants. Researchers apply systems biology and biosystems design research to understand, predict, emulate, and design biological processes as a basis for new approaches to renewable biofuels and bioproducts, biotechnology, and low carbon biomanufacturing.

The DOE Bioenergy Research Centers (BRCs) provide a fundamental understanding of plants and microbes as a basis for developing sustainable innovative processes for clean bioenergy and a range of bioproducts from inedible lignocellulosic biomass. These multi-disciplinary, multi-institutional centers will accelerate the scientific groundwork necessary for a more bio-based economy that promises to yield new fuels, chemicals, materials, and other products from renewable resources.

Environmental Genomics supports research on understanding plants and soil microbial communities and their impact on environmental cycling and/or sequestration of carbon, nutrients, and contaminants. This includes studying natural and model microbiomes in environments relevant to bioenergy and environmental research.

Computational Biosciences supports systems biology research through the development of on-line, open access bioinformatics and modeling capabilities within the DOE Systems Biology Knowledgebase (KBase) and the National Microbiome Data Collaborative (NMDC). These integrated resources support large-scale collaborative data science investigations of plant and microbial systems to reveal biological processes that will accelerate the development of renewable fuels and bioproducts.

Biomolecular Characterization and Imaging Science
Biomolecular characterization and imaging science supports integrative approaches to detect, visualize, and measure biological processes to gain a predictive understanding of cellular function, critical for expanding the boundaries of bioengineering and bioenergy research. This effort includes innovative QIS-enabled imaging concepts and sensor/detector design based on correlated materials.

Biological Systems Facilities and Infrastructure
The DOE Joint Genome Institute is the only federally funded major genome sequencing center focused on genome discovery and analysis in plants and microbes for energy and environmental applications. This scientific user facility provides high-throughput DNA sequencing capabilities on organisms and groups of organisms to identify key genes that may link to biological function as a foundational basis for BER's basic bioenergy research efforts.

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Biological Systems Science	**$463,685**	**$453,895**	**-$9,790**
Genomic Science	$328,685	$316,420	-$12,265
Foundational Genomics research supports new research on microorganisms with advantageous bioenergy and bioproduct traits. Biosystems design research accelerates the ability to design plants and microorganisms with specific beneficial low carbon clean energy, bioproduct and biomaterials production traits. New efforts provide emerging technologies to develop integrated automated sensors that scale from laboratory fabricated ecosystems to field ecosystems as part of the Accelerate initiative.		Foundational Genomics research prioritizes understanding the mechanisms controlling plant and microbial interactions in soils that underpin clean energy and carbon management initiatives. Funding in the Accelerate and Biotechnology to Transform Advanced Manufacturing initiatives shift to priority bioenergy/bioeconomy research. Biosystems design research continues efforts to accelerate the ability to design plants and microorganisms with specific beneficial low carbon clean energy, bioproduct and biomaterials production traits. Efforts will continue to support emerging technologies to develop integrated automated sensors that scale from laboratory fabricated ecosystems to field ecosystems. Support for research on a wide variety of microorganisms and plants with clean energy, carbon sequestration and bio-inspired bioproduct-relevant traits continues in order to broaden the range of platform organisms available for biotechnology use, underpinning innovations for clean energy and a more decarbonized bioeconomy.	Foundational Genomics efforts in Secure Biosystems Design and microbial biofuels research ramps down to fully fund efforts within the BRCs for clean energy and carbon management initiatives. The funding for Accelerate and Biotechnology to Transform Advanced Manufacturing initiatives will shift to other priority basic biofuels and bioproducts research supporting a growing bioeconomy. Emerging technologies will integrate *in situ* sensors, imaging, 'omics analysis, and autonomous controls and continuous data acquisition and analysis.
BER launches Energy Earthshot Research Centers to address key biological research challenges at the interface between currently supported basic research and applied research and development activities.		BER will expand Energy Earthshot research and continue Centers initiated in FY 2023 to include additional key biological research challenges at the interface between currently supported basic research and applied research supporting development	Funding will support additional research for the DOE Earthshot activities.

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
	activities to help speed translation of basic discoveries to industry.	
Environmental Genomics continues plant functional genomics research to understand genotype to phenotype translations leading to beneficial bioenergy or bioproduct traits in potential bioenergy crops.	Environmental Genomics continues basic plant functional genomics research to understand genotype to phenotype translations leading to bioenergy crop improvement.	Funding will support efforts in plant genomics to extend advances in plant genome science by generating experimental evidence of gene function to improve productivity and sustainability of renewable feedstocks for fuels and chemical production.
Environmental microbiome science continues efforts to understand the functions of environmentally relevant microbial communities in a variety of ecosystems.	Environmental microbiome science continues efforts to understand the functions of environmentally relevant microbial communities controlling the cycling of carbon and nutrients in a variety of ecosystems.	Funding will support efforts in the ability to predictively understand the activity of microbial communities controlling carbon and nutrient cycling in relevant environmental microbiomes.
BRaVE expands to build out a computational platform and experimental workflow through which a distributed network of data and experimental capabilities can be accessed by multidisciplinary teams of scientists working together on urgent multiprogram priorities, including low dose radiation research.	BRaVE will continue to add functionality to its expanding computational platform and experimental workflows. BRaVE continues to build a distributed network of data and experimental capabilities that can be accessed by multidisciplinary teams of scientists working together on urgent multiprogram priorities and/or emergency situations. BRaVE will expand low dose radiation research efforts.	BRaVE efforts will continue to support burgeoning biopreparedness activities and expand low dose radiation research. The BRaVE pilot effort to develop the scope of biopreparedness research relevant to BER science concludes.
The FAIR initiative strengthens clean energy genomic research at HBCUs and MSIs, building partnerships with the DOE national labs.	The FAIR initiative will expand and include both environment and biology activities in BER at emerging research institutions, underserved communities, and HBCUs and MSIs, increasing partnerships with the DOE national laboratories in DOE mission science for, clean energy and climate research.	FAIR will encompass all environmental and biological BER activities and expand to support additional opportunities at emerging research institutions, underserved communities, and HBCU and MSIs.
Computational Bioscience supports research efforts within Genomic Science by providing bioinformatics, simulation and modeling capabilities through the KBase platform and within the NMDC. Both platforms	Computational Bioscience will support research efforts within Genomic Science by providing bioinformatics, simulation, and modeling capabilities through the KBase platform and within the NMDC.	Funding will support research and intergrative linkages among the bioinformatic platforms of KBase, NMDC and JGI supporting basic genomic science

