Basic Energy Sciences

Overview

The Basic Energy Sciences (BES) program's mission is to support fundamental research to understand, predict, and ultimately control matter and energy at the electronic, atomic, and molecular levels, generating knowledge that can enable development of energy technologies critical to the Nation's economic and national security. BES research provides the scientific foundations for innovations that advance technologies for the generation, conversion, transmission, and storage of energy, as well as critical and emerging technologies in quantum information science and microelectronics, thereby supporting the DOE missions in energy and national security. Such advances necessarily require the discovery, design, and control of materials and chemical systems across large scales of time and space. BES accomplishes this through sustained investment in leading-edge scientific research and the stewardship of world-class scientific user facilities that enable cutting-edge research and development.

The research disciplines that BES supports—condensed matter and materials physics, chemistry, geosciences, and aspects of biosciences—touch virtually every important aspect of efficient energy resource production, conversion, transmission, and storage, providing a knowledge base for achieving a secure, abundant, and affordable energy future. The BES Advisory Committee (BESAC) report, "A Remarkable Return on Investment in Fundamental Research,"[a] provides key examples of major technological, commercial, and national security impacts that are directly traceable to BES-supported basic research. This mission-relevance of BES research results from a long-standing strategic planning process, which encompasses BESAC reports, community workshops and reports, and rigorous program reviews. BES balances its research investments between discovery-oriented transformational basic research and use-inspired basic research.

BES scientific user facilities consist of complementary x-ray sources, neutron sources, and centers for research utilizing nanoscale science. Capabilities at BES facilities can probe materials and chemical systems with ultrahigh spatial, temporal, and energy resolutions to investigate the critical functions of matter—transport, reactivity, excitations, and motion—to answer challenging science questions and to provide insights on the scientific basis for energy technologies. The above-noted BESAC report recounts the central role of user facilities in U.S. scientific and industrial leadership. BES has a long history of delivering major construction projects on time and on budget, and of providing reliable availability and support to users for operating facilities.[b] This record of accomplishment includes rigorous community engagement in planning and in performance assessment for operating facilities and construction.

Key to exploiting scientific discoveries for future energy systems is the ability to create new materials using forefront innovative synthesis and processing techniques to precisely define the atomic arrangements, and to discover, design, and direct chemical processes. These innovations, based on principles revealed by fundamental science and using experimental tools with advanced computational, artificial intelligence, and data science, enable better control of physical and chemical transformations and conversions of energy from one form to another generating useful information for the development and improvement of energy technologies and industrial processes. Working closely with other DOE offices, BES research is informed by practical technology challenges and findings are disseminated to the broader community to translate federal investments to industrial impact and economic prosperity.

BES is focused on enhancing research and user communities across the Nation. The grand challenge and use-inspired scientific research that is necessary to address National priorities requires a sustained and integrated ecosystem of scientists, engineers, and enabling capabilities. Collectively, BES research and facilities provide a significant strategic advantage for the Nation to advance scientific frontiers while laying the foundation for future energy innovations that will sustain American energy dominance.

[a] https://science.osti.gov/~/media/bes/pdf/BESat40/BES_at_40.pdf

[b] https://www.gao.gov/assets/gao-08-641.pdf

Highlights of the FY 2026 Request

The BES FY 2026 Request of $2,241.0 million is a decrease of $347.3 million below the FY 2025 Enacted level.

Research

Guided by strategic planning, including BESAC and Basic Research Needs workshop reports, the Request underscores continues support for EFRCs, NQISRCs , and BES core scientific research programs. Continued funding for the Established Program to Stimulate Competitive Research (EPSCoR) will maintain support of institutions in U.S. states and territories that do not historically have large federally supported academic research programs, thereby enhancing research and user communities from across the Nation to ensure a strong scientific foundation in the BES ecosystem. The FY 2026 Request:

- Increases funding for Artificial Intelligence and Machine Learning (AI/ML) research to accelerate fundamental discoveries, enhance user facility operations, and advance interpretation of massive data sets. As part of this portfolio, BES will expand efforts focused on AI/ML for science within the Theoretical Condensed Matter Physics and Computational and Theoretical Chemistry programs.
- Increases funding for QIS research, which includes a robust core research portfolio to complement the NQISRCs, which are undergoing recompetition/renewal in FY 2025.
- Increases funding for Critical Minerals and Materials (CMM) research to expand understanding of the role of rare earth elements (REEs), platinum-group elements (PGEs), and other critical elements in determining the functional properties of materials and catalysts across different length scales, discover chemical processes and materials that can enhance recovery and reuse of critical elements, and develop fundamental knowledge of how best to reduce or eliminate the need for critical elements in chemical processes and energy technologies.
- Continues funding for muti-disciplinary microelectronics research in which materials, chemistries, devices, systems, architectures, algorithms, and software are developed in a closely integrated, co-design approach. As part of this portfolio, the Microelectronics Science Research Centers (MSRCs) comprise a network of multiple team awards, with individual awards focused on a dimension related to a common research topic for each center. The multidisciplinary teams include researchers from national laboratories, universities, and industry. The Request will enable support for BES research awards that contribute to these cross-SC Research Centers.
- Continues funding for the highest priority research that provides foundational knowledge for the development of next-generation energy technologies.

Facility Operations

The Request balances support for user access with the need to ensure safe operations of five BES-supported x-ray light sources, two neutron sources, and five Nanoscale Science Research Centers (NSRCs). Preconceptual planning continues for beamline MIE projects.

Projects

Support continues for the Linac Coherent Light Source-II High Energy (LCLS-II-HE), Second Target Station (STS), and Cryomodule Repair and Maintenance Facility (CRMF) line-item projects. Funding is requested for the Advanced Light Source Upgrade (ALS-U) line-item project consistent with a new project baseline budget to be established in FY 2026. Funding for the NSLS-II Experimental Tools (NEXT)–III and High Flux Isotope Reactor (HFIR) Pressure Vessel Replacement (PVR) projects is deferred.

Basic Energy Sciences
Funding

(dollars in thousands)

	FY 2024 Enacted	FY 2025 Enacted	FY 2026 Request	FY 2026 Request vs FY 2025 Enacted
Basic Energy Sciences				
Scattering and Instrumentation Sciences Research	114,646	81,396	25,497	-55,899
Condensed Matter and Materials Physics Research	198,714	205,714	144,022	-61,692
Materials Discovery, Design, and Synthesis Research	91,297	87,297	48,698	-38,599
Established Program To Stimulate Competitive Research EPSCoR	25,000	25,000	25,000	–
Energy Frontier Research Centers - Materials	65,000	65,000	58,000	-7,000
Energy Earthshot Research Centers - Materials	3,500	3,500	–	-3,500
Energy Innovation Hubs - Materials	25,913	25,913	25,913	–
Computational Materials Sciences	13,492	13,492	4,000	-9,492
Total, Materials Sciences and Engineering	**537,562**	**507,312**	**331,130**	**-176,182**
Fundamental Interactions Research	133,593	140,593	101,315	-39,278
Chemical Transformations Research	118,658	114,658	61,858	-52,800
Photochemistry and Biochemistry Research	131,460	99,710	45,107	-54,603
Energy Frontier Research Centers - Chemical	65,000	65,000	60,000	-5,000
Energy Earthshot Research Centers - Chemical	3,500	3,500	–	-3,500
Energy Innovation Hubs - Chemical	20,758	20,758	20,758	–
General Plant Projects - Chemical	1,000	1,000	1,000	–
Computational Chemical Sciences	13,492	13,492	4,000	-9,492
Total, Chemical Sciences, Geosciences, and Biosciences	**487,461**	**458,711**	**294,038**	**-164,673**
X-Ray Light Sources	709,134	778,865	805,106	+26,241
High-Flux Neutron Sources	375,163	373,367	385,146	+11,779
Nanoscale Science Research Centers	150,880	159,230	165,770	+6,540
Other Project Costs	14,000	9,500	5,000	-4,500
Major Items of Equipment	25,000	–	–	–
Scientific User Facilities, Research	65,800	67,800	33,467	-34,333
Total, Scientific User Facilities (SUF)	**1,339,977**	**1,388,762**	**1,394,489**	**+5,727**
Subtotal, Basic Energy Sciences	**2,365,000**	**2,354,785**	**2,019,657**	**-335,128**

