Biological and Environmental Research

Overview

The mission of the Biological and Environmental Research (BER) program is to support fundamental research and scientific user facilities to achieve a predictive understanding of complex biological, climatic, and environmental systems for a secure and sustainable energy future.

The program seeks to understand how genomic information is translated to functional capabilities, enabling more confident redesign of microbes and plants for sustainable biofuels production, improved carbon storage, and understanding the biological transformation of materials such as nutrients and contaminants in the environment. BER research also advances understanding of the roles of the earth's biogeochemical systems (the atmosphere, land, oceans, sea ice, and subsurface) in determining climate in order to predict climate decades or centuries into the future to provide information that will inform plans for future energy and resource needs.

BER research uncovers nature's secrets from the diversity of microbes and plants to understand how biological systems work, how they interact with each other, and how they can be manipulated to harness their processes and products. Starting with the genetic potential encoded by organisms' genomes, BER scientists seek to define the principles that guide the translation of the genetic code into functional proteins and the metabolic and regulatory networks underlying the systems biology of plants and microbes as they respond to and modify their environments.

BER plays a unique and vital role in supporting research on atmospheric processes, climate modeling, interactions between ecosystems and greenhouse gases (especially carbon dioxide [CO_2]), and analysis of impacts and interdependencies of climatic change with energy production and use. BER research addresses the three most important sources of uncertainty in our understanding of the earth's radiant energy balance—clouds, aerosols, and atmospheric greenhouse gases—through coordinated efforts in climate modeling and observation. BER also supports research to understand the impacts of climatic change (e.g., warmer temperatures, changes in precipitation, increased levels of greenhouse gases, and changing distributions of weather extremes) on different ecosystems such as forests, grasslands, and farmland. Finally, BER research seeks understanding of the critical role that biogeochemical processes play in controlling the cycling and mobility of materials (e.g., carbon, nutrients, radionuclides and heavy metals) in the earth's subsurface and across key surface-subsurface interfaces in the environment.

BER's scientific impact has been transformative. Efforts to map the human genome, including the U.S.-supported international Human Genome Project, which DOE formally began in 1990, initiated the era of modern biotechnology and genomics-based systems biology. Today, with its Genomic Sciences activity and the DOE Joint Genome Institute (JGI), BER researchers are using the powerful tools of plant and microbial systems biology to pursue fundamental breakthroughs needed to develop cost-effective cellulosic biofuels. The three DOE Bioenergy Research Centers lead the world in fundamental biofuels-relevant research.

Since the 1950s, BER has been a critical contributor to climate science research in the U.S., beginning with atmospheric circulation studies that were the forerunners of modern climate models. Today, BER research contributes to the Community Earth System Model, a leading U.S. climate model, and addresses two of the most critical areas of uncertainty in contemporary climate science—the impacts of clouds and aerosols—through support of the Atmospheric Radiation Measurement Climate Research Facility (ARM), which is used by hundreds of scientists worldwide. Also, BER has been a pioneer of ecological and environmental studies in terrestrial ecosystems. BER's Environmental Molecular Sciences Laboratory (EMSL) provides the scientific community with powerful suites of instruments and a high performance computer to characterize biological organisms and molecules.

Highlights of the FY 2015 Budget Request

Biological and Environmental Research will support key core research areas and scientific user facilities in bioenergy, climate, and environmental research.

Biological Systems Science

Investments will provide the fundamental biological system science to underpin advances in bioenergy production, carbon cycling in the environment and bioremediation processes. Research targets the development of biosystems design tools and the development of integrative analysis of experimental datasets to examine cross-scale (mesoscale to molecular) relationships among biological processes. Core research in foundational genomics continues for the DOE Bioenergy Research Centers. Genomic Sciences research activities in cellulosic ethanol and biohydrogen are completed, genomics enabled research on carbon cycle processes have been reduced, and the expansion of biodesign enabled biofuels synthesis activities has leveled off. The Mesoscale to Molecules activity will complement and build on successes from the pilot projects initiated in FY 2014 and continue development of new integrative bioimaging technology to translate molecular-scale understanding to systems biology descriptions of cellular and multicellular processes. Activities for human nuclear medicine are completed and radiation studies shift toward linking laboratory-based research with epidemiological research on low dose radiation effects. The Joint Genome Institute (JGI) remains an essential component for DOE systems biology efforts providing high quality genome sequence data and analysis techniques to the research community. JGI's new strategic plan incorporates new capabilities to not only sequence DNA but to interpret, manipulate and synthesize DNA in support of biofuels, biodesign, and environmental research.

Climate and Environmental Sciences

Climate and Environmental Research activities will conduct preliminary scientific analysis of the sensitivity and uncertainty of climate predictions to explore climate sensitive geographies or processes not represented by the Next Generation Ecosystem Experiment (NGEE) Arctic and Tropics studies. New observations of clouds, aerosols, and sensitive ecosystems will address uncertainty in climate models. Increased investment is made to produce an earth system model with improved resolution that will include new codes for running on numerous processors, flexibility toward future computer architectures, and enhanced usability, testing, adaptability, multi-scale treatments, and provenance. The modeling efforts will be validated against new observations. Terrestrial Ecosystem research continues to focus on characterizing the complex interdependent processes and interrelationships between climate change and critical Arctic and tropical ecosystems

ARM continues long-term measurements at fixed sites selected for scientific impact on improving climate models, and the mobile facilities will rotate deployments to three climate-sensitive regions demanding focused and targeted measurements in the Arctic, the tropics, and the Pacific Ocean. ARM will rotate the deployment of the mobile facilities. EMSL undergoes strategic planning to optimize instrument systems available to users in priority biological and environmental molecular sciences, and in preparation for new capabilities in the outyears.

The Data Management effort will focus on a new Climate and Environmental Data Analysis and Visualization activity that will incorporate high resolution earth system models with interdependent components involving energy and infrastructure sector models, field observations, raw data from environmental field experiments, and analytical tools for system diagnostics, validation, and uncertainty quantification.