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
continue integrative activities among each other within the Advanced Computing Initiative and with the JGI.	Both platforms will continue integrative activities with each other and with the JGI.	research underpinning bioenergy, biotechnology, and bioeconomy innovations.
The four BRCs continue with 5-year renewal to support multidisciplinary clean energy research underpinning a broader bio-based economy. The BRCs broaden their collaborative activities to accelerate plant and microbial genome engineering with AI/ML techniques to diversify the range of products that can be sustainably produced from plant biomass, expand understanding of plant-microbe interactions to create better agronomic practices for clean bioenergy production, develop new plant varieties with expanded capabilities for biofuels and bioproduct production and increase collaboration among the broader research community (including HBCUs) and within rural communities where new crop-based clean energy and bioproduct production could spark new industries and bioeconomy development.	The BRCs will broaden their collaborative activities to accelerate plant and microbial genome engineering with AI/ML techniques to diversify the range of products that can be sustainably produced from plant biomass, expand understanding of plant-microbe interactions to create better agronomic practices for clean bioenergy production, develop new plant varieties with expanded capabilities for biofuels and bioproduct production and increase collaboration among the broader research community (including emerging research institutions, underserved communities, and HBCU and MSIs) and within rural communities where new crop-based clean energy and bioproduct production could spark new industries and bioeconomy development.	The four BRCs will expand efforts on broad theme-based collaborative research requiring a multi-BRC approach to accelerate genome engineering for plants and microbes advance sustainability research through research on plant-microbe interactions, develop new plant varieties with an expanded range of biofuels and bioproducts, and engage a broader spectrum of the research community (including emerging research institutions, underserved communities, and HBCU and MSIs) and rural communities where this research could lead to new bioeconomy opportunities.
Funding supports early-stage R&D, including research that underpins DOE energy technology programs, the SC Energy Earthshots initiative, and innovations for climate science. Following the previous year's focus on State-National Laboratory Partnership awards, FY 2023 emphasizes Implementation Awards to larger multiple investigator teams that develop research capabilities in EPSCoR jurisdictions. Investment continues in early career research faculty from EPSCoR-designated jurisdictions and in co-investment with other programs for awards to eligible institutions.	Funding will support EPSCoR Implementation awards, larger multiple investigator teams that develop research capabilities, including investment in instrumentation, in EPSCoR jurisdictions.	Continued support for research in EPSCoR jurisdictions.

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Biomolecular Characterization and Imaging Science $45,000	$43,910	-$1,090
New multimodal bioimaging research supports new capabilities to characterize, measure, visualize and test hypotheses on plant and microbial cell function and metabolism. Quantum-enabled science concepts for imaging techniques will continue.	New multimodal bioimaging research will provide new capabilities to characterize, measure, visualize and test hypotheses on plant and microbial cell function and metabolism. Quantum-enabled science concepts for imaging techniques will continue.	Funding will support multimodal bioimaging research activities. The decrease represents completion of a subset of awards.
Biological Systems Facilities & Infrastructure $90,000	$93,565	+$3,565
JGI provides users with high quality genome sequences and new analysis techniques for complex plant and microbiome samples. Integrative activities with KBase and the NMDC provides new crossplatform capabilities for users. Genome-based discovery efforts for natural product production in microbial isolates continues in concert with expanded metagenomics analysis techniques. The multi-year instrument and equipment refresh continues at a reduced pace to support the integrative activities with KBase and the NMDC.	JGI will provide users with high quality genome sequences and new analysis techniques for complex plant and microbiome samples. Integrative activities with KBase and the NMDC will provide new cross-platform capabilities for users. Genome-based discovery efforts for natural product production in microbial isolates continues in concert with expanded metagenomics analysis techniques. The multi-year instrument and equipment refresh will continue at a reduced pace to support the integrative activities with KBase and the NMDC. New plant transformation research will be conducted to explore needed techniques to transform a wider variety of plants for genome interrogation and design.	Funding will support expanded integrative efforts with KBase and the NMDC to provide new analysis capabilities for microbiome science. The continuing instrument and equipment refresh will be slowed to support the expanded integrative activities with KBase and the NMDC. Funding will also support a new plant transformation activity to provide the genomic tools to more broadly understand, modify, and design plants with beneficial traits for bioenergy and bioproducts.

Note:

- *Funding for the subprogram above, includes 3.65 percent of research and development (R&D) funding for the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs, excluding facility operations.*

Description

The Earth and Environmental Systems Sciences subprogram supports fundamental research and scientific user facilities that enable enhanced predictability of dynamically changing climate, environmental, and Earth systems, in support of DOE's mission involving transformative science for energy and national security. This includes improving predictability of climate trends and extremes that influence the design and deployment of next generation energy systems, based on experimental and modeling research on atmospheric, terrestrial, and human components of the Earth system; modeling of oceanic and Great Lakes systems; studies involving the interdependence and perturbations involving cloud, aerosol, marine, ecological, hydrological, biogeochemical, and cryospheric processes; analysis of the vulnerabilities of energy infrastructures and communities to climate change and extreme events; and uncertainty quantification. This integrated portfolio extends from molecular-level to field-scales and spans time scales from sub-seasonal to centennial. The research makes use of DOE's major facilities, in particular the Atmospheric Radiation Measurement User Facility, Environmental Molecular Sciences Laboratory, and DOE's exascale-class computing. Investments emphasize the most difficult challenges limiting prediction certainty, including cloud-aerosol interactions; the role of biogeochemistry; and human activities as they couple with the natural system. The research is used to inform the design, development, financing, and deployment pathways of climate friendly technical energy solutions that promote social equity and enhance urban resilience in response to the climate crisis.