(dollars in thousands)

	FY 2024 Enacted	FY 2025 Enacted	FY 2026 Request	FY 2026 Request vs FY 2025 Enacted
Construction				
24-SC-10 HFIR Pressure Vessel Replacement (PVR), ORNL	4,000	6,000	–	-6,000
24-SC-12 NSLS-II Experimental Tools - III (NEXT-III), BNL	2,556	5,500	–	-5,500
21-SC-10 Cryomodule Repair & Maintenance Facility (CRMF), SLAC	9,000	20,000	20,000	–
19-SC-14 Second Target Station (STS), ORNL	52,000	52,000	52,000	–
18-SC-11 Spallation Neutron Source Proton Power Upgrade (PPU), ORNL	15,769	–	–	–
18-SC-12 Advanced Light Source Upgrade (ALS-U), LBNL	57,300	50,000	50,000	–
18-SC-13 Linac Coherent Light Source-II-High Energy (LCLS-II-HE), SLAC	120,000	100,000	99,343	-657
Subtotal, Construction	**260,625**	**233,500**	**221,343**	**-12,157**
Total, Basic Energy Sciences	**2,625,625**	**2,588,285**	**2,241,000**	**-347,285**

SBIR/STTR funding:

- FY 2024 Enacted: SBIR $35,002,000 and STTR $4,922,000
- FY 2025 Enacted: SBIR $33,354,000 and STTR $4,691,000
- FY 2026 Request: SBIR $21,204,000 and STTR $2,982,000

Basic Energy Sciences
Explanation of Major Changes

	(dollars in thousands) FY 2026 Request vs FY 2025 Enacted
Materials Sciences and Engineering Research will continue to support fundamental scientific opportunities for materials innovations. Research priorities include energy technologies (e.g., nuclear, energy storage, and grid), microelectronics research (including the MSRCs), AI/ML, critical materials, and QIS. The Request also includes funding for continued support of the EFRCs, the Batteries and Energy Storage Energy Innovation Hub, the NQISRCs (recompetition/renewal in FY 2025), and EPSCoR.	-$176,182
Chemical Sciences, Geosciences, and Biosciences Research will continue to support fundamental scientific opportunities for innovations in chemistry, geosciences, and biosciences. Research priorities include energy (e.g., geothermal, fuels and high commodity chemicals), AI/ML, QIS, microelectronics (including the MSRCs), and critical materials. The Request also includes funding for continued support of the EFRCs, the NQISRCs (recompetition/renewal in FY 2025), and the Fuels from Sunlight Hub (renewal in FY 2025).	-$164,673
Scientific User Facilities (SUF) The 12 BES user facilities will be supported in a manner balancing safe operation and user access. Continued facilities research priorities include accelerator and detector R&D and expansion of AI/ML. The Request also provides Other Project Costs (OPC) to support the LCLS-II-HE project.	+$5,727
Construction The Request provides continuing support for the LCLS-II-HE, STS, CRMF, and ALS-U projects.	-$12,157
Total, Basic Energy Sciences	-$347,285

Basic and Applied R&D Coordination

As a program that supports fundamental scientific research relevant to many DOE mission areas, BES strives to build and maintain close connections with other DOE program offices. BES coordinates with DOE R&D programs through a variety of Departmental activities, including workshops, strategic planning activities, solicitation development, and program review, as elaborated below. BES also coordinates with DOE technology offices in the Small Business Innovation Research (SBIR) and Small-Business Technology Transfer Research (STTR) program, including topical area planning, solicitations, reviews, and award recommendations.

BES has robust interactions with DOE technology offices through formal and informal coordination activities. Historically, co-siting of research by BES and other DOE programs at the same institutions has facilitated close integration of basic and applied research. The DOE national laboratory system plays a crucial role in achieving this integration of basic and applied research.

BES program managers also participate in intra-DOE information exchange and coordination on solicitations and in program reviews and project selections. These activities facilitate cooperation and coordination between BES and other parts of DOE, notably the energy technology offices.

Program Accomplishments

- In FY 2024, over 13,700 unique users accessed BES user facilities,[c] approximately 27 percent taking advantage of remote access.
- The APS-U project completed installation of the upgraded storage ring and achieved first light, delivering x-rays to the resonant inelastic x-ray scattering beamline, one of multiple beamlines upgraded as part of the project. Following this milestone, APS has resumed its user program, with more than three dozen beamlines available to the scientific community.
- Researchers from one of the DOE's NQISRCs developed a new technique for characterizing the sources of energy loss in superconducting qubits. Through a comparison of devices made using different combinations of superconducting material and substrate preparation, the research team discovered that tantalum-based qubits on annealed sapphire showed dramatically reduced losses. This finding may enable qubit designs with improved coherent times, of interest to many industrial quantum computing companies.
- An EFRC demonstrated, for the first time, the concept of "edge of chaos", or semi-stability, in an artificial system. The phenomenon, observed in nature as the self-amplification of electrical signals passing through axons in the brain, allows an electrical signal to pass through a metallic conductor without requiring amplifiers to address signal loss due to resistance. The result has the potential to revolutionize chip design and performance by making them simpler and more efficient.
- Led by an EFRC, a multi-institutional group from several DOE laboratories and universities in the U.S. and Germany combined experiments and theory to capture the first image of electron motion decoupled from nuclear motion, revealing the immediate electronic response to ionizing radiation. Leveraging the availability of attosecond pump/probe x-ray pulses at the LCLS, the team developed an entirely new technique for this work–all x-ray attosecond transient absorption spectroscopy in liquids—opening new directions for attosecond science.
- A team of researchers from multiple U.S. universities developed a recyclable macrocyclic chelator capable of selectively separating the rare earth elements neodymium and dysprosium in aqueous solutions. This new chelator offers a promising new approach to the separation of complex electronic waste containing these and other valuable materials used in a wide range of energy and information technologies.
- A collaboration between users and staff from a nanoscience research center developed a new class of supramolecular organo-ionic electrolytes that can be utilized in solid-state batteries (SSBs) to enable direct cathode recycling under more modest conditions. The new electrolytes, which are viscoelastic solids, offer benefits to solid-state battery fabrication, and show excellent performance in both new and refurbished SSBs.

[c] Note that the number of users was less than prior fiscal years due to the APS outage for facility upgrades.