Biological and Environmental Research
Funding ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Biological Systems Science					
Genomic Science					
Foundational Genomics Research	67,588	73,341	73,341	73,228	-113
Genomics Analysis and Validation	10,000	10,000	10,000	10,000	0
Metabolic Synthesis and Conversion	19,887	19,462	19,462	16,262	-3,200
Computational Biosciences	16,395	16,395	16,395	16,395	0
Bioenergy Research Centers	75,000	75,000	75,000	75,000	0
Total, Genomic Science	**188,870**	**194,198**	**194,198**	**190,885**	**-3,313**
Mesoscale to Molecules	**0**	**7,949**	**7,949**	**9,680**	**+1,731**
Radiological Sciences					
Radiochemistry and Imaging Instrumentation	10,000	11,800	11,800	2,665	-9,135
Radiobiology	6,159	3,200	3,200	2,409	-791
Total, Radiological Sciences	**16,159**	**15,000**	**15,000**	**5,074**	**-9,926**
Biological Systems Facilities and Infrastructure					
Structural Biology Infrastructure	13,878	14,895	14,895	14,895	0
Joint Genome Institute	65,000	69,800	69,800	69,500	-300
Total, Biological Systems Facilities and Infrastructure	**78,878**	**84,695**	**84,695**	**84,395**	**-300**
SBIR/STTR	0	9,929	9,929	9,858	-71
Total, Biological Systems Science	**283,907**	**311,771**	**311,771**	**299,892**	**-11,879**
Climate and Environmental Sciences					
Atmospheric System Research	**26,392**	**26,392**	**26,392**	**26,392**	**0**
Environmental System Science					
Terrestrial Ecosystem Science	38,786	45,001	45,001	44,034	-967
Subsurface Biogeochemical Research	23,695	24,033	24,033	25,449	+1,416
Total, Environmental System Science	**62,481**	**69,034**	**69,034**	**69,483**	**+449**
Climate and Earth System Modeling					
Climate Model Development and Validation	0	0	0	29,010	+29,010
Regional and Global Climate Modeling	29,068	28,578	28,578	28,159	-419
Earth System Modeling	35,408	35,569	35,569	35,569	0
Integrated Assessment	8,422	9,853	9,853	9,853	0
Total, Climate and Earth System Modeling	**72,898**	**74,000**	**74,000**	**102,591**	**+28,591**

	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Climate and Environmental Facilities and Infrastructure					
Atmospheric Radiation Measurement Climate Research Facility	68,074	68,429	68,429	68,429	0
Environmental Molecular Sciences Laboratory	44,132	46,700	46,700	45,501	-1,199
Data Management	2,773	3,496	3,496	5,000	+1,504
General Purpose Equipment (GPE)	0	250	250	0	-250
General Plant Projects (GPP)	0	250	250	0	-250
Total, Climate and Environmental Facilities and Infrastructure	**114,979**	**119,125**	**119,125**	**118,930**	**-195**
SBIR/STTR	0	9,374	9,374	10,712	+1,338
Total, Climate and Environmental Sciences	**276,750**	**297,925**	**297,925**	**328,108**	**+30,183**
Total, Biological and Environmental Research	**560,657**	**609,696**	**609,696**	**628,000**	**+18,304**

SBIR/STTR Funding:

- FY 2013 transferred: SBIR $15,613,069; STTR $2,023,916
- FY 2014 projected: SBIR $16,890,000; STTR $2,413,000
- FY 2015 Request: SBIR $18,077,000; STTR $2,493,000

Biological and Environmental Research
Explanation of Major Changes ($K)

	FY 2015 vs. FY 2014 Enacted
Biological Systems Science:	
Foundational genomic research investments in biosystems design, computational biology, and the Bioenergy Research Centers are continued. Targeted research in metabolic synthesis and conversion on cellulosic ethanol and biohydrogen has been completed. Funding for Radiological Sciences decreases as activities are focused on bioenergy and environmental process research. Mesoscale to Molecules research continues development of new integrative bioimaging technology to translate molecular-scale understanding to systems biology descriptions of cellular and multicellular processes. JGI continues to provide DNA sequencing and analysis.	-11,879
Climate and Environmental Sciences: Climate and Earth System Modeling increases with investment in the Climate Model Development and Validation activity that will incorporate finer resolution (less than 10 km) scale-aware physics into climate models not currently available to the community, through a comparison with ARM data and adapting climate model code to make optimal use of current and next-generation high performance computing resources. Terrestrial Ecosystem Science continues, including the Next Generation Ecosystem Experiments (NGEE) Tropics activity. Subsurface biogeochemical research increases to focus on environmental research across scales as a continuum of complex interdependent processes. ARM continues to provide essential cloud and aerosol observations for climate research. Within the Data Management effort, the Climate and Environmental Data Analysis and Visualization activity increases to provide infrastructure that enables database interoperability and visualization. Environmental Molecular Sciences Laboratory (EMSL) funding for operations decreases as facility strategic planning focuses on optimizing instrument systems available to users and planning for new capabilities.	+30,183
Total, Biological and Environmental Research	**+18,304**

Basic and Applied R&D Coordination

BER research underpins the needs of DOE's energy and environmental missions. Basic research on microbes and plants provide fundamental understanding that can be used to develop new bioenergy crops and improved biofuel production processes that are cost effective and sustainable. This research is relevant to other DOE offices and agencies, including DOE's Office of Energy Efficiency and Renewable Energy and the Advanced Research Projects Agency-Energy, and the U.S. Department of Agriculture. Coordination with other federal agencies on priority 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, and under the White House Office of Science and Technology Policy (OSTP).

BER research to understand and predict future changes in the earth's climate system provides important tools that link climate predictions to evaluations of new energy policies and help to guide the design criteria for next generation energy infrastructures. An example is the Water-Energy "Tech" Team (WETT) that was created in mid-2013 and brings together the Science, Energy Technology, and Policy Offices of the Department. WETT addresses not only water required for all facets of energy production, from biofuels to thermoelectric cooling, but also the energy required to provide water for various uses. BER research on the transport and transformation of energy-related substances in subsurface environments provides understanding that can enable DOE's Office of Environmental Management (EM) to develop new strategies for the remediation of weapons-related and other contaminants at DOE sites. In general, BER coordinates with DOE's applied technology programs through regular joint program manager meetings, by participating in their internal program reviews and in joint principal investigator meetings, as well as conducting joint technical workshops. Coordination with other federal agencies on priority climate science needs occurs through the interagency U.S. Global Climate Change Research Program under OSTP.

Program Accomplishments

Systems biology for next-generation biofuels. Scientists at the DOE Bioenergy Research Centers (BRCs) are addressing critical barriers to the production of next-generation biofuels from non-food plant biomass. Major recent advances have included the discovery of a new plant gene mediating synthesis of lignin, the component of biomass that is most resistant to deconstruction. Advanced microscopy techniques were used for real time nanoscale imaging of novel cellulose-degrading enzymes attacking biomass in plant cells, allowing researchers to map this process at an unprecedented level of detail. BRC scientists also developed a new genetic tool for high-throughput screening of product synthesis by bioengineered microbes, permitting rapid identification of modified strains producing the largest amounts of biofuels.