The subprogram prioritizes Energy Earthshot Research Centers and Earthshot research; the Established Program to Stimulate Competitive Research (EPSCoR); and Reaching a New Energy Sciences Workforce (RENEW) activities. Additionally, the subprogram will increase inclusion of emerging research institutions, underserved communities, and HBCUs and MSIs within BER research to broaden participation and advance equity and inclusion in Office of Science-sponsored research.

Atmospheric System Research

Atmospheric System Research (ASR) is the primary U.S. research activity addressing the main source of uncertainty in climate and Earth system models: the interdependence of clouds, aerosols, precipitation, and radiative transfer processes. These processes must be improved for models to inform appropriate deployment of energy systems. ASR coordinates with the Atmospheric Radiation Measurement Facility (ARM), using the facility's continuous long-term datasets that are collected from a variety of dynamical and turbulence conditions in climate-sensitive regions around the world.

Environmental System Sciences

Environmental System Science (ESS) supports research on physical and hydro-biogeochemical processes and variable geomorphology, from the subsurface to the top of the vegetative canopy. The activity combines process modeling with new multi-scale data spanning regions where surface changes are particularly impactful for energy and adaptability, including the Arctic, the midlatitude boreal zone, the Tropics, mountainous zones, urban and rural systems, and coastal regions. ESS coastal activities include the Delaware and Susquehanna River watersheds, the Great Lakes, and Puget sound. The four Urban Integrated Field Laboratories (IFLs) integrate field data within a next-generation Earth System Modeling framework. Funding also supports efforts to enhance accessibility and utility of data on greenhouse gas fluxes from natural systems, consistent with the National Strategy to Advance an Integrated U.S. Greenhouse Gas Measurement, Monitoring, and Information System.

Earth and Environmental Systems Modeling

Earth and Environmental Systems Modeling develops the physical, biogeochemical, and dynamical underpinning for fully coupled climate and Earth System Models (ESMs), in coordination and complementary with other Federal efforts and with a focus on weeks to decades timescales and on the variability of extreme phenomena that particularly impact energy systems. Using DOE's flagship Energy Exascale Earth System Model (E3SM) and other models, the Artificial Intelligence for Earth System Predictability (AI4ESP) effort motivates the radical acceleration of predictive capabilities across the DOE climate model-data-experiment enterprise, taking advantage of emerging AI/ML techniques, robust couplers, diagnostics, performance metrics, and use of DOE's exascale computers.

Earth and Environmental Systems Sciences Facilities and Infrastructure

The Earth and Environmental Systems Sciences Facilities and Infrastructure activity supports data management and two scientific user facilities for the Earth and environmental systems sciences communities. The scientific user facilities, ARM and EMSL, provide the broad scientific community with technical capabilities, scientific expertise, and unique information to facilitate cutting edge science in atmospheric and molecular science areas integral to BER's mission.

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Earth and Environmental Systems Sciences **$445,000**	**$472,330**	**+$27,330**
Atmospheric System Research $36,000	$35,750	-$250
Funding for ASR continues research on clouds, aerosols, and thermodynamic processes, with a focus on data from the ARM fixed sites as well as recent field campaigns conducted in the Arctic during FY 2020 and data from the TRACER and SAIL campaigns. ASR continues to make use of data generated by Large Eddy Simulations at the ARM Oklahoma site.	ASR will continue research on clouds, aerosols, and thermodynamic processes, with a focus on data from the ARM long-term sites as well as data from the completed TRACER and SAIL campaigns, and the on-going campaigns Cape-K (Cloud and Precipitation Experiment at Kennaook) in Tasmania and CoURAGE (Coast-Urban-Rural Atmospheric Gradient Experiment) in Baltimore, Maryland. ASR will continue to make use of data generated by Large Eddy Simulations as part of ARM facility deployments. Scope will be expanded to include urban areas.	Analyses of data from the MOSAiC campaign are completed. Funding will continue to prioritize urban areas and coastal regions.

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Environmental System Sciences $120,800	$155,020	+$34,220
Funding for ESS focuses research on permafrost and maintains investments in studies of boreal ecology and modeling hydrobiogeochemistry of watersheds and terrestrial-aquatic interfaces, with a focus on the coastal zones encompassed by the Delaware and Susquehanna watersheds and the Great Lakes, and Puget Sound. The Urban IFLs expand to support climate science. The NVCL is fully implemented and continues to provide access to the single portal to DOE lab climate capabilities. Funding initiates the network of climate centers focused on resilience. RENEW expands to provide undergraduate and graduate training opportunities for students and academic institutions not currently well represented in the U.S. S&T ecosystem.	ESS will begin a new climate initiative. The new research will advance a hybrid capability to evaluate risks to environmental, infrastructure, and human activities based on model-data fusion. ESS will continue research on permafrost, boreal ecology, and modeling hydrobiogeochemistry of watersheds and terrestrial-aquatic interfaces, with a focus on the coastal zones encompassed by the Delaware and Susquehanna watersheds and the Great Lakes, and Puget Sound. Urban IFLs will be enhanced to support and coordinate urban climate science. The NVCL will continue to serve as a portal that describes DOE lab climate science and resilience capabilities as well as training and outreach opportunities, to an audience that includes emerging research institutions, underserved communities, HBCUs, and MSIs interested in DOE climate science research for energy security. The network of climate resilience centers will increase. The RENEW initiative expands targeted efforts, including a RENEW graduate fellowship, to increase participation and retention of individuals from underserved communities in SC research activities. Funding will also support efforts on the accessibility and utility of data on greenhouse gas fluxes from natural systems, consistent with the National Strategy to Advance an Integrated U.S. Greenhouse Gas Measurement, Monitoring, and Information System.	The funding will initiate new climate research leading to a robust predictive capability for America's rural and semi-urban regions, with greater accuracy for use by a wide variety of energy stakeholders. The Urban IFLs will expand coordination and collaboration, with more integrated field data also designed for a next generation Earth System Modeling framework and create a science capability to advance climate and energy research as a unified co-dependent system. The increase broadens RENEW activities across BER. Funding will support new efforts enhancing accessibility and utility of data on greenhouse gas fluxes from natural systems, consistent with the National Strategy to Advance an Integrated U.S. Greenhouse Gas Measurement, Monitoring, and Information System.