- An international team from the U.S., Germany, and Japan demonstrated that a 2D device made of three atomic layers of tungsten diselenide could perform all-optical processing of information using only a small number of photons. This approach, which leverages the world-unique Quantum Press at Brookhaven National Laboratory, shows promise for improving the speed and energy efficiency of telecommunications and for secure quantum communication.
- Researchers created 3D-printable semiconductor "inks" made from the more earth-abundant hafnium and zirconium that show very high photoluminescence for blue and green emission. The class of materials, ionic halide perovskites, can be synthesized with high-purity at low temperatures and offer significant benefits for applications in electronics and energy.
- A collaboration between DOE scientific user facilities led to the development of a software toolkit for AI-driven autonomous high-resolution scanning microscopy that demonstrates a greater than 70 percent reduction in the data and dose required to yield a representative scanning x-ray microscopy image. The new toolkit, which incorporates AI and edge computing at the beamline, gives users the ability to make smarter scans focused on areas of interest in a sample, mitigating some of the challenges that are expected due to forthcoming upgrades at DOE user facilities.
- An international team of researchers demonstrated the impact of the microenvironment within zeolite pores on the dehydration of cyclohexanol, a common biomass chemical. The work offers insight into how microenvironments in porous systems like zeolites can be tailored at the atomic level to promote the conversion of biomass or other starting materials into high value industrial chemicals.
- The DOE EPSCoR program, designed to enhance geographic balance through support for research institutions in states that have traditionally received less federal R&D funding, provided $37 million in grants from SC's six major research programs as well as DOE technology offices for research at academic institutions in 19 EPSCoR jurisdictions.
- A team of DOE laboratory researchers discovered a new approach to reducing dinitrogen to other nitrogen containing compounds under ambient conditions. The team designed new compounds that link common rare-earth or d-block metals using simple organic linkers to create cavities dinitrogen can diffuse into to bind the metals and become activated for further reactions. The results will guide potential strategies for reducing the energy intensity of ammonia production.

Description

Materials are critical to nearly every aspect of energy generation, storage, transmission, and end-use, as well as numerous other critical technologies, including in the areas of quantum information science (QIS) and microelectronics. Materials limitations are often a significant barrier to longer lifetimes of infrastructure and devices, the introduction of new energy technologies, or improved energy efficiencies. The Materials Sciences and Engineering (MSE) subprogram supports research to provide the fundamental understanding and control of materials synthesis, properties, and functionality that will enable solutions to challenges in energy generation, storage, and use. The research explores the origin of macroscopic material behaviors; their fundamental connections to atomic, molecular, and electronic structures; and their evolution as materials move from nanoscale building blocks to mesoscale systems. At the core of the subprogram is experimental, theoretical, computational, and instrumentation research that will enable the predictive discovery, design, and characterization of new materials with novel structures, properties, and functions. To accomplish these goals, the portfolio includes three integrated research activities:

- Scattering and Instrumentation Sciences Research
- Condensed Matter and Materials Physics Research
- Materials Discovery, Design, and Synthesis Research

The Request continues the highest-priority fundamental research that supports the DOE mission and establishes the foundational knowledge necessary to accelerate innovation to advance energy technologies, critical emerging technologies, and other national priorities. The portfolio emphasizes understanding of how to direct and control energy flow in materials systems over multiple time and length scales, and translation of this understanding to prediction of material behavior, transformations, and processes in challenging real-world systems. This will establish a foundational knowledge base for future advanced energy and information technologies, as well as industrial processes. The research supported explores a broad spectrum of materials science, including new frontiers of emergent materials behavior; utilization of nanoscale control; and metastable or far from equilibrium materials systems that enable novel materials design and advanced manufacturing.

Research activities in quantum materials emphasize the development of systems that realize unique properties required for QIS technologies. Materials science for microelectronics provides the advances needed for future computing, sensors, detectors, and communication critical for energy and for leadership in advanced research. An increasingly important aspect of materials research is the use of artificial intelligence/machine learning (AI/ML) and data science techniques to enhance the utility of both theoretical and experimental data for predictive design and discovery of materials. The MSE subprogram supports the development of advanced characterization tools, instruments, and techniques that can assess a wide range of space and time scales, especially in combination and under operando conditions to analyze non-equilibrium materials, conditions, and excited-state phenomena. In addition to a multifaceted portfolio of single-investigator and small-group research projects, the MSE subprogram supports multi-investigator, multi-disciplinary team-science research modalities, including Energy Frontier and Microelectronics Science Research Centers, Energy Innovation Hubs, Computational Materials Sciences, and the National QIS Research Centers (NQISRCs). This subprogram also includes the DOE Established Program to Stimulate Competitive Research (EPSCoR) program to broaden investments in foundational science and early-stage energy research for U.S. states and territories that do not historically have large federally supported academic research programs.

Scattering and Instrumentation Sciences Research

This activity supports innovative techniques and instrumentation development for advanced materials science research with scattering, spectroscopy, and imaging using electrons, neutrons, and x-rays, including development of science to understand ultrafast dynamics. These techniques provide precise and complementary information about the relationship among structure, dynamics, and properties, and are critical in advancing understanding and discovery of novel quantum materials, including materials for next-generation

systems to advance microelectronics and QIS. The tools and capabilities developed in this activity are broadly applicable to other fields, including chemistry, biology, and geoscience. The unique interactions of electrons, neutrons, and x-rays with matter enable a range of complementary tools with different sensitivities and resolution for the characterization of systems at length- and time-scales spanning many orders of magnitude. Included is the use of cryogenic environments to evaluate properties only occurring at low temperatures and to learn about processes and interfaces in materials damaged by the probes used to characterize them. In parallel with the development of advanced instrumentation, application of novel data science approaches, including those leveraging AI/ML, to improve the collection, processing, and analysis of very large data sets is critical to ensuring optimal use of such instruments.

Condensed Matter and Materials Physics Research

This activity supports fundamental experimental and theoretical research to discover, understand, and control novel phenomena in solid materials. These electronic, magnetic, optical, thermal, and structural materials make up the infrastructure for innovative energy advances, accelerator and detector technologies for SC facilities, and microelectronics and QIS. This activity supports research to understand the role of critical materials in determining material properties and functionality, so that they can be reduced or eliminated from key energy technology supply chains.

Experimental research in this activity emphasizes discovery and characterization of materials' properties that have the potential to be exploited for new technological functionalities. Complementary theoretical research aims to explain such properties across a broad range of length- and time-scales. Theoretical research also includes development and integration of predictive theory and modeling for discovery of materials with targeted properties. Advanced computational and data science techniques, including AI/ML, are enabling knowledge to be extracted from large materials databases of theoretical calculations and experimental measurements. This activity supports the development of such databases, the computational tools that can take advantage of them, and innovative physics-guided AI approaches to accelerate discovery. This activity continues to emphasize understanding and control of quantum materials. The research advances the fundamental understanding of electronic, magnetic, thermal, and optical properties relevant to energy-efficient microelectronics and QIS. Specifically, the MSE subprogram's dedicated QIS portfolio supports fundamental research with potentially transformative impact on the development and characterization of qubit platforms for future quantum computing, sensing, and communication systems. Activities also emphasize research to understand how materials respond to temperature, light, radiation, corrosive chemicals, and other environmental conditions.

In FY 2026, BES will continue to partner with other SC programs in the NQISRC program. NQISRC research supported by the MSE subprogram includes theory of materials for quantum applications in computing, communication, and sensing; device science for next-generation QIS systems; and synthesis, fabrication, and characterization of quantum materials. BES will also continue to partner with other SC programs on activities to support multi-disciplinary basic research to accelerate the advancement of microelectronic technologies in a co-design innovation ecosystem, where the design of materials, devices, architectures, and algorithms are integrated as part of a single R&D pipeline.[d] BES contributes to the SC Microelectronics Science Research Centers (MSRCs) program, a portfolio of awards that support research in energy efficiency for microelectronics or their operation in extreme environments. Materials, chemistries, devices, systems, architectures, algorithms, and software are being developed in tandem .

Materials Discovery, Design, and Synthesis Research

This activity supports the predictive design, discovery, and development of new materials with desired properties, which is the engine that drives science frontiers and technology innovations. It aims to grow and maintain U.S. leadership in materials discovery by investing in advanced synthesis capabilities and by coupling these with state-of-the-art user facilities and advanced computational capabilities at DOE laboratories, generating scientific knowledge that is foundational to the BES mission.