Genomics-enabled exploration of soils and the subsurface. The combination of modern -omics approaches, advanced imaging, and computational modeling have led to new discoveries on the bioprocesses of plant roots and microbial communities in soils and the deeper subsurface. BER funded researchers have identified an abundant new class of soil microbes that consume the greenhouse gas nitrous oxide, a discovery with significant implications in predicting climate change impacts and developing sustainable bioenergy systems. The Joint Genome Institute (JGI) recently completed metagenomic sequencing for the root microbiome of the model plant *Arabidopsis thaliana*, an important step toward understanding the coupled processes of plants and associated soil microbes. Collaborating researchers at national laboratories and academic institutions also developed a new computational bioinformatics approach for tracking dynamic changes in subsurface microbial community composition and functional properties related to biogeochemical cycling and contaminant transformation.

Improving Arctic system predictability. The Arctic region is especially sensitive to global change, with sea-ice decline, vegetation shifts, and permafrost degradation. BER research has a growing emphasis on understanding critical Arctic processes and improving their representation in earth system models. This improved representation is generally recognized as a major need for coupled earth system models. Detailed observations of Arctic clouds and aerosols from the ARM site in Barrow, AK have led to significant improvements in how Arctic clouds are represented in the models. The NGEE-Arctic program is improving our understanding and model representation of Arctic soils and permafrost. New representations of high latitude biogeochemistry, carbon fluxes, potential influence of human and natural land use changes, and sea-ice changes have been implemented in the Community Earth System Model. The high-resolution Regional Arctic System Model provides greater detail for many of these Arctic processes.

Mystery of Methylmercury Formation Solved. Methylmercury is a potent neurotoxin, found in many environments contaminated by mercury. It has long been known that inorganic mercury is converted to this toxic form by anaerobic bacteria; however, the genetic mechanism of this transformation had remained unclear. BER-funded scientists combined chemical reasoning with analyses of genome sequence information from two different methylmercury forming bacteria to discover that two genes are required. The identified genes are present in all known mercury-methylating bacteria. The resulting understanding identifies the mechanisms of a fascinating microbial process, informs efforts to detect and manage mercury contamination, and addresses other environmental processes that produce toxic substances.

Biological and Environmental Research
Biological Systems Science

Description

Biological Systems Science integrates discovery- and hypothesis-driven science with technology development on plant and microbial systems relevant to DOE bioenergy mission needs. Systems biology is the multidisciplinary study of complex interactions specifying the function of entire biological systems—from single cells to multicellular organisms—rather than the study of individual components. The Biological Systems Science subprogram focuses on utilizing systems biology approaches to define the functional principles that drive living systems, from microbes and microbial communities to plants and other whole organisms.

Key questions that drive these studies include:

- What information is encoded in the genome sequence?
- How is information exchanged between different subcellular constituents?
- What molecular interactions regulate the response of living systems and how can those interactions be understood dynamically and predictively?

The subprogram builds upon a successful track record in defining and tackling bold, complex scientific problems in genomics—problems that required the development of large tools and infrastructure; strong collaboration with the computational sciences community and the mobilization of multidisciplinary teams focused on plant and microbial bioenergy research. The approaches employed include genome sequencing, proteomics, metabolomics, structural biology, high-resolution imaging and characterization, and integration of information into computational models that can be iteratively tested and validated to advance a predictive understanding of biological systems from molecules to mesoscale.

The subprogram supports operation of a scientific user facility, the DOE Joint Genome Institute (JGI), and use of structural biology facilities through the development of instrumentation at DOE's national user facilities. Support is also provided for research at the interface of the biological and physical sciences and instrumentation for radiochemistry to develop new methods for real-time, high-resolution imaging of dynamic biological processes.

Genomic Science

The Genomic Science activity supports research aimed at identifying the fundamental principles that drive biological systems relevant to DOE missions in energy, climate, and the environment. These principles guide the translation of the genetic code into functional proteins and the metabolic/regulatory networks underlying the systems biology of plants, microbes, and communities. Advancing fundamental knowledge of these systems will enable new solutions to national challenges in sustainable bioenergy production, understanding the fate and transport of materials such as nutrients and contaminants in the environment, and developing new approaches to examine the role of biological systems in carbon cycling, biosequestration, and global climate.

The major objectives of the Genomic Science activity are to determine the molecular mechanisms, regulatory elements, and integrated networks needed to understand genome-scale functional properties of microbes, plants, and communities; develop "-omics" experimental capabilities and enabling technologies needed to achieve a dynamic, system-level understanding of organism and community functions; and develop the knowledgebase, computational infrastructure, and modeling capabilities to advance predictive understanding, manipulation and design of biological systems.

The Systems Biology Knowledgebase (KBase) is an integrated experimental framework for accessing, comparing, analyzing, modeling, and testing large scale Genomic Science data. The team-based multi-institutional DOE Bioenergy Research Centers focus on innovative research to achieve the basic science breakthroughs needed to develop sustainable and effective methods of producing advanced biofuels from cellulosic plant material.

Mesoscale to Molecules

BER approaches to systems biology have focused on the rich terrain between genotype and phenotype—from the genome up through the mechanisms that power living cells, communities of cells, and whole organisms. But there is also a need to explore the terrain between the mesoscale structures within living cells and the molecular effects in biological macromolecules. The Mesoscale to Molecules activity will encourage joint efforts among systems biologists, physical scientists, and engineers, to focus on fostering interdisciplinary approaches and leveraging tools and resources at the national scientific user facilities to improve understanding of the genomic and physical rules that govern the formation, structure, and function of subcellular organelles and their integration within biological systems operating at organism scale.

Radiological Sciences

Radiological Sciences supports radionuclide tracer synthesis and imaging research for real-time visualization of dynamic biological processes in energy and environmentally relevant contexts. The activity has significantly transitioned from its historical focus on nuclear medicine research and applications for human health to focus on real-time, whole organism understanding of metabolic and signaling pathways in plants and nonmedical microbes. Radionuclide imaging continues to be a singular tool for studying living organisms in a manner that is quantitative, three dimensional, temporally dynamic, and non-perturbative of the natural biochemical processes. The instrumentation research focuses on improved metabolic imaging in the living systems, including plants and microbial-communities, relevant to biofuels production and bioremediation of relevance to DOE. The transition from medical imaging application to biofuels and environmental research continues.

The activity also supports fundamental research on integrated gene function and response of biological organisms to low dose radiation exposure, through systems genetics analysis in model systems and epidemiological studies. This activity contributes a scientific foundation for informed decisions regarding remediation of contaminated DOE sites and for determining acceptable levels of human health protection and for both cleanup workers and the public.

Biological Systems Science Facilities and Infrastructure

Biological Systems Science supports unique scientific facilities and infrastructure related to genomics and structural biology that are widely used by researchers in academia, the national laboratories, and industry. The DOE Joint Genome Institute (JGI) is the only federally funded major genome sequencing center focused on genome discovery and analysis in plants and microbes for energy and environmental applications. High-throughput DNA sequencing underpins modern systems biology research, providing fundamental biological data on organisms and groups of organisms. By understanding shared features of multiple genomes, scientists can identify key genes that may link to biological function. These functions include microbial metabolic pathways and enzymes that are used to generate fuel molecules, affect plant biomass formation, degrade contaminants, or capture CO_2, leading to the optimization of these organisms for biofuels production and other DOE missions.