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Earth and Environmental Systems Modeling $115,500	$114,610	-$890
Funding for Earth and Environmental Systems Modeling focuses investments on further refinement of the science underpinning non-hydrostatic adaptive mesh modeling and incorporating the necessary software for deployment of the model onto more advanced exascale computing architectures. The E3SM version 2 incorporates AI and unsupervised learning capabilities and enables more sophisticated research based on higher model resolution, through the Integrative AI4ESP. The new version adds advanced capabilities for exploring cryosphere-ocean dynamics' impacts of climate variability on Antarctic ice shelf melting, continental ice sheet evolution and sea level rise, and the effects of changing water cycles on watershed and coastal hydrological systems. Funding also initiates foundational modeling for the offshore wind and hydrogen Energy Earthshots.	Earth and Environmental Systems Modeling will focus investments on further refinement of the science underpinning non-hydrostatic adaptive mesh modeling and incorporating the necessary software for deployment of the model onto more advanced exascale computing architectures. The E3SM will enhance AI/ML capabilities and enable more sophisticated science that demands higher model resolution and greater accuracy, through the Artificial Intelligence Framework for AI4ESP. As the ECP concludes, the exascale research activities will transition from the ECP to apply a broader software practice for advanced computing and sustainability across current and future computing platforms. The new E3SM version 3 will add advanced capabilities for exploring cryosphere-ocean dynamics' impacts of climate variability on Antarctic ice shelf melting, continental ice sheet evolution and sea level rise, the effects of changing water cycles on watershed and coastal hydrological systems, and new research involving urban systems. The Request will also support foundational modeling in support of Energy Earthshot topics requiring robust climate projections to inform the design and deployment of clean energy initiatives.	AI will enhance the efficiency and accuracy of climate predictions, for trends, modes of variability, and extreme events. The ECP research activities will continue to transition ECP researchers, software, and technologies into core research efforts. New investments enhance support for Earthshot topics, that focus on efficient design, deployment, and effectiveness of renewable and clean energy infrastructures to combat climate change. The reduction is due to completion of adaptive mesh capabilities for E3SM as applied to coastal simulations.

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Funding focuses on core research in model intercomparisons and diagnostics. In addition, research incorporates limited fine scale physics and dynamics that can be applied to metrics for application to coastal zones (including the Great Lakes and Puget Sound), mid-latitude-Arctic interactions, and high-resolution studies of urban and urban-rural transition regions.	The Request will focus on core research in model intercomparisons and diagnostics. In addition, research will incorporate limited fine scale physics and dynamics that can be applied to metrics for application to coastal zones (including the Great Lakes and Puget Sound), and high-resolution studies of urban and urban-rural transition regions.	Research funding will place greater emphasis on highly heterogeneous and boundary regions, such as are found in large urban regions as well as coastal zones that encompass the mid-Atlantic, the Great Lakes, and Puget Sound.
Earth and Environmental Systems Sciences Facilities and Infrastructure $172,700	$166,950	-$5,750
Funding for ARM continues to provide new observations through long term measurements at fixed sites in Alaska, Oklahoma, and the Eastern North Atlantic site. An ARM mobile unit completes installation and begin operations in Alabama. The funding prioritizes all ARM activities for critical observations needed to improve the E3SM model. ARM continues and completes deployment of its second mobile facility to Colorado; and it prepares and deploys its first mobile facility to San Diego. Scientists are using the precipitation radars together with sophisticated meteorological instrumentation to learn more about cloud and aerosol interactions in a variety of geographic domains, including urbanized coastal regions and mountainous terrain. After rebaselining to meet FAA requirements, acceptance testing and evaluation are completed on the Air-ARM aircraft, including modifications to the air frame as needed to install numerous existing and new atmospheric aerosol, cloud, turbulence, and other sensors. The ARM support for the Urban IFL for climate science continues as well as continuing a multi-year instrumentation refresh.	ARM will continue to provide new observations through long term measurements at fixed sites in Alaska, Oklahoma, and the Eastern North Atlantic site. The ARM mobile unit in Alabama will be fully operational. The Request prioritizes all ARM activities for critical observations needed to improve the E3SM model. Scientists will use cloud and precipitation radars together with sophisticated meteorological instrumentation to learn more about cloud and aerosol interactions in a variety of geographic domains, including urban and forested regions. A second mobile unit deploys to Baltimore, Maryland in support of urban research. A third ARM unit will continue deployment to Tasmania to study cloud-aerosol interactions. Air-ARM will continue testing for research operations in FY 2026.	Funding will support ARM site operations, and mobile facilities operations. Two mobile units, one located in Tasmania, Australia and another in Baltimore, Maryland, will deliver new observations. After major investments in FY 2022 and FY 2023 to install the third ARM unit to Alabama, this capability will routinely collect data in support of community science. A cloud chamber project will be initiated to complement ARM's field observations of cloud-aerosol interactions. Reductions are due to the completion of the installation of the Alabama site.