[d] https://science.osti.gov/-/media/bes/pdf/reports/2019/BRN_Microelectronics_rpt.pdf

The FY 2026 Request continues support of materials discovery and synthesis research to understand the unique properties of critical materials, with the goal of reducing their use. Understanding the science of synthesis will enable design of new systems that are easier to efficiently convert into similar products with comparable or enhanced complexity, functionality, and value. The activity also supports fundamental research in solid-state chemistry to enable discovery of new functional materials and the development of new crystal growth methods and thin film deposition techniques to create complex materials with targeted structure and properties. In addition to research on chemical and physical synthesis processes, the portfolio includes research to understand how to use bio-mimetic and biology-inspired approaches to design and synthesize novel materials with some of the unique properties found in nature. The activity supports the development of new AI/ML-based approaches aimed at accelerating materials discovery and enabling scalable, automated synthesis with real-time adaptive control.

Established Program to Stimulate Competitive Research (EPSCoR)

The DOE EPSCoR program funds fundamental and early-stage research that supports DOE's science and energy mission in states and territories with historically lower levels of federal academic research funding. The program emphasizes research that will improve the capability of designated states and territories to conduct nationally competitive fundamental and early-stage energy-related research; jumpstart research capabilities through workforce development in energy-related areas; and build beneficial relationships between scientists and engineers in the designated jurisdictions and DOE laboratories. Managed by BES, funding for the EPSCoR program is distributed among the six major research programs within SC.[e] Annual EPSCoR funding opportunities alternate between research performed in collaboration with the DOE laboratories and larger-team implementation awards. The FY 2026 program is planned to focus on EPSCoR State-National Laboratory Partnership awards promoting single-investigator and small-group interactions with the unique capabilities of the DOE national laboratory system. The technical scope will focus on the research topics supported by SC program offices and early-stage energy research broadly. The program will continue to support other SC programs, including the Early Career Research Program.

Energy Frontier Research Centers

The EFRC research modality brings together the skills and talents of teams of investigators to combine discovery science and energy-relevant basic research whose scope and complexity is beyond what is possible from single-investigator or small-group awards. These multi-investigator, multi-disciplinary centers aim to accelerate basic research to enable transformative scientific advances and uncover new and innovative solutions to the most difficult problems in materials sciences. EFRCs supported in this subprogram focus on the design, discovery, synthesis, characterization, and understanding of novel, solid-state materials that generate and convert energy; the understanding of materials and processes foundational for electrical energy storage; quantum materials and QIS; microelectronics; and materials for future nuclear energy. The FY 2026 Request continues support for EFRC awards made in FY 2024 and supports plans to recompete EFRC awards made in FY 2022 along with new priority topics.

Energy Innovation Hubs

The Batteries and Energy Storage Energy Innovation Hub program will continue to tackle forefront, basic scientific challenges for next-generation electrochemical energy storage. Hubs focus on collaborative research to overcome key scientific barriers for major energy challenges that require large, multidisciplinary teams to provide the required science foundations and innovations. The Request will continue to support the Hub awards initiated in prior years.

Computational Materials Sciences

This program has focused on research leading to computational codes and associated experimental/computational databases for the design of materials with advanced functionalities. This included development of new ab initio theory, contributing the generated data to databases; advanced characterization and controlled synthesis to provide the data to validate computational predictions; and design of computational codes to take advantage of DOE's world-leading exascale high-performance computers.

[e] Per direction in the explanatory statement accompanying the FY 2023 Consolidated Appropriations Act

In FY 2026, the program will focus on development of novel AI/ML-based tools and techniques for accelerated scientific discovery. Support for the maintenance and further development of high value, widely used software previously developed under the program may be considered based on program priorities.

Activities and Explanation of Changes

(dollars in thousands)

FY 2025 Enacted	FY 2026 Request	Explanation of Changes FY 2026 Request vs FY 2025 Enacted
Materials Sciences and Engineering $507,312	**$331,130**	**-$176,182**
Scattering and Instrumentation Sciences Research $86,396	$30,497	-$55,899
Funding continues to focus on the development and use of advanced characterization tools, including the use of multiscale, multimodal, and cryogenic techniques to extract information on multiple length and time scales. Advanced instrumentation research can be applied to diverse national priorities, including QIS, advanced industrial processes, and preparedness for biological threats (cryogenic microscopy).	The Request will continue to focus on the development and use of advanced characterization tools to extract information on multiple length and time scales. Advanced instrumentation research will be applied to a breadth of national priorities, including QIS, microelectronics, critical minerals, energy science, and advanced industrial processes.	Reductions will be based on programmatic priorities.
Condensed Matter and Materials Physics Research $200,714	$139,022	-$61,692
Funding continues to emphasize the understanding and control of the fundamental properties of materials, including critical materials, that are central to their functionality in a wide range of energy-relevant technologies. Exploration of quantum materials remains a high priority, and particularly the role that these materials play in microelectronics, accelerators, and QIS. The program will partner with other SC program offices in the recompetition of the NQISRCs as the original awards complete five years of research. Investments continue to support awards as part of the Microelectronics Science Research Centers.	The Request will continue to emphasize the understanding and control of the fundamental properties of materials that are central to their functionality in a wide range of clean energy-relevant technologies. Exploration of quantum materials remains a high priority, specifically the role they play in microelectronics, accelerators, and QIS. The program will partner with other SC program offices in the NQISRCs and the MSRCs. Additional investments will expand support for research to leverage AI/ML to accelerate materials discovery and characterization.	Expanded investments will include additional support for AI/ML. Reductions in other areas of core research will be based on programmatic priorities.

(dollars in thousands)

FY 2025 Enacted	FY 2026 Request	Explanation of Changes FY 2026 Request vs FY 2025 Enacted
Materials Discovery, Design, and Synthesis Research $87,297	$48,698	-$38,599
Funding continues to support design, discovery, and synthesis of novel forms of matter with desired properties and functionalities with an emphasis on advancing the fundamental science relevant to future low-carbon industrial processes and energy technologies. Research on bio-mimetic and biology-inspired materials is relevant to energy technologies as well as other national priorities such as preparedness for and response to biological threats.	The Request will continue support for the design, discovery, and synthesis of novel forms of matter with desired properties and functionalities with an emphasis on advancing the fundamental science relevant to future industrial processes and energy technologies, as well as developing and implementing novel AI-based techniques to accelerate synthesis and characterization. Research on bio-mimetic and biology-inspired materials is relevant to energy technologies as well as other national priorities such as critical minerals and materials.	Reductions will be based on programmatic priorities.
Established Program to Stimulate Competitive Research (EPSCoR) $25,000	$25,000	$ —
Funding continues to support early-stage R&D, including research that underpins DOE energy technology programs and the SC Energy Earthshots initiative Following the previous year's focus on State-Lab partnership awards, FY 2025 continues to emphasize implementation awards, larger multiple investigator teams that develop research capabilities, including investment in instrumentation, in EPSCoR jurisdictions. Investments continue in early career research faculty from EPSCoR-designated jurisdictions.	The Request will continue to support fundamental science and early-stage R&D, including research that underpins DOE energy technology programs. FY 2026 will support State-National Laboratory Partnership awards. Investment will continue in early career research faculty from EPSCoR-designated jurisdictions and in co-investment with other initiatives.	Funding will focus on State-National Laboratory Partnership awards promoting interactions between EPSCoR institutions and the DOE national laboratory system.