JGI is developing aggressive new strategies for interpreting complex genomes through new high-throughput functional assays, DNA writing and manipulation techniques and, genome analysis tools in association with the DOE Systems Biology Knowledgebase (KBase). These new capabilities are part of JGI’s latest strategic plan to provide users with additional capabilities supporting biosystems design efforts for biofuels and environmental process research. JGI also performs metagenome (genomes from multiple organisms) sequencing and analysis from environmental samples and is developing single cell sequencing techniques on hard-to-culture cells from environments relevant to the DOE missions.

BER also supports development and use of specialized instrumentation for biology at major DOE user facilities, such as synchrotron light sources and neutron facilities, in collaboration with the other SC program offices. These research facilities enable science aimed at understanding the structure and properties of biological systems at resolutions and scales not accessible with instrumentation available in university, institute, or industrial laboratories. This information is critical in contributing to our understanding of the relationship between genome, biological structure, and function. BER is also taking steps to ensure that the data will be integrated into the KBase to help accelerate practical applications of this knowledge for energy and the environment.

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Genomic Science		
Continued investments will advance core research areas in Foundational Genomics Research with emphasis on continued development of biosystems design tools and biodesign technologies for bioenergy research, integrative analysis of large experimental genomic science datasets, and efforts to gain a predictive understanding of carbon cycling in the environment. The research portfolio will stress the integration of experimental genome genomic science with computational modeling to advance a predictive understanding of the design, function, and regulation of plants, microbes, and biological communities contributing to the cost-effective production of next generation biofuels as a major secure national energy resource. At least 5% of the funding for biodesign efforts will be used to study the environmental, ethical, legal, and societal impacts. Support will provide for core research activities in plant and microbial systems-level functional genomics and networks, with completion of Metabolic Synthesis and Conversion targeted research on cellulosic ethanol and biohydrogen. Research efforts at the Bioenergy Research Centers will advance biofuels development from foundational biological systems science. Computational Biosciences will advance the DOE KBase effort to develop predictive simulation efforts in plant and microbial community interactions.	Genomic Science research remains a priority activity. Foundational Genomics Research will continue to support development of biosystems design tools and biodesign technologies for plant and microbial systems relevant to bioenergy production, and genomics enabled approaches to examine impacts of bioenergy production and climate change on carbon and nutrient cycling processes in terrestrial ecosystems. At least 5% of the funding for biodesign efforts will be used to study the environmental, ethical, legal, and societal impacts. Genomics Analysis and Validation will integrate experimental biology and technology development to improve functional characterization of genomic datasets. The emphasis of research in Metabolic Synthesis and Conversion will shift to advancing systems biology understanding and developing tools for the genetic modification of a broader set of plant and microbial species relevant to carbon cycling and bioenergy production. Research efforts at the Bioenergy Research Centers will continue to advance biofuels development from foundational biological systems science. Computational Biosciences will continue to support the operation of the DOE KBase, providing the research community with online tools for data integration and predictive modeling and increasing development of interoperable platforms for varying data types and scaling of data environments across multiple levels of biological organization.	Foundational Genomic Research investments in biosystems design will be leveled off and funding for genomics enabled carbon cycle research is decreased. Targeted research in Metabolic Synthesis and Conversion on cellulosic ethanol and biohydrogen has been completed. Genomic Analysis and Validation, the DOE Bioenergy Research Centers, and Computational Biosciences Research continue.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Mesoscale to Molecules		
Research is initiated to understand the genomic and physical rules that govern the formation and architecture of subcellular organelles in biological systems. The relationship between composition and function will be explored, leveraging imaging tools and resources at the national scientific user facilities.	The properties of many complex systems at one observational scale cannot be extrapolated accurately from processes at another scale because the nature of the scaling relationships is unknown. Increased investment will complement pilot projects initiated in FY 2014 and continue efforts to understand the spatial organization of metabolic processes in cells and the physical rules that govern metabolism in subcellular organelles in biological systems. Identifying scaling relationships allows accurate representation of functional relationships within the cell, facilitating improved predictions of multicellular interactions and biological organism behavior with respect to energy and the environment. New modeling concepts will be developed and validated with new imaging tools and resources at the national scientific user facilities and within the DOE KBase.	Emphasis will be placed on integrated experimental and computational approaches to investigate the scaling properties of processes occurring from the molecular to the mesoscale and multicellular organization
Radiological Sciences		
Core research activities will emphasize radiotracer synthetic chemistry for real-time visualization of dynamic biological processes in the energy and environmentally-relevant contexts. Human nuclear medicine research is transitioned to integrative training opportunities in nuclear medicine. Radiobiology research continues to emphasize a systems biology approach to understanding the effects of low dose radiation on cellular processes and epidemiological studies to uncover statistically significant effects of low dose radiation in large populations.	Core activities in Radiochemistry and Imaging Instrumentation will continue to stress development of radiotracer techniques and instrumentation to visualize metabolic processes in plants and microbes non-invasively and in real time. Core efforts in radiobiology will continue to evaluate methods to translate molecular-scale effects of low dose radiation to whole model organisms.	Radionuclide imaging research for real-time visualization of dynamic biological processes in energy and environmentally-relevant contexts continues, while concluding training activities in nuclear medicine research. Decreases in radiobiology reflect a shift towards bioenergy and environmental research within the Biological Systems Science portfolio. Ongoing efforts in radiobiology emphasize a systems biology approach to understanding the subtle effects of low dose radiation on cell processes and epidemiological studies to evaluate statistically significant effects of low dose radiation exposure in large populations.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Biological Systems Science Facilities and Infrastructure		
JGI will emphasize large scale, complex sequencing of plants and microbial communities in support of fundamental research for DOE bioenergy and environmental missions. JGI will facilitate genome science through its massive sequencing capability coupled with high performance computing for data management, integration, and analysis. JGI activities are closely coordinated with DOE's KBase effort and will seek opportunities to integrate high-throughput technologies that can bring added functional understanding to the genome sequences generated. The priority needs for these technologies are informed by the report from the community workshop, "JGI Strategic Planning for the Genomic Sciences," held in FY 2012. JGI sequencing capabilities also support biosystems design efforts.	JGI will maintain its efforts to provide high quality DNA sequence and also bring on new capabilities to interpret, manipulate, and write DNA in support of biofuels, biodesign, and environmental research as part of the implementation of JGIs' new strategic plan. JGI will continue to maintain a close linkage with the DOE KBase allowing the research community to access and analyze the latest genome sequence information produced by JGI.	JGI will increasingly emphasize understanding comparative or community-scale plant and microbial genomics.
Support continues to develop new instrumentation and end stations for structural biology and new research capabilities at the Office of Science synchrotron light sources and neutron facilities.	Support will continue for the instrumentation and end stations for structural biology at the DOE synchrotron light and neutron sources. Additional efforts will be made to link the resulting data from these stations with the DOE KBase.	Support continues for the development of instrumentation at SC's synchrotron light sources, neutron sources, and next-generation user facilities for analyzing biological structure-function relationships.