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
	BER will initiate the Drizzle, Aerosol, and Cloud Observation (DRACO) chamber project with other project cost (OPC) funding, a cloud chamber effort to complement ARM's field observations of cloud-aerosol interactions.	BER will initiate the new Drizzle, Aerosol, and Cloud Observation (DRACO) chamber project with other project cost (OPC) funding.
Funding for EMSL emphasizes new science that requires combinations of advanced technologies, such as mass spectrometry, live cell imaging, Quiet Wing, Dynamic Transmission Electron Microscopy, and high-performance computing. A multi-year instrumentation refresh continues. Other Project Cost support the microbial molecular phenotyping capability planned project.	EMSL will emphasize new science that requires combinations of advanced technologies, such as mass spectrometry, live cell imaging, Quiet Wing, Dynamic Transmission Electron Microscopy, and high-performance computing. The initial construction of microbial molecular phenotyping capability begins.	Funding will promote multi-disciplinary science using various combinations of EMSL's most sophisticated instrumentation. Reallocations within EMSL rebalances operations and research.
GPP funding provides for minor new construction, for other capital alterations and additions, and for improvements to land, buildings, and utility systems to maintain the productivity and usefulness of DOEowned facilities and to meet requirements for safe and reliable operation. In FY 2023 GPP supports improved cooling for High Performance Computing infrastructure at EMSL and remodeling EMSL laboratories to create lab spaces to co-locate capabilities that cross-cut EMSL's integrated research platforms.	GPP activities are completed.	Efforts are completed.

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Funding for the Earth and Environmental Sciences Data Management activity enhances support to maintain existing and new critical software and data archives in support of ongoing experimental and modeling research. Essential data archiving and storing protocols, capacity, and provenance are maintained. Advanced analytical methodologies such as Machine Learning is used to improve the predictability of extreme events more rapidly using the combination of field observations with Earth system models.	The Earth and Environmental Sciences Data Management activity will continue support to maintain existing and new critical software and data archives in support of ongoing experimental and modeling research. Essential data archiving and storing protocols, capacity, and provenance will be maintained. Advanced analytical methodologies such as AI and Machine Learning will be enhanced and used to improve the predictability of extreme events more rapidly using the combination of field observations with Earth system models.	Increases associated with AI and machine learning will lead to greater efficiencies in model development, improved accuracy in predictions, and data gap filling in difficult-to-observed regions.

Note:

- *Funding for the subprogram above, includes 3.65 percent of research and development (R&D) funding for the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs, excluding facility operations.*

Description

This subprogram supports line-item construction for the BER program. All Total Estimated Costs (TEC) are funded in this subprogram, including engineering, design, and construction. The FY 2025 Request of $19,000,000 continues the Microbial Molecular Phenotyping Capability project.

24-SC-31, Microbial Molecular Phenotyping Capability (M2PC), PNNL

The M2PC project will design and construct a new capability that will provide a range of 24,500 -50,000 gross square feet (GSF) of instrumentation and support spaces conducive for highly autonomous operations, with a target of 38,500 GSF. In addition, the M2PC design will include acquisition of analytical instrumentation and microbial culturing and characterization capabilities that will be modular and expandable, self-contained, and operate in an automated pod configuration. Capabilities will include a suite of 5 to 10 microbial culturing pods, 3 to 5 biological and functional assay pods, and 4 to 5 analytical phenotyping workflow pods. This new capability will position BER to take a global lead in answering the most pressing challenge in biology—generating molecular phenotypic data at a pace that matches the rapid developments in high throughput genome sequencing and synthesis. Applicability of this capability to BER interests in biofuels production, lignocellulose breakdown, and carbon/nutrient/elemental cycling, would create a knowledge ecosystem that would provide data to amplify BER's genome engineering and biosystems design efforts, as well as mechanistic hydro-biogeochemistry modeling capabilities. In FY 2025, the TEC funding of $19,000,000 will be used to continue design activities associated with the facility, develop performance specifications for the vendor equipment, develop plans for integrating the facility with the equipment, and continue planning and development of contractual requirements for both the facility and vendor contracts.

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Construction $ —	**$19,000**	**+$19,000**
24-SC-31, Microbial Molecular Phenotyping Capability (M2PC), PNNL $ —	$19,000	+$19,000
No funding was requested in FY 2023.	Funding will support the new M2PC project at PNNL.	Funding will continue to support the new M2PC project at PNNL.

Biological and Environmental Research
Capital Summary

(dollars in thousands)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Capital Operating Expenses						
Capital Equipment	N/A	N/A	34,950	23,130	19,150	-15,800
Minor Construction Activities						
General Plant Projects	N/A	N/A	10,000	5,000	–	-10,000
Total, Capital Operating Expenses	**N/A**	**N/A**	**44,950**	**28,130**	**19,150**	**-25,800**

Capital Equipment

(dollars in thousands)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Capital Equipment						
Major Items of Equipment						
Earth and Environmental Systems Sciences						
Atmospheric Radiation Measurement (ARM) Aerial Observation Capability (Air-ARM)	27,186	17,486	9,700	–	–	-9,700
Total, MIEs	N/A	N/A	9,700	–	–	-9,700
Total, Non-MIE Capital Equipment	N/A	N/A	25,250	23,130	19,150	-6,100
Total, Capital Equipment	**N/A**	**N/A**	**34,950**	**23,130**	**19,150**	**-15,800**

Note:

- *The Capital Equipment table includes MIEs located at a DOE facility with a Total Estimated Cost (TEC) > $10M and MIEs not located at a DOE facility with a TEC >$2M.*

Minor Construction Activities

(dollars in thousands)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
General Plant Projects (GPP)						
GPPs (greater than $5M and $34M or less)						
HPC Infrastructure Upgrades (GPP HPC Upgrades [Refresh]), PNNL	5,000	–	5,000	–	–	-5,000
Project 2 - Crosscutting Capabilities (3020EMSL Remodel to Cross-Cut IRPs), PNNL	5,000	–	5,000	–	–	-5,000
Project 3 - Relocations (3020EMSL Remodel to Unpack and Relocate), PNNL	5,000	–	–	5,000	–	–
Total GPPs (greater than $5M and $34M or less)	N/A	N/A	10,000	5,000	–	-10,000
Total, General Plant Projects (GPP)	**N/A**	**N/A**	**10,000**	**5,000**	**–**	**-10,000**
Total, Minor Construction Activities	**N/A**	**N/A**	**10,000**	**5,000**	**–**	**-10,000**

Note:

- *GPP activities $5M and less include design and construction for additions and/or improvements to land, buildings, replacements or addition to roads, and general area improvements. AIP activities $5M and less include minor construction at an existing accelerator facility.*