(dollars in thousands)

FY 2025 Enacted	FY 2026 Request	Explanation of Changes FY 2026 Request vs FY 2025 Enacted
Energy Frontier Research Centers $65,000	$58,000	-$7,000
Funding provides the fourth year of support for four-year EFRC awards that were made in FY 2022 and the second year of funding for awards made in FY 2024 in a broad range of topics relevant to national priorities on energy technologies.	The Request will provide the third year of support for four-year EFRC awards that were made in FY 2024. In addition, BES will recompete awards made in FY 2022, with emphasis on a broad range of topics relevant to energy and other national priorities.	Technical emphasis for the EFRC program will broaden to include new research directions that cut across BES programmatic efforts, as well as those identified in recent strategic planning activities related to energy, QIS, microelectronics, and other national priorities.
Energy Earthshot Research Centers $3,500	$—	-$3,500
Funding provides support for the EERCs that were initiated in prior fiscal years.	The EERC activity will sunset in FY 2025.	No funding is requested.
Energy Innovation Hubs $25,913	$25,913	$—
Funding supports the third year of funding for new Batteries and Energy Storage Hub awards initiated in prior years through an open competition.	The Request will support the fourth year of funding for Batteries and Energy Storage Hub awards initiated in prior years through an open competition.	No change.
Computational Materials Sciences $13,492	$4,000	-$9,492
Funding supports the third year of funding for awards made in FY 2023 and the second year of funding for awards planned for FY 2024. The Request continues to support research aimed at the development of open source, validated software that takes advantage of DOE's leadership computing facilities.	The CMS activity will develop AI-based tools and techniques for materials discovery and characterization. Support for the maintenance and further development of high value, widely used software previously developed under the program may be considered based on program priorities.	Fundamental research will target AI for accelerated scientific discovery.

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

Development of innovative energy technologies relies on understanding and ultimately controlling transformations of energy among forms and conversions of matter across multiple scales starting at the atomic level. The Chemical Sciences, Geosciences, and Biosciences subprogram supports research to discover fundamental knowledge of chemical reactivity and energy conversion foundational to energy-relevant chemical processes, such as catalysis, synthesis, separations, and light-driven chemical transformations. The research addresses how physical and chemical phenomena at the scales of electrons, atoms, and molecules—including quantum phenomena—control complex and collective behavior of macroscopic-scale energy and matter conversion systems. Fundamental knowledge developed through this subprogram can enable science to tailor chemical transformations with atomic and molecular precision and achieve predictive understanding of complex chemical, geochemical, and biochemical systems.

To address these challenges, the portfolio includes coordinated research activities in three areas:

- Fundamental Interactions Research
- Chemical Transformations Research
- Photochemistry and Biochemistry Research.

The Request continues the highest-priority fundamental research that supports the DOE mission and provides foundational knowledge that can advance affordable, reliable, and secure energy technologies. Research will discover and develop chemical processes that are energy and atom efficient and increase understanding of the phenomena relevant to QIS. This fundamental science can lead to new approaches for industrial processes, innovations in microelectronics, and reduced dependence on critical materials and minerals. Fundamental biochemistry will discover principles that could enable biomimetic and biohybrid energy systems and guide development of new biotechnologies. Integration of artificial intelligence/machine learning (AI/ML), data science, and computational chemistry will provide tools and infrastructure needed for shared data repositories and accelerated discovery and characterization of complex chemical systems.

The CSGB subprogram supports a multifaceted portfolio of single-investigator and small-group research projects as well as multi-investigator, multi-disciplinary team-science research including Energy Frontier and Microelectronics Science Research Centers, Energy Innovation Hubs, Computational Chemical Sciences, and the National QIS Research Centers (NQISRCs).

Fundamental Interactions Research

This activity emphasizes structural and dynamical studies of atoms, molecules, and nanostructures to understand their interactions in full quantum detail. Research is conducted at the boundary of chemistry and physics to understand reactive chemistry in the gas phase, in condensed phases, and at interfaces. This activity provides leadership for ultrafast chemistry and advances ultrafast tools and approaches to probe and control chemical processes. It supports theory and computation for accurate descriptions of molecular reactions and chemical dynamics, optimal use of exascale computing facilities, and potential application of future quantum computers to computational quantum chemistry. In support of SC's broader AI/ML Initiative, this activity supports AI/ML efforts that can advance use of exascale or quantum computing hardware to simulate chemical systems and processes for fundamental discovery as well as methods to accelerate the analysis of complex experimental data. It also supports a program of QIS research at the intersection of chemistry, quantum physics, and information theories that can advance foundational understanding of quantum information control in complex molecular systems. This fundamental research can lay the foundation for the chemical design principles needed to realize next-generation quantum technologies in computing, sensing, and communication.

In FY 2026, BES will continue as a partner in the NQISRC program, which is undergoing a recompetition/renewal in FY 2025. The research in this portfolio will advance state-of-the-art science and technology to realize the full

potential of quantum-based applications and pave the path to quantum computing in the longer term. BES will also continue to partner on microelectronics research to unravel complex mechanisms of chemical reactions at interfaces to inform design and synthesis of new materials and chemical processes.[f] As part of this portfolio, the Microelectronics Science Research Centers (MSRCs) comprise a network of multiple team awards, with individual awards focused on a dimension related to one of two common research topics for each Center—energy efficiency or extreme environments. The multidisciplinary teams include researchers from universities, national laboratories, and industry and are developing chemistries, materials, devices, systems, architectures, algorithms, and software in a co-design innovation ecosystem.

Chemical Transformations Research

This activity seeks fundamental knowledge of chemical reactivity, matter and charge transport, and chemical separation and stabilization processes foundational to development of affordable and reliable energy technologies. Fundamental research in this activity spans catalysis science, separation science, heavy element chemistry, and geosciences to advance mechanistic understanding of charge transport and reactivity, catalytic efficiency and selectivity, critical materials recovery, conversion of energy resources, and chemistry in subsurface and aqueous systems important in chemical processes.

In the FY 2026 Request, this activity will continue to investigate transformative approaches for energy. Research will focus on discovery and design of catalytic and separation processes and provide fundamental knowledge of subsurface processes such as mineralization, crack propagation, and rock fracture to foster innovation in the use of the subsurface for energy generation and storage. Research will also address critical minerals and materials with a focus on approaches for resource identification and extraction, selective separation, and substitution of critical elements. Research will also examine quantum phenomena enabled by rare earth elements and actinides. AI/ML approaches will be emphasized to accelerate the generation of scientific knowledge foundational to the BES mission.

Photochemistry and Biochemistry Research

This activity supports research on the molecular mechanisms of light energy capture and its conversion into chemical and electrical energy in both natural and man-made systems. It integrates research at the interface of chemistry, physics, and biology and plays a leadership role for basic research on natural photosynthesis and photochemistry. This research can inspire new strategies for energy conversions and inform development of innovative energy technologies. To understand energy capture and conversion across spatial and temporal scales, research explores charge transport and reactivity and redox interconversion of atoms and small molecules important in production of commodity and specialty chemicals and fuels. Research also examines ionizing radiation effects on chemical reactions that can provide insights for nuclear reactor design, remediation, and fuel-cycle separation as well as other chemical transformations.

In the FY 2026 Request, the activity will continue to focus on molecular-level understanding of biochemical, biophysical, and photochemical processes. Research will aim to discover and design chemical processes, complex structures, and bio-inspired and biohybrid systems to advance affordable energy technologies, including microelectronics. This activity supports research to understand quantum phenomena such as coherence in natural and artificial systems, providing insights for enhancing energy conversion and potentially inspiring materials development for QIS. It also supports development of AI/ML-based methods to accelerate discovery of chemistries and new materials for energy conversion and to identify and characterize biochemical and biophysical processes based on large, complex datasets. Research will include studies to better harness light energy for chemical conversions and to reduce use of critical and rare earth elements in catalysts and light absorbers.