Biological and Environmental Research
Climate and Environmental Sciences

Description

The Climate and Environmental Sciences subprogram supports fundamental science and research capabilities that enable major scientific developments in climate-relevant atmospheric-process and ecosystem research and modeling, in support of DOE's mission goals for basic science, energy, and national security. This includes research on clouds, aerosols, and the terrestrial carbon cycle; large-scale climate change and earth system modeling; the effects of climate change on ecosystems; and integrated analysis of climate change impacts on energy and related infrastructures. It also supports subsurface biogeochemical research that advances fundamental understanding of coupled physical, chemical, and biological processes controlling the environmental fate and transport of energy byproducts. This integrated portfolio of research from molecular-level to field-scales emphasizes the coupling of multidisciplinary experimentation and advanced computer models and is aimed at developing predictive, systems-level understanding of the fundamental science associated with climate change and other energy-related environmental challenges. The Department will continue to advance the science necessary to further develop predictive climate and earth system models targeting resolution at the regional spatial scale and interannual to centennial time scales and to focus on areas of critical uncertainty including Arctic permafrost thaw and carbon release, in close coordination with the U.S. Global Change Research Program (USGCRP) and the international science community.

The subprogram supports three primary research activities and two national scientific user facilities. The two user facilities are the Atmospheric Radiation Measurements Climate Research Facility (ARM) and the Environmental Molecular Sciences Laboratory (EMSL). ARM provides unique, multi-instrumented capabilities for continuous, long-term observations needed to develop and test understanding of the central role of clouds and aerosols on the earth's climate. EMSL provides integrated experimental and computational resources needed to understand the physical, chemical, and biological processes that underlie DOE's energy and environmental mission.

<u>Atmospheric Systems Research</u>

Atmospheric System Research (ASR) is the primary U.S. activity addressing two major areas of uncertainty in climate change model projections: the role of clouds and the effects of aerosols on precipitation and the atmospheric radiation balance. ASR coordinates with ARM, utilizing the facility's continuous long-term datasets that provide three-dimensional measurements of radiation, aerosols, clouds, precipitation, dynamics, and thermodynamics over a range of environmental conditions at diverse climate-sensitive locations. The long-term observational datasets are supplemented with laboratory studies and shorter-duration ground-based and airborne field campaigns to target specific atmospheric processes under a diversity of locations and atmospheric conditions. ASR research results are incorporated into earth system models developed by Climate and Earth System Modeling to both understand the processes that govern atmospheric components and to advance earth system model capabilities with greater certainty of predictions. ASR seeks to develop integrated, scalable test-beds that incorporate process-level understanding of the life cycles of aerosols, clouds, and precipitation into dynamic models.

<u>Environmental System Science</u>

Environmental System Science supports research to provide a robust, predictive understanding of terrestrial surface and subsurface ecosystems, including the effects of climate change, from the subsurface to the top of the vegetated canopy and from molecular to global scales. This includes understanding the role of ecosystems in climate with an emphasis on carbon cycling and the role of subsurface biogeochemical processes in the fate and transport of carbon, nutrients, radionuclides, and heavy metals.

A significant fraction of the carbon dioxide (CO_2) released to the atmosphere during fossil fuel combustion is taken up by terrestrial ecosystems, but the impacts of climatic change, particularly warming, on the uptake of CO_2 by the terrestrial biosphere remain poorly understood. The significant sensitivity of climate models to terrestrial carbon cycle feedback and the uncertain signs of that feedback make resolving the role of the terrestrial biosphere on the carbon balance a high priority. The research focuses on understanding, observing, and modeling the processes controlling exchange rates of greenhouse gases, in particular CO_2 and methane (CH_4), between atmosphere and terrestrial biosphere, evaluating terrestrial source-sink mechanisms for CO_2 and CH_4, and improving and validating the representation of terrestrial ecosystems in coupled earth system models.

Subsurface biogeochemical research supports integrated research, ranging from molecular to field scales, to understand and predict the role that biogeochemical processes play in controlling the cycling and mobility of energy-relevant materials in the subsurface and across key surface-subsurface interfaces in the environment, including environmental contamination from past nuclear weapons production.

Climate and Earth System Modeling

Climate and Earth System Modeling develops physical, chemical, and biological model components, as well as fully coupled earth system models. This research includes the interactions of human and natural earth systems needed to simulate climate variability and change from years to decades to centuries at regional and global scales. The research specifically focuses on quantifying and reducing the uncertainties in earth system models based on more advanced model development, diagnostics, and climate system analysis. Priority model components include the ocean, sea-ice, land-ice, aerosols, atmospheric chemistry, terrestrial carbon cycling, multi-scale dynamical interdependencies, and dynamical cores.

In FY 2015, BER will initiate a major new investment in Climate Model Development and Validation. The focus of the investment will be on restructuring model architecture, exploiting new software engineering and computational upgrades, and incorporating scale-aware physics in all model components. In addition, new DOE modeling activities will be based on modularized components that can act either alone or as a system, thus allowing greater certainty of predictions in a flexible structure. The BER climate modeling activities will produce earth system model codes that will run optimally on current and next-generation supercomputers with numerous processors. Also, this effort will consider algorithm and code design in conjunction with architecture evolution, for co-design and next generation computation. This capability will enable BER to produce earth-system models with improved resolution that are compatible with near-term and next generation computing hardware. Advanced code engineering enhances usability, testing for performance and accuracy, and also for validation with respect to ARM observations and data. Work will begin to develop workflows that automate comparison of model with diverse measurements (satellite, ground-based, and radar measurements), to provide analysis platforms, including methods to characterize and bound projection uncertainty. Because model development requires systematic validation along each step, the increased investments in model validation will use the three dimensional ARM data available from both fixed and mobile field platforms. The model development activities will focus on the rapid development and use of more efficient representations of scale-aware atmospheric parameters in earth systems models. This will improve climate predictability from hydrostatic (currently at 10 km resolution) to nonhydrostatic physics (at resolutions finer than 10 km). Advances in ARM measurement capabilities and DOE computing capability/modeling resolution will allow ARM data to be used to validate climate models under a variety of conditions and regions, providing high resolution model testbeds. This validation activity will focus on three critical areas:

- Developing methodologies to produce high resolution data sets enabling ARM data to be assimilated into advanced sub-grid scale model elements that extend resolutions below 10 km. This effort will be developed to exploit data from each ARM fixed facility and will be a component of each mobile facility deployment—providing unique and specialized testbeds for model improvement and validation based on recent ARM enhancements.
- Simultaneous ARM deployment and downscaling research embedded within the 10 km footprint of ARM observations.
- The high resolution ARM and model ensemble data bases will be integrated into the advanced data management infrastructure effort, Climate and Environmental Data Analysis, and Visualization activity, for use by the scientific research community.