Biological and Environmental Research
Major Items of Equipment Description(s)

Earth and Environmental Systems Sciences Facilities and Infrastructure:

Atmospheric Radiation Measurement Research Facility (ARM) – Air-ARM

The Air-ARM project is expected to complete in FY 2026 with CD-4 in December 2025. The Air-ARM project received CD-2/3 approval on November 12, 2018, with an original total project cost of $17,700,000. BER-supported scientists require high-quality and well-characterized in situ aircraft observations of aerosol and cloud microphysical properties and coincident dynamical and thermodynamic properties to continue to improve fundamental understanding of the physical and chemical processes that control the formation, life cycle, and radiative impacts of cloud and aerosol particles. To meet these needs, the ARM user facility has been using a dedicated large twin-turboprop Gulfstream-1 (G-1) aircraft to conduct weeks- to months-long intensive observational campaigns over a range of meteorological conditions and locations around the world. The G-1 aircraft used by ARM was built in 1961, was one of only 10 G-1's that remain in service worldwide and is at the end of its service life. BER retired and replaced the aircraft in FY 2019. The FY 2019 Enacted Budget included funding to replace the Battelle-owned G-1 aircraft that supported airborne data collection as part of ARM field campaigns. Since FY 2020, the newly acquired aircraft has undergone testing and evaluation, including modifications to the air frame needed to install numerous existing and new atmospheric aerosol, cloud, turbulence, and other sensors. Also, the aircraft will undergo ground-based and airborne testing to prepare it for scientific studies. Due to changes in FAA policies and procedures after the passage of the Aircraft Certification, Safety, and Accountability Act in December 2020, time required for the FAA to implement these new policies, and delays due to COVID, the total project cost has increased (+$9.7M), and planned research flight operations will be delayed until FY 2026**.**

Minor Construction Description(s)

General Plant Projects $5 Million to less than $30 Million

Outfitting of Research and Collaborations Spaces
General Plant Project Details

Project Name:	Project 3 – Relocations (3020EMSL Remodel to Unpack and Relocate), PNNL
Location/Site:	Pacific Northwest National Laboratory
Type:	GPP
Total Estimated Cost:	$5,000,000
Construction Design:	$0
Project Description:	EMSL developed plans to backfill a number of laboratory spaces from which both instrumentation and scientists were vacated as a result of their relocation from spring through fall of 2022 into the new Energy Sciences Capability (ESC) building at PNNL. Approximately 13,000 square feet equivalent of lab modules were relocated from EMSL to the ESC. EMSL identified strategic plans for reconfiguring and renovating this laboratory space during FY 2022. Through support provided in a FY 2023 general plant project (GPP), EMSL has been reconfiguring/renovating approximately half of the total square footage of these lab modules. A second GPP effort for reconfiguring/renovating the remaining lab modules and unpacking crowded laboratories in EMSL has been included in the FY 2024 President's budget request. Pending appropriation of funding in FY 2024, the second GPP project will complete activities related to reconfiguring/renovating the full 13,000 square feet equivalent of lab modules in EMSL.

Biological and Environmental Research
Construction Projects Summary

(dollars in thousands)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
XX-SC-32, ARM Cloud Chamber, TBD						
Total Estimated Cost (TEC)	44,100	-	-	-	-	-
Other Project Cost (OPC)	2,600	-	-	-	1,000	+1,000
Total Project Cost (TPC)	**46,700**	**-**	**-**	**-**	**1,000**	**+1,000**
24-SC-31, Microbial Molecular Phenotyping Capability (M2PC), PNNL						
Total Estimated Cost (TEC)	107,000	-	-	-	19,000	+19,000
Other Project Cost (OPC)	5,000	-	250	950	-	-250
Total Project Cost (TPC)	**112,000**	**-**	**250**	**950**	**19,000**	**+18,750**
Total, Construction						
Total Estimated Cost (TEC)	**N/A**	**N/A**	**-**	**-**	**19,000**	**+19,000**
Other Project Cost (OPC)	**N/A**	**N/A**	**250**	**950**	**1,000**	**+750**
Total Project Cost (TPC)	**N/A**	**N/A**	**250**	**950**	**20,000**	**+19,750**

Biological and Environmental Research
Scientific User Facility Operations

The treatment of user facilities is distinguished between two types: TYPE A facilities that offer users resources dependent on a single, large-scale machine; TYPE B facilities that offer users a suite of resources that is not dependent on a single, large-scale machine.

(dollars in thousands)

	FY 2023 Enacted	FY 2023 Current	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Scientific User Facilities - Type B					
Environmental Molecular Sciences Laboratory	**64,750**	**64,624**	**45,435**	**65,000**	**+250**
Number of Users	750	682	750	775	+25
Joint Genome Institute	**90,000**	**89,836**	**85,550**	**93,565**	**+3,565**
Number of Users	2,300	2,373	2,350	2,380	+80
Atmospheric Radiation Measurement Research Facility	**87,000**	**86,452**	**78,440**	**88,200**	**+1,200**
Number of Users	1,200	1,157	1,200	1,200	–
Total, Facilities	**241,750**	**240,912**	**209,425**	**246,765**	**+5,015**
Number of Users	4,250	4,212	4,300	4,355	+105

Note:

- *Percent optimal operations defines what is achieved at this funding level. This includes staffing, up-to-date equipment and software, operations and maintenance, and appropriate investments to maintain world leadership.*

Biological and Environmental Research
Scientific Employment

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Number of Permanent Ph.Ds (FTEs)	1,750	1,805	1,785	+35
Number of Postdoctoral Associates (FTEs)	460	480	470	+10
Number of Graduate Students (FTEs)	640	685	685	+45
Number of Other Scientific Employment (FTEs)	430	435	435	+5
Total Scientific Employment (FTEs)	**3,280**	**3,405**	**3,375**	**+95**

Note:
- *Other Scientific Employment (FTEs) includes technicians, engineers, computer professionals and other support staff.*

24-SC-31, Microbial Molecular Phenotyping Capability (M2PC), PNNL
Pacific Northwest National Laboratory, PNNL
Project is for Design and Construction

1. Summary, Significant Changes, and Schedule and Cost History

Summary

The FY 2025 Request for the Microbial Molecular Phenotyping Capability (M2PC) project is $19,000,000 of Total Estimated Cost (TEC) funding. This Construction Project Data Sheet (CPDS) is an update of the FY 2024 CPDS for this project. The project will design and construct a new research capability for the M2PC that will be broadly available to the scientific community as part of an Office of Science User Facility. DOE approved Critical Decision (CD)-0 on April 28, 2021, and CD-1 on February 15, 2024, with a preliminary Total Project Cost (TPC) range of $80,000,000 to $122,000,000 and a CD-4 range of FY 2026 to FY 2029.