Energy Frontier Research Centers

The EFRC research modality brings together the skills and talents of teams of investigators to combine discovery science and energy-relevant, basic research whose scope and complexity are beyond what is possible from single-investigator or small-group awards. These multi-investigator, multi-disciplinary centers aim to accelerate

[f] https://science.osti.gov/-/media/bes/pdf/reports/2019/BRN_Microelectronics_rpt.pdf

basic research to enable transformative scientific advances and uncover new and innovative solutions to the most difficult problems in chemical sciences, geosciences, and biosciences. EFRCs supported in this subprogram focus on the design, discovery, characterization, and control of chemical, biochemical, and geological processes for improved electrochemical conversion; the understanding of catalytic chemistry and biochemistry that is foundational for production of fuels and chemicals and for separations; QIS; nuclear energy and the chemistry of waste processing; and the advanced characterization of the Earth's subsurface. The FY 2026 Request continues support for EFRC awards made in FY 2024 and supports plans to recompete awards made in FY 2022.

Energy Innovation Hubs

Energy Innovation Hubs focus on collaborative research to overcome key scientific barriers for major energy challenges that require large, multidisciplinary efforts. The Fuels from Sunlight Hub program addresses both new directions and long-standing challenges in solar fuels generation identified in the report from the Liquid Solar Fuels Roundtable.[g]

The two Fuels from Sunlight Hub awards conduct fundamental research on key scientific challenges for fuels production that uses light energy, water, and carbon dioxide as the only inputs. These awards received the final year of funding in FY 2024 for their initial five-year award term. Both projects were evaluated via peer review on an annual basis since initiation. Given the latest review results, the progress of both projects, and the distinct role of the awards in the BES portfolio, the Department is considering both awards for renewal in FY 2025 and will make renewal determinations based on the outcome of external peer review. Renewals would allow the projects to capitalize on their achievements during the initial funding period and to further advance research addressing critical needs in solar fuels development. FY 2026 funding will continue to support the Fuels from Sunlight Hub program consistent with outcomes of the FY 2025 renewal decisions.

Computational Chemical Sciences

This program has supported basic research to develop validated, open-source codes and associated experimental/ computational databases for modeling and simulation of complex chemical processes and phenomena and that can take advantage of today's exascale high-performance computers. Research has supported establishment of a publicly accessible website[h] of open source, robust, validated, user-friendly software that captures the essential physics and chemistry of relevant chemical systems. The broader research community and industry are using these codes/data to accelerate U.S. chemical research.

In FY 2026, the program will focus on development of novel AI/ML-based tools and techniques for accelerated scientific discovery. Support for the maintenance and further development of high value, widely used software previously developed under the program may be considered based on program priorities.

General Plant Projects

General Plant Projects funding provides for minor new construction, other capital alterations and additions, and improvements to land, buildings, and utility systems to maintain the productivity and usefulness of DOE-owned facilities and to meet requirements for safe and reliable facilities operation.

[g] https://science.osti.gov/-/media/bes/pdf/reports/2020/Liquid_Solar_Fuels_Report.pdf
[h] https://ccs-psi.org/

Activities and Explanation of Changes

(dollars in thousands)

FY 2025 Enacted	FY 2026 Request	Explanation of Changes FY 2026 Request vs FY 2025 Enacted
Chemical Sciences, Geosciences, and Biosciences **$458,711**	**$294,038**	**-$164,673**
Fundamental Interactions Research $135,593	$96,315	-$39,278
Funding continues to develop innovative ultrafast approaches, with emphasis on use of x-ray free electron lasers; determine how reactive intermediates affect reaction pathways; and characterize quantum phenomena underlying QIS. Research also targets the understanding and control of interfacial chemical conversion mechanisms and quantum phenomena to advance clean energy technologies for improved energy capture and conversion, AI/ML, and microelectronics. This activity generates and uses advanced theoretical and computational approaches that can take advantage of exascale computing capabilities and data science methods for knowledge discovery. The program partners with other SC program offices in the recompetition/renewal of the NQISRCs as the original awards complete five years of research. Continued investments supports awards as part of the Microelectronics Science Research Centers.	The Request will continue to develop innovative ultrafast approaches, with emphasis on use of x-ray free electron lasers; determine how reactive intermediates affect reaction pathways; and characterize quantum phenomena underlying QIS. Research will also target the understanding and control of interfacial chemical conversion mechanisms and quantum phenomena to advance novel energy technologies for improved energy capture and conversion and microelectronics. The program will partner with other SC program offices for the NQISRCs and the MSRCs. Additional investments will expand support for research to leverage AI/ML to accelerate discovery and characterization.	Expanded investments will include additional support for AI/ML. Reductions in other areas will be based on programmatic priorities.
Chemical Transformations Research $114,658	$61,858	-$52,800
Funding continues fundamental research to understand catalytic mechanisms for thermo- and electro-chemical conversions and	The Request will continue fundamental research to understand catalytic mechanisms for thermo- and electro-chemical	Reductions will be based on programmatic priorities.

(dollars in thousands)

FY 2025 Enacted	FY 2026 Request	Explanation of Changes FY 2026 Request vs FY 2025 Enacted
to develop atomically precise synthesis of catalysts important for reliable energy. Research in separation science continues to focus on innovative mechanisms for high-efficiency chemical separations and processes. Heavy element research continues to advance understanding of actinide speciation and reactivity and f-electron systems. Geosciences research continues to reveal subsurface phenomena, such as mineralization and rock fracture propagation, that can be foundational to new energy technologies. Research continues to advance the separations and extraction of rare earth elements from complex and dilute mixtures and the development of alternative approaches to reduce use of critical elements.	conversions and to develop atomically precise synthesis of catalysts important for affordable and reliable energy. Research in separation science will continue to focus on innovative mechanisms for high-efficiency chemical separations and processes. Heavy element research will continue to advance understanding of actinide speciation and reactivity and f-electron systems. Geosciences research will continue to reveal subsurface phenomena that can be foundational to new energy technologies. Research will continue to advance the separations and extraction of rare earth elements from complex and dilute mixtures and the development of alternative approaches to reduce use of critical elements. AI/ML and data science approaches will be leveraged across the activity to accelerate discovery and characterization.	
Photochemistry and Biochemistry Research $104,710	$50,107	-$54,603
Funding continues research on physical, chemical, biophysical, and biochemical processes of light energy capture and conversion which could inspire innovations for reliable energy. Biochemical studies can provide insights for bio-inspired and biohybrid systems with desired functions and properties, as well as for new strategies for artificial photosynthesis, carbon dioxide removal, and biotechnology. Solar fuels research addresses molecular mechanisms of photon capture, charge transport, product selectivity, and reduced critical element use in photoabsorbers and catalysts. Biological and chemical studies	The Request will continue research on physical, chemical, biophysical, and biochemical processes of light energy capture and conversion which could inspire technology innovations for affordable and reliable energy. Biological and chemical studies will examine the role of quantum phenomena in energy conversion. Biochemical studies can provide insights for bio-inspired and biohybrid systems with desired functions and properties and new strategies for artificial photosynthesis, energy conversions, and biotechnology. Solar fuels research will address molecular mechanisms of photon capture, charge transport, product selectivity, and reduced critical	Reductions will be based on programmatic priorities.