The Regional and Global Climate modeling activity continues to provide scientific analyses using DOE's investments in climate and earth system model development. Scientific analyses will study the predictability of statistical distributions of future weather extremes; causes and distributions of droughts; biogeochemical controls on abrupt climate change; the role of the highly resolved patterns of carbon budgets on regional and global climate change; and the roles of cryospheric phenomena (sea ice, glaciers, ice sheets, and permafrost thaw) on Arctic climate, sea level rise, and large scale modes of variability. Also, new research will explore model derived analogs that combine historical and projected climate changes, with an objective to validate and improve the uncertainty characterization of future climate projections based on the prediction successes using existing data testbeds. To rapidly and efficiently advance model capabilities, BER supports a unique and powerful intercomparison resource, the Program for Climate Model Diagnosis and Intercomparison (PCMDI), for global climate model development, validation, diagnostics, and outputs, using over 40 world-leading climate models. This set of diagnostic and intercomparison activities combined with scientific analysis, ensures BER funded researchers can exploit the best available science and practice within each of the world's leading climate research programs.

The Earth System Modeling activity in BER will continue to coordinate with the National Science Foundation (NSF) to provide support for the Community Earth System Model system (CESM). CESM is designed by the research community with open access and broad use by climate researchers worldwide. This system of models provides a critical capacity for regional climate projections, including information on how the frequency of occurrence and intensity of storms, droughts, and heat waves will change as climate evolves. The scientific priorities for improvement of the community model system are based on efforts to quantify uncertainties relative to specific scientific questions; and the outputs of the intercomparison and validation resource allow one to determine best features of all global models that can be considered for incorporation into DOE's modeling platform. DOE has also provided computational power and expertise to the climate research community through a partnership between BER and the Office of Science's Advanced Scientific Computing Research (ASCR) program, which is innovating code design for optimal model computation on its petascale computers. Climate modeling tools are essential for informing investment decision-making processes for infrastructures associated with future large-scale deployment of energy supply and transmission.

The Integrated Assessment activities in BER continue to support the development of integrated assessment model components to the DOE Earth System Modeling activities, with a focus on assessing the interdependencies of energy, water, and land sector activities that are coupled to the physical and biogeochemical drivers of climate and earth system change. The investments will address uncertainty characterization of both the individual physical, biogeophysical, and sectorial (including energy infrastructure as well as emerging clean energy technology deployment) drivers, extending from macroscale (greater than 50 km resolution) to the much finer scales of earth system prediction (order of 10 km). Interdependencies, feedbacks, scale aware predictions, and uncertainty characterization will be broadly developed to support the DOE mission.

Climate and Environmental Facilities and Infrastructure

Climate and Environmental Facilities and Infrastructure include two scientific user facilities, and climate data management for the climate science community. The scientific user facilities—the Atmospheric Radiation Measurement Climate Research Facility (ARM) and the Environmental Molecular Sciences Laboratory (EMSL)—provide the broad scientific community with technical capabilities, scientific expertise, and unique information to facilitate science in areas integral to BER's mission.

ARM is a multi-platform multi-site national scientific user facility, providing the world's most comprehensive continuous field measurements of climate data to advance atmospheric process understanding and climate models through precise observations of atmospheric phenomena. ARM currently consists of four fixed long-term measurement facility sites (in Oklahoma, Alaska, the Azores, and the western tropical Pacific (to be closed in late 2014)), three mobile facilities, and an airborne research capability that operates at sites selected by the scientific community. The ARM fixed sites and mobile measurement campaigns are distributed around the world in locations where the scientific community most critically needs enhanced understanding and data to incorporate into climate models, thereby improving model performance and predictive capabilities. Each of the ARM sites includes scanning radars, lidar systems, and in situ meteorological observing capabilities; the sites are additionally used to demonstrate technologies as they are developed by the community. ARM experiments to study the impact of evolving clouds, aerosols, and precipitation on the earth's radiative balance and rate of climate change address the two most significant scientific uncertainties in climate research. Also, BER is maintaining the exponentially increasing data archive to support enhanced analyses and model development. The data extracted from the archive are used to improve climate projections at higher resolution, greater sophistication, and lower uncertainty.

EMSL provides integrated experimental and computational resources for discovery and technological innovation in the environmental molecular sciences. With more than more than 75 premier instruments as well as a high performance computer and associated software, EMSL enables users to undertake molecular-scale experimental and theoretical research on biological systems, biogeochemistry, aerosol chemistry, and interfacial and surface science relevant to climate, energy, and environmental challenges facing DOE and the Nation. This includes science supporting alternative energy sources, improved catalysts and materials for industrial applications, insights into factors influencing climate change and carbon sequestration processes, and subsurface biogeochemical drivers.

Data sets generated by ARM, other DOE and Federal earth observing activities, and earth system modeling activities, are large. The information in earth observations data can be used to achieve broad benefits ranging from planning and development of energy infrastructure to natural disaster impact mitigation to commercial supply chain management to natural resource management. Access to and uses of these data are fundamental to supporting decision-making, scientific discovery, and technological innovation. DOE's data management activities will be coordinated with the Big Data Research and Development Initiative (http://www.whitehouse.gov/sites/default/files/microsites/ostp/big_data_press_release_final_2.pdf), that in turn involves two important processes for the earth observation community, the civil Earth Observation Assessment (EOA) and the Big Earth Data Initiative (BEDI), both which are overseen by the newly chartered U.S. Group on Earth Observations (USGEO) Subcommittee of the Committee on Environment, Natural Resources, and Sustainability. BER's data investments are internally collaborative with the Advanced Scientific Computing Research program.

In FY 2015, the BER Data Management effort includes the Climate and Environmental Data Analysis and Visualization activity that focuses on combining ensembles of new generations of adaptive grid high resolution earth system prediction models with interdependent components involving energy and infrastructure sector models, field observations from ARM, the AmeriFlux Network, ongoing and planned NGEE projects, raw data from environmental field experiments, and analytical tools for system diagnostics, validation, and uncertainty quantification.