Significant Changes

DOE conducted both an Independent Project Review (IPR) and an Independent Cost Review (ICR) of the project in June 2023, as pre-requisites for a CD-1 decision. Through the development of the CD-1 materials and in response to comments from the IPR and ICR reviews, the project scope, schedule, and cost range have been further defined, as reflected in the tables below. The project TPC range is now $100,000,000 to $167,000,000, and the CD-4 range is now FY 2029 to FY 2032. In accordance with the tailoring requirements permitted by DOE's Project Management Order (DOE O 413.3B), the project is pursuing a tailoring strategy to combine CD-2 and CD-3.

In FY 2024, the project will begin design activities associated with the facility, the vendor equipment integration, and facility and equipment coordination design for the TEC funding of $10,000,000. The project will prepare for CD-2/3 for the OPC funding of $950,000.

In FY 2025, the TEC funding of $19,000,000 will be used to continue design activities associated with the facility, develop performance specifications for the vendor equipment, develop plans for integrating the facility with the equipment, and continue planning and development of contractual requirements for both the facility and vendor contracts.

A Federal Project Director with the appropriate certification of level II has been assigned to the project.

Critical Milestone History

Fiscal Year	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	CD-4
FY 2025	4/28/21	6/30/22	2/15/24	3Q FY 2025	4Q FY 2026	3Q FY 2025	1Q FY 2032

CD-0 – Approve Mission Need for a construction project with a conceptual scope and cost range; **Conceptual Design Complete** – Actual date the conceptual design was completed (if applicable); **CD-1** – Approve Alternative Selection and Cost Range; **CD-2** – Approve Performance Baseline; **Final Design Complete** – Estimated/Actual date the project design will be/was complete(d); **CD-3** – Approve Start of Construction; **D&D Complete** – Completion of D&D work; **CD-4** – Approve Start of Operations or Project Closeout

Project Cost History

(dollars in thousands)

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Except D&D	OPC, Total	TPC
FY 2024	11,000	104,000	115,000	5,000	5,000	120,000
FY 2025	29,000	88,000	117,000	5,000	5,000	122,000

2. Project Scope and Justification

Scope

The M2PC project will design and construct a new capability that will provide a range of 24,500–50,000 gross square feet (GSF) of instrumentation and support spaces conducive for highly autonomous operations, and a target of 38,500 GSF. In addition, the M2PC design will include acquisition of analytical instrumentation and microbial culturing and characterization capabilities that will be modular and expandable, self-contained, and operate in an automated pod configuration. Capabilities will include a suite of 5 to 10 microbial culturing pods, 3 to 5 biological and functional assay pods, and 4 to 5 analytical phenotyping workflow pods.

Justification

Within the Biological and Environmental Research (BER) program, basic research to gain a predictive understanding of biological systems provides the foundation for harnessing and integrating the latest biosystems design techniques with data science and multi-scale modeling approaches. This effort will advance a burgeoning bioeconomy, enable prediction of the future state of the Earth system, and provide transformative science and technology solutions to enable DOE to meet its energy and environmental challenges. Toward systems-level understanding, BER-supported research has increasingly embraced the integration of multi-omics analyses together with phenotypic characterization of microbial isolates and communities to determine the function of expressed genes and pathways.

While the number of microbial isolates and chassis microbes interrogated is expanding rapidly along with advances in next generation genome sequencing and synthesis, incomplete and constrained genome annotation limits the ability to understand and model the range of activities and functions of individual microbes, engineered microbial consortia with bio-industrial potential or ecological relevance, and microbial communities from natural soil environments. Specifically, there is a significant gap in the ability of the scientific community to identify proteins and biochemical pathways of unknown function in microbes at the single-cell to microbial-community scales, in part because the phenotypes of microbes change rapidly due to environmental factors and perturbations. To address this gap, BER proposes a research capability for a Microbial Molecular Phenotyping Capability that would be broadly available to the scientific community as part of a DOE Office of Science User Facility.

An emphasis on coupled high-throughput autonomous experimental and multimodal analytical capabilities would be the primary components of the instrumentation part of the M2PC. These capabilities would be integrated with, and amplify, existing BER data platforms within the DOE JGI, the NMDC, and the KBase to speed the discovery of new protein functions and metabolic pathways in microbial systems, including fungi, algae, bacteria, protists, archaea, and viruses.

This new capability will position BER to take a global lead in answering the most pressing challenge in biology—generating molecular phenotypic data at a pace that matches the rapid developments in high throughput genome sequencing and synthesis, and it will advance the DOE mission to ensure America's security and prosperity by addressing energy and environmental challenges through transformative science and technology solutions. Applicability of this capability to BER interests in biofuels production, lignocellulose breakdown, and carbon/nutrient/elemental cycling, would create a knowledge ecosystem that would provide data to amplify BER's genome engineering and biosystems design efforts, as well as mechanistic hydro-biogeochemistry modeling capabilities.

While the Office of Science is exempt from DOE O 413.3B, Program and Project Management for the Acquisition of Capital Assets, the M2PC project intends to deploy a certifiable earned value management system and be conducted in accordance with the project management principles of DOE O 413.3B.[a]

Key Performance Parameters (KPPs)

The KPPs are preliminary and may change as the project continues towards CD-2. At CD-2 approval, the KPPs will be baselined. The Threshold KPPs represent the minimum acceptable performance that the project must achieve. Achievement of the Threshold KPPs will be a prerequisite for approval of CD-4, Project Completion. The Objective KPPs represent the desired project performance.