(dollars in thousands)

FY 2025 Enacted	FY 2026 Request	Explanation of Changes FY 2026 Request vs FY 2025 Enacted
examine the role of quantum phenomena in energy conversion.	element use in photoabsorbers and catalysts. AI/ML and data science methods will continue to be integrated across the activity to accelerate discovery and characterization.	
Energy Frontier Research Centers $65,000	$60,000	-$5,000
Funding provides the fourth year of support for four-year EFRC awards that were made in FY 2022 and the second year of funding for awards made in FY 2024 in a broad range of topics relevant to energy and other national priorities.	The Request will provide the third year of support for the four-year EFRC awards that were made in FY 2024. In addition, BES will recompete awards made in FY 2022, with emphasis on a broad range of topics relevant to energy and other national priorities.	Technical emphasis for the EFRC program will broaden to include new research directions that cut across BES programmatic efforts, as well as those identified in recent strategic planning activities related to energy, QIS, microelectronics, and other national priorities.
Energy Earthshot Research Centers $3,500	$ —	-$3,500
Funding provides support for the EERCs that were initiated in prior fiscal years.	The EERC activity will be sunset in FY 2026.	No funding is requested.
Energy Innovation Hubs $20,758	$20,758	$ —
The two Hub awards are being considered for renewal of up to five years. Renewal allows each project to capitalize on its achievements during the initial funding period and to further advance research efforts on solar fuels generation for energy. The renewal decisions are based on research progress, external peer review, and programmatic priorities.	The Request will continue support for the Hub awards made in FY 2025 to further advance research efforts on solar fuels generation for affordable and secure energy.	Fundamental research will continue to target innovative artificial photosynthesis approaches for fuels generation using only sunlight, carbon dioxide, and water as inputs.

(dollars in thousands)

FY 2025 Enacted	FY 2026 Request	Explanation of Changes FY 2026 Request vs FY 2025 Enacted
Computational Chemical Sciences $13,492	$4,000	-$9,492
Funding continues the development of public, validated, open-source software that takes advantage of DOE's leadership computing facilities. BES is recompeting awards made in FY 2021 and 2022. BES is prioritizing transitioning ECP researchers and software utilization into these research efforts.	The CCS activity will develop AI-based tools and techniques for discovery and characterization in the chemical sciences. Support for the maintenance and further development of high value, widely used software previously developed under the program may be considered based on program priorities.	Fundamental research will target AI for accelerated scientific discovery.
General Plant Projects $1,000	$1,000	$ —
Funding supports minor facility improvements at Ames National Laboratory.	The Request will support minor facility improvements at Ames National Laboratory.	No change.

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 Scientific User Facilities subprogram supports the operation of a geographically and technically diverse suite of major research facilities that provide unique tools to thousands of researchers from universities, industry, and government laboratories to advance a broad range of scientific domains and technology areas that are critical to DOE's mission and to many other National priorities. The BES user facilities portfolio consists of a complementary set of intense x-ray sources, neutron scattering facilities, and research centers for nanoscale science. These facilities allow researchers to probe materials in space, time, and energy with the resolution to interrogate the inner workings of matter to help understand the fundamental aspects of the natural world. Operated on an open access, competitive, merit review basis, scientists from every state can utilize the facilities' capabilities and sophisticated instrumentation. The 12 BES scientific user facilities collectively contribute to important scientific results across basic and applied research in chemistry, physics, geology, materials science, environmental science, biology, and biomedical science that can lead to the discovery and design of advanced materials and novel chemical processes with broad societal impacts. In FY 2024, more than 13,000 scientists and engineers in many fields of science and technology used BES scientific facilities.

User facilities conduct hundreds of experiments simultaneously around the clock, generating vast quantities of raw experimental data that must be stored and analyzed to translate the data into information to yield answers to important scientific questions. The data challenges continue to grow as new capabilities and advanced detector technologies come online. Data science and AI/ML methods coupled with advanced computing hardware are required to address these challenges and get the highest value data from user experiments. There are also AI/ML opportunities to improve the efficiency and reliability of accelerator and instrument operations. The Request increases support for the research needed to realize these opportunities in AI/ML.

Maintaining world-leading capabilities is crucial for international competitiveness as advances in tools and instruments often drive scientific discovery. Major upgrades to BES facilities are supported through line-item construction and Major Items of Equipment (MIEs), including support for new and upgraded x-ray and neutron experimental stations and forefront nanoscience instrumentation. The subprogram also supports research in accelerator and detector development to explore technology options for the next generations of x-ray and neutron sources that will keep BES accelerator-based facilities at the forefront.

The FY 2026 Request supports user facilities' operational budget requirements determined by the user facilities. Base requirements for operations continue to increase due to the steady rise in the cost of staff, utilities, maintenance, and materials; evolution of remote use; increased data and computational costs; and the transition of new capabilities from facility upgrades to operations. Funding will require a careful balance to meet costs to ensure safe operations and user access.

X-Ray Light Sources

X-rays are an essential tool for studying the structure of matter and have long been used to see things that visible light cannot resolve. X-rays are critical tools for assessing dynamics as materials, chemistries, and biological systems evolve. Large-scale light source facilities have vastly enhanced the utility of existing x-ray techniques and have given rise to entirely new ways to do experiments that are not otherwise feasible with conventional x-ray machines. Owing to their broadly tunable wavelengths, coherence, ultrafast pulses, and polarization control, light source facilities are incisive probes for advanced research.

BES operates five light sources, including a free electron laser, the Linac Coherent Light Source (LCLS) at SLAC, and four storage ring-based sources—the Advanced Light Source (ALS) at LBNL, the Advanced Photon Source (APS) at ANL, the Stanford Synchrotron Radiation Light Source (SSRL) at SLAC, and the National Synchrotron Light Source (NSLS)-II at BNL. BES provides funding to support facility operations, technical support, computational tools for data analysis, and user program administration, which are made available to all researchers with access determined via peer review of user proposals. All facilities are multidisciplinary and have

extensive outreach efforts to ensure that researchers have fair and equitable access regardless of their research focus, geographical location, or institutional size. Upgrade projects are underway for the APS, ALS, and LCLS to ensure ongoing world leadership for these facilities. The initial suite of seven beamlines at NSLS-II in FY 2015 has expanded to 29 beamlines with three under construction and room for about 30 more. To adopt the most up-to-date technologies and provide the most advanced capabilities, BES has a phased approach to new beamlines at NSLS-II, as was done for other BES facilities. The NSLS-II Experimental Tools-II (NEXT-II) MIE project, started in FY 2020, provides three best-in-class beamlines to support the needs of the U.S. research community. In FY 2024, planning and conceptual design funds were provided for NEXT-III, a line-item construction project to deliver the next cadre of beamlines. The Request supports continued preliminary planning for future beamline MIEs.

High-Flux Neutron Sources

BES supports two neutron sources at ORNL, the High Flux Isotope Reactor (HFIR) and the Spallation Neutron Source (SNS). Neutron sources are used to understand the factors that determine the properties and functions of matter and provide foundational insights for development of new materials and molecules with desired functionality. Thermal and cold neutrons are unique tools for the study of atomic-scale structure and dynamics. The wavelength and energy of neutrons are similar to interatomic distances and elementary excitations in materials, allowing atomic-resolution studies of structure and an investigation of material dynamics. As they carry no charge, neutrons can assess bulk properties. Critically, neutrons can discriminate different isotopes of the same element, making them a unique probe to resolve, for example, the location of hydrogen atoms in organic and biological materials via isotope substitution of deuterium for hydrogen. In addition, their magnetic moments allow investigation of magnetism, important for electronic technologies and systems.