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Atmospheric System Research		
ASR focuses on process studies and modeling efforts that improve formulations of aerosols, mixed phase clouds, and precipitation process interdependencies, in order to improve estimates of feedbacks on climate in mid-latitude, tropical, and Arctic regions. Specific focuses include the description of aerosol-cloud-precipitation interdependences during larger scale dynamical events, such as those that occur in the tropics and mid-latitudes.	ASR will continue to focus on highest priority areas of uncertainty in climate projections—the behavior and function of clouds and aerosols and their role in controlling the atmospheric radiation balance.	Research will continue to improve formulations for aerosols, clouds, and aerosol-cloud-precipitation interactions in order to improve estimates of how these feedbacks have and will impact climate.
Environmental System Science		
The research will emphasize the Arctic and tropics Next Generation Ecosystem Experiments (NGEE) and AmeriFlux to improve the representation of the major carbon sinks associated with changing climates. Specific NGEE Tropics field studies will be conducted based on the recommendations provided during the NGEE Tropics Workshop held in FY 2012. Support for terrestrial modeling activities will be shifted to the Climate and Earth System Modeling portfolio to promote stronger model research coordination and cost efficiencies. In addition, efficiency will be gained by consolidating investments in terrestrial and subsurface biogeochemistry, nutrient flow, and soil science.	Research continues to understand and predict the roles of terrestrial ecosystems in the larger earth system. NGEE Arctic will begin the transition to Phase II of the project, building from three years of field sampling and process modeling at the Barrow site for Phase I and extending to seven additional years of multiple site sampling, multiple site process modeling, and dynamic model integration into regional climate simulations for Phase II. NGEE Tropics continues with investments to carefully connect field and modeling activities. AmeriFlux will emphasize efforts to encourage common practices and protocols across the network. Subsurface biogeochemistry will continue to focus on fundamental processes that control the fate and transport of energy-related materials in the subsurface.	The activity will provide continued support for understanding and modeling Arctic and tropical carbon vulnerability and will support experimental field activities at the NGEE Tropics to study and contribute to predictive models that characterize the relationships between various tropical ecosystems and climate change. Subsurface biogeochemical research continues to focus on environmental research across scales as a continuum of complex interdependent processes, increasing integration of subsurface modeling and process research.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Climate and Earth System Modeling		
Research on climate model development and analysis focuses on the science underpinning high-resolution predictability using adaptive grids and uncertainty characterization. Emphasis is placed on regional predictions for the Arctic and tropics that map into extended Community Land Model capabilities using data from the NGEE experiments. In addition, understanding dynamical interdependencies that describe larger scale variabilities (such as El Niño) that influence regional climate predictability is prioritized.	Climate Model Development and Validation advanced software and improved algorithms for DOE Climate Modeling will lead to major improvements to earth system model code that is designed to run optimally on next-generation supercomputers with numerous processors. Investments in scale-aware parameterizations, multi-component uncertainty characterization, and modularized model system components will additionally allow the transition of climate predictions to extend to finer resolutions, (below 10 km) with improved predictability. In order to systematically validate model developments at each step of the process, Climate Model Development and Validation using ARM data will be based on three-dimensional testbeds that will be developed and incorporated into the model development agenda. Testbeds will be based on recent advances in ARM data resolution to produce high resolution three-dimensional data sets enabling assimilation into advanced sub-grid scale model elements. Research on climate model development and analysis continues to focus on the science underpinning high-resolution predictability using adaptive grids and uncertainty characterization—both of which are challenging and long-term needs for the community. Emphasis continues on land and atmosphere modeling investments that parallel and connect with investments in the process research aspects of the subprogram.	Emphasis in the first year of activities for Climate Model Development and Validation will be on initiating the activity that combines advanced software code development and numerical methods with new ARM data testbeds that in turn will produce new conceptual designs for a next generation earth system prediction model platform. The model development and procedures for code development and testing will additionally incorporate adaptive and modular architectures, with multi-scale treatments and provenance. Efforts will focus on initiating the activity and developing three-dimensional ARM testbeds that will be systematically incorporated into the model development process. In addition, downscaling of model resolution to be compatible with high resolution observational data sets will be studied to advance predictability to resolutions below 10 km.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
	Core research in Regional and Global Climate Modeling, Earth System Modeling and Integrated Assessment continues to underpin high-resolution predictability using adaptive grids and uncertainty characterization.	Investments continue to evolve climate modeling capabilities using more flexible and adaptive software to support new physics and be compatible with next generation high performance computing assets. Basic research will focus on the science underpinning high-resolution predictability and uncertainty quantification using adaptive grids.
Climate and Environmental Facilities and Infrastructure		
ARM will fully support its long-term measurements at fixed sites, and the mobile facilities will be deployed to three climate-sensitive regions demanding targeted measurements: the Amazon Basin; Oliktok, Alaska; and Finland. These observations are key to reducing the earth system model uncertainties attributed to clouds and aerosols. The ARM fixed site in the Tropical Western Pacific (TWP) will be closed in late 2014; instrumentation from this site will be assimilated into the fixed site at the Southern Great Plains (SGP) (Oklahoma).	ARM will continue to support its long-term measurements at fixed sites, and the mobile facilities will be deployed to three climate-sensitive regions demanding targeted measurements. The first mobile facility will remain in the Amazon Basin; the second will be deployed on the NOAA ship Ron Brown for a campaign in the Pacific Ocean; the third will continue the experiment in Oliktok, Alaska. These observations are key to reducing the earth system model uncertainties attributed to clouds and aerosols.	Funding continues for ARM. Users may be reduced during the relocation of instrumentation from TWP to SGP.
EMSL will support facility operations that underpin user research to obtain a fundamental understanding of the physical, chemical, and biological processes that map to DOE mission needs. New capabilities of the Radiological Annex, including x-ray photo emission spectrometers, electron microscopy, electron probe microanalyzer, transmission electron microscopy, and scanning electron microscopy, come on line in FY 2014 to study contaminated materials and examine radionuclides and chemical signatures. All components of the High Resolution and Mass Accuracy Capability (HRMAC) will be integrated into the complete system.	EMSL continues to support users and their research in biological systems, biogeochemistry, aerosol chemistry, and interfacial and surface science relevant to climate, energy, and environmental challenges facing DOE and the Nation. Emphasis will be placed on utilization of new capabilities in the Radiological Annex and Quiet wing. In FY 2015 the integrated HRMAC system will be tested to meet specifications, and procedures will be developed for user operations. EMSL will develop a plan for targeting and attracting users for the new capability.	EMSL funding for operations decreases with prioritization of instrument systems available to users.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
BER will participate in the Big Earth Data Initiative to adapt the ARM data archive and other DOE earth data sets to specifications aimed at increasing interoperability and compatibility with the needs of the scientific community. In addition, ARM will continue to format its databases in order to conform to the needs of the evolving climate modeling community.	The Climate and Environmental Data Analysis and Visualization activity combines high resolution earth system models with interdependent components involving energy and infrastructure sector models, field observations, raw data from environmental field experiments, and analytical tools for system diagnostics, validation, and uncertainty quantification. Existing data management activities are combined with new capabilities to create this Climate and Environmental Data Analysis and Visualization activity which will integrate and add value to the subprogram's high resolution modeling needs and output, expanding observational data sets and extensive data from field and laboratory experiments and observations. Participation in the Big Earth Data Initiative continues.	Emphasis for this year will be on assembling and making available existing data sets, cataloging user needs from process and modeling communities and developing mechanisms to meet those needs.
General Plant Projects (GPP) and General Purpose Equipment (GPE) are provided for Oak Ridge Institute for Science and Education (ORISE).	In FY 2015, ORISE GPP/GPE is transferred to the Science Laboratories Infrastructure program.	N/A

Biological and Environmental Research
Performance Measures

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program. For more information, refer to the Department's FY 2013 Annual Performance Report. The following table shows the targets for FY 2013 through 2015.