Performance Measure	Threshold	Objective
Demonstrate high-throughput (HTP) Culturing	Capacity to operate with 500 Experiments/Week*	Capacity to operate with 2,000 Experiments/Week*
Demonstrate HTP Microbiome Culturing	Capacity to operate with 100 Microbiome Experiments/Week	Capacity to operate with 500 Microbiome Experiments/Week
Demonstrate HTP Assaying and Phenotyping	Capacity to obtain 1,000,000 Multi-Modal Analytical Measurements/Month	Capacity to obtain 3,000,000 Multi-Modal Analytical Measurements/Month
Remote Capability to Access Operations	Demonstrate that remote users can run pre-defined EMSL protocols to be executed autonomously within M2PC across culturing, assaying, and analyses**	Demonstrate remote users can perform dynamic experimental intervention with help from EMSL staff by modifying an executed protocol during the experimental timeframe**
Total Building Size (GSF)	24,500 sq. ft.	50,000 sq. ft.
*A microbiome start is an experiment consisting of a mix of 2-8 microbial species cultured under a defined set of conditions. **Protocol settings will have built-in acceptable safe operating ranges for selection within established instrument specifications from vendors, EMSL protocol best-practices, and PNNL EH&S safe research operating windows.		

3. Financial Schedule

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Estimated Cost (TEC)			
Design (TEC)			
FY 2024	10,000	10,000	10,000
FY 2025	19,000	19,000	19,000
Total, Design (TEC)	**29,000**	**29,000**	**29,000**
Construction (TEC)			
Outyears	88,000	88,000	88,000
Total, Construction (TEC)	**88,000**	**88,000**	**88,000**
Total Estimated Cost (TEC)			
FY 2024	10,000	10,000	10,000

[a] Memorandum For Office of Science Associate Directors, From W.F. Brinkman, Director, Office of Science, "Office of Science is Exempt from DOE Order 413.3B, Program and Project Management for the Acquisition of Capital Assets," dated February 2, 2011.

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Estimated Cost (TEC)			
FY 2025	19,000	19,000	19,000
Outyears	88,000	88,000	88,000
Total, Total Estimated Cost (TEC)	**117,000**	**117,000**	**117,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Other Project Cost (OPC)			
FY 2023	250	250	250
FY 2024	950	950	950
Outyears	3,800	3,800	3,800
Total, Other Project Cost (OPC)	**5,000**	**5,000**	**5,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Project Cost (TPC)			
FY 2023	250	250	250
FY 2024	10,950	10,950	10,950
FY 2025	19,000	19,000	19,000
Outyears	91,800	91,800	91,800
Total, TPC	**122,000**	**122,000**	**122,000**

4. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design	20,500	7,700	**N/A**
Design - Contingency	8,500	3,300	**N/A**
Total, Design (TEC)	**29,000**	**11,000**	**N/A**
Construction	66,000	72,700	**N/A**

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Construction - Contingency	22,000	31,300	**N/A**
Total, Construction (TEC)	**88,000**	**104,000**	**N/A**
Total, TEC	**117,000**	**115,000**	**N/A**
Contingency, TEC	*30,500*	*34,600*	***N/A***
Other Project Cost (OPC)			
OPC, Except D&D	3,900	4,000	**N/A**
Conceptual Design	1,100	1,000	**N/A**
Total, Except D&D (OPC)	**5,000**	**5,000**	**N/A**
Total, OPC	**5,000**	**5,000**	**N/A**
Contingency, OPC	***N/A***	*N/A*	***N/A***
Total, TPC	**122,000**	**120,000**	**N/A**
Total, Contingency (TEC+OPC)	***30,500***	***34,600***	***N/A***

5. Schedule of Appropriations Requests

(dollars in thousands)

Fiscal Year	Type	Prior Years	FY 2023	FY 2024	FY 2025	Outyears	Total
FY 2024	TEC	—	—	10,000	—	105,000	115,000
	OPC	—	250	950	—	3,800	5,000
	TPC	—	250	10,950	—	108,800	120,000
FY 2025	TEC	—	—	10,000	19,000	88,000	117,000
	OPC	—	250	950	—	3,800	5,000
	TPC	—	250	10,950	19,000	91,800	122,000

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	1Q FY 2032
Expected Useful Life	50 years
Expected Future Start of D&D of this capital asset	1Q FY 2082

Related Funding Requirements
(dollars in thousands)

	Annual Costs		Life Cycle Costs	
	Previous Total Estimate	Current Total Estimate	Previous Total Estimate	Current Total Estimate
Operations	N/A	223	N/A	11,150
Utilities	N/A	145	N/A	7,250
Maintenance and Repair	N/A	331	N/A	16,550
Total, Operations and Maintenance	N/A	699	N/A	34,950

7. D&D Information

The new area being constructed in this project is not replacing existing facilities.

	Square Feet
New area being constructed by this project at PNNL	24,500-50,000
Area of D&D in this project at PNNL	—
Area at PNNL to be transferred, sold, and/or D&D outside the project, including area previously "banked"	—
Area of D&D in this project at other sites	—
Area at other sites to be transferred, sold, and/or D&D outside the project, including area previously "banked"	24,500-50,000
Total area eliminated	—

8. Acquisition Approach

The Acquisition Strategy for the M2PC project was reviewed and approved as part of the CD-1 process. It will include two major acquisitions: the research equipment vendor and facility contract. Both acquisitions will be best value source selections timed to support CD-2/3. The research equipment vendor will provide a turn-key solution (design, procurement, installation, fabrication, assembly, testing, KPP verification, training, etc.) for the high-throughput microbial molecular phenotyping capability needed to meet the research-related KPPs. The facility will be procured via a design-build strategy. It will house and provide utilities to operate the research equipment and will meet the facility space KPP.