	FY 2013	FY 2014	FY 2015
Performance Goal (Measure)	**BER Climate Model—Develop a coupled climate model with fully interactive carbon and sulfur cycles, as well as dynamic vegetation to enable simulations of aerosol effects, carbon chemistry, and carbon sequestration by the land surface and oceans and the interactions between the carbon cycle and climate**		
Target	Use new climate model simulations to quantify interactions between clouds and climate changes	Use global models to estimate most sensitive elements of terrestrial carbon to climate change for tropics, mid-latitudes, and polar regions	Develop capabilities to extend temporal resolution to sub-decadal for earth system models.
Result	Met	Not Applicable	Not Applicable
Endpoint Target	BER supports the Community Earth System Model, a leading U.S. climate model, and addresses two of the most critical areas of uncertainty in contemporary climate science—the impacts of clouds and aerosols. Delivery of improved scientific data and models (with quantified uncertainties) about the potential response of the earth atmosphere system to more accurately predict the earth's future climate is essential to plan for future energy needs, water resources, and land use. DOE will continue to advance the science necessary to further develop predictive climate and earth system models at the regional spatial scale and decadal to centennial time scales, involving close coordination with the U.S. Global Change Research Program and through the international science community.		

	FY 2013	FY 2014	FY 2015
Performance Goal (Measure)	**BER Predictive Understanding of Biological Systems—Advance an iterative systems biology approach to the understanding and manipulation of plant and microbial genomes as a basis for biofuels development and predictive knowledge of carbon and nutrient cycling in the environment.**		
Target	Not Applicable	Not Applicable	Develop 1 new computationally enabled approach to analyze complex genomic datasets.
Result	Not Applicable	Not Applicable	Not Applicable
Endpoint Target	BER will advance understanding of the operating principles and functional properties of plants, microbes, and complex biological communities relevant to DOE missions in energy and the environment. Deciphering the genomic blueprint of organisms and determining how this information is translated to integrated biological systems permits predictive modeling of bioprocesses and enables targeted redesign of plants and microbes. BER research will address fundamental knowledge gaps and provide foundational systems biology information necessary to advance development of sustainable bioenergy systems and predict impacts of changing environmental conditions on carbon cycling and other biogeochemical processes.		
Performance Goal (Measure)	**BER Facility Operations—Average achieved operation time of BER user facilities as a percentage of total scheduled annual operation time**		
Target	≥ 98%	≥ 98%	≥ 98%
Result	Met	Not Applicable	Not Applicable
Endpoint Target	Many of the research projects that are undertaken at the Office of Science’s scientific user facilities take a great deal of time, money, and effort to prepare and regularly have a very short window of opportunity to run. If the facility is not operating as expected the experiment could be ruined or critically setback. In addition, taxpayers have invested millions or even hundreds of millions of dollars in these facilities. The greater the period of reliable operations, the greater the return on the taxpayers’ investment.		

Biological and Environmental Research
Capital Summary ($K)

	Total	Prior Years	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Capital Operating Expenses Summary							
Capital equipment projects under $2 million TEC	n/a	n/a	3,131	6,217	6,217	4,667	-1,550
General plant projects (GPP) under $5 million TEC	n/a	n/a	0	250	250	0	-250
Total, Capital Operating Expenses	**n/a**	**n/a**	**3,131**	**6,467**	**6,467**	**4,667**	**-1,800**

Funding Summary ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Research	369,573	390,069	409,105	+19,036
Scientific user facilities operations and research	191,084	199,824	198,325	-1,499
Major items of equipment	0	0	0	0
Other[a]	0	19,803	20,570	+767
Total, Biological and Environmental Research	**560,657**	**609,696**	**628,000**	**+18,304**

Facility Operations ($K)

	FY 2013 Current	FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Structural Biology Infrastructure[b]	$13,878	$14,895	$14,895	$0
Joint Genome Institute	$65,000	$69,800	$69,500	-$300
Achieved operating hours	8,760	N/A	N/A	
Scheduled operating hours	8,760	8,585	8,616	+31
Optimal hours	8,760	8,616	8,616	0
Percent of optimal hours	100.0%	99.6%	100.0%	
Unscheduled downtime hours	0	N/A	N/A	
Number of users	1,155	1,000	1,000	0

[a] Includes SBIR, STTR, GPE, and non-Facility related GPP.

[b] Structural Biology Infrastructure activities are at Basic Energy Sciences user facilities and the user statistics are included in the BES user statistics.

	FY 2013 Current	FY 2014 Enacted	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Atmospheric Radiation Measurement Climate Research Facility (ARM)	$68,074	$68,429	$68,429	0
Achieved operating hours	7,979	N/A	N/A	
Scheduled operating hours	7,906	7,906	7,906	0
Optimal hours	7,906	7,906	7,906	0
Percent of optimal hours	100.9%	100.0%	100.0%	
Unscheduled downtime hours	0	N/A	N/A	
Number of users	983	1,000	900	-100
Environmental Molecular Sciences Laboratory	$44,132	$46,700	$45,501	-$1,199
Achieved operating hours	4,281	N/A	N/A	
Scheduled operating hours	4,272	4,272	4,272	0
Optimal hours	4,272	4,272	4,272	0
Percent of optimal hours	100.2%	100.0%	100.0%	
Unscheduled downtime hours	0	N/A	N/A	
Number of users	750	750	750	0
Total Facilities	$191,084	$199,824	$198,325	-$1,499
Achieved operating hours	21,020	NA	NA	
Scheduled operating hours	20,938	20,763	20,794	+31
Optimal hours	20,938	20,794	20,794	0
Percent of optimal hours (funding weighted)	100.4%	99.9%	100.0%	0
Unscheduled downtime hours	0	N/A	NA	
Number of users	2,888	2,750	2,650	-100

Scientific Employment

	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	FY 2015 vs. FY 2014
Number of permanent Ph.D.'s	1,428	1,290	1,375	+85
Number of postdoctoral associates	316	315	335	+20
Number of graduate students	461	400	465	+65