HFIR generates neutrons via fission. It operates at 85 megawatts and provides state-of-the-art facilities for neutron scattering, isotope production, materials irradiation, and neutron activation analysis. It is the world's leading production source of elements heavier than plutonium for medical, industrial, and research applications. There are 12 neutron scattering beamlines in the user program at HFIR, which include state-of-the-art instruments for spectroscopy, diffraction, imaging, and small angle scattering. Operations funding in the FY 2026 Request will continue to support efforts to replace the beryllium reflector at HFIR.

SNS produces neutron beams using an accelerator to generate proton pulses that strike a mercury target. As a result of impacts, cascades of neutrons are produced in a process known as spallation. It is the world's brightest pulsed neutron facility and presently offers 19 beamlines. This is a world-leading suite of instruments for very high-resolution spectroscopy and diffraction, reflectometry, spin echo, and small angle spectrometers. Demand is strong for SNS instruments (3.6x oversubscribed) across a very broad range of scientific disciplines and technology areas. Current construction projects at SNS focus on maintaining world-leadership for neutron scattering.

At both HFIR and SNS, investments will advance data science, AI/ML, and computing hardware to support experiment planning, data analysis, and operational efficiency of the accelerator, reactor, and beamlines.

Nanoscale Science Research Centers

Developments at the nanoscale are foundational for delivery of remarkable scientific discoveries that transform our understanding of energy and matter. The Nanoscale Science Research Centers (NSRCs) provide the tools and capabilities for experimental and computational research that lead to technological innovations, new experimental tools, and new computational and modelling capabilities. NSRCs comprise a suite of unique tools and platforms, as well as expert scientific staff that enable and advance probing, manipulating, and assembling single atoms, clusters of atoms, and molecular structures for transformative science providing the foundation for the development of next-generation technologies.

The five NSRCs are the Center for Nanoscale Materials (CNM) at ANL, the Center for Functional Nanomaterials (CFN) at BNL, the Molecular Foundry (MF) at LBNL, the Center for Nanophase Materials Sciences (CNMS) at ORNL, and the Center for Integrated Nanotechnologies (CINT) at SNL and LANL. Each center has

complementary expertise and capabilities for synthesis and assembly; theory, modeling, and simulation; imaging and spectroscopy; and nanostructure fabrication and integration. Selected thematic areas include quantum materials, next generation semiconductors, nanoscale photonics, catalysis, and soft/biological materials. These facilities include clean rooms, nanofabrication resources, one-of-a-kind signature tools, custom advanced instrumentation laboratories, and unique AI/ML and data science analytical capabilities. Each NSRC is co-located with other scientific user facilities and/or complementary capabilities, enabling users to more easily take advantage of these additional world-leading experimental and computational resources. Operating funds ensure cutting-edge research capabilities, technical support, and administration of the user program, which serves academic, government, and industry researchers.

Going forward, the NSRCs will continue to spearhead the development of flexible infrastructure and enabling capabilities for materials synthesis, device fabrication, metrology, modeling, and simulation. Investments will focus on evolving these capabilities to address the most pressing national needs, including QIS and next-generation microelectronics. Coordination across the NSRCs will grow to support development of cross-cutting, mutually beneficial techniques and facilitate access to complementary instrumentation.

Other Project Costs

Total project cost (TPC) is comprised of total estimated cost (TEC) and other projects costs (OPC). TEC includes post-Critical Decision (CD)-1 costs for engineering; the acquisition of equipment; and construction/fabrication. OPC represents all other costs incurred during the initiation and definition phase for planning, conceptual design, research, and development, and during the execution phase for startup and commissioning. OPC is always funded via operating funds.

Major Items of Equipment

BES supports MIE projects to ensure continual development and upgrade of scientific facility capabilities, by fabricating upgraded and new stand-alone instruments and capabilities at X-Ray Light Sources, High-Flux Neutron Sources, and NSRCs.

Research

This activity supports research from conceptual studies of accelerator physics and instrumentation to their translation into components or techniques that improve BES user facilities and maintain international competitiveness. Production of beams with increased average flux/brightness and detection tools responsive to high beam intensities are required components for the advancement of light and neutron sources. Research on superconducting undulators will focus on increasing magnetic fields and eliminating liquid helium use. Higher beam availability is needed to respond to the increasing number of facility users, requiring research on techniques to support multiple beamlines simultaneously. Detectors require higher computational capabilities per pixel, improved readout rates, radiation hardness, and better energy and temporal resolutions. Higher neutron-flux capabilities at the SNS demand tight control of beam losses and detectors designed for advanced neutron imaging. BES coordinates with the SC Offices of High Energy Physics and Nuclear Physics on crosscutting accelerator research and technology areas. BES accelerator R&D research is informed by recent workshops.[i] Investments will continue to support development of data science methods and AI/ML-enabled tools to address data and information challenges.

[i] https://science.osti.gov/-/media/bes/pdf/brochures/2024/24-G00737-BRN-ABI-brochure-Final.pdf

Activities and Explanation of Changes

(dollars in thousands)

FY 2025 Enacted	FY 2026 Request	Explanation of Changes FY 2026 Request vs FY 2025 Enacted
Scientific User Facilities (SUF) $1,388,762	**$1,394,489**	**+$5,727**
X-Ray Light Sources $778,865	$805,106	+$26,241
Funding supports operations at five BES light sources (LCLS, APS, ALS, NSLS-II, and SSRL). Development of capabilities for biopreparedness, computational techniques, and data will continue.	The Request will support operations at five BES light sources (LCLS, APS, ALS, NSLS-II, and SSRL). Development of AI/ML-enabled capabilities for computational techniques, and data analysis methods will continue.	Funding will support LCLS, APS, ALS, NSLS-II and SSRL operations, accounting for inflation, supply chain costs, staffing support, remote operations, and costs for operation of new/upgraded capabilities.
High-Flux Neutron Sources $373,367	$385,146	+$11,779
Funding supports operations at SNS and HFIR (including ongoing funding for maintenance of HFIR with the beryllium reflector replacement). Development of capabilities for biopreparedness, computational techniques, and data continues.	The Request will support operations at SNS and HFIR (including ongoing funding for maintenance of HFIR with the beryllium reflector replacement). Development of AI/ML-enabled capabilities for computational techniques, and data analysis methods will continue.	Funding will support operations for SNS and HFIR, accounting for inflation, supply chain costs, staffing support, remote operations, and costs for operation of new/upgraded SNS capabilities.
Nanoscale Science Research Centers $159,230	$165,770	+$6,540
Funding supports five NSRCs (CFN, CNM, CNMS, MF, and CINT). The NSRCs continue to develop infrastructure and capabilities to maintain world-leading synthesis, device fabrication, characterization, modeling, and simulation.	The Request will provide funding for five NSRCs (CFN, CNM, CNMS, MF, and CINT). The NSRCs will continue to develop infrastructure and capabilities to maintain world-leading synthesis, device fabrication, characterization, modeling, and simulation.	Funding will support operations for the five NSRCs, accounting for inflation, supply chain costs, staffing support, remote operations, and other costs.
Other Project Costs $9,500	$5,000	-$4,500
Funding supports OPC for the HFIR-PVR project at ORNL and the NEXT-III project at BNL.	The Request will support OPC for the LCLS-II-HE project at SLAC.	OPC will support conceptual design and planning for the LCLS-II-HE project at SLAC.
Research $67,800	$33,467	-$34,333
Funding supports high-priority research activities for accelerators, detectors, and applications of data science techniques to accelerator	The Request will support high-priority research activities for accelerators, detectors, and applications of AI/ML and other data	Funding will support investment in future accelerator and detector technologies to continue to provide the world's most

(dollars in thousands)

FY 2025 Enacted	FY 2026 Request	Explanation of Changes FY 2026 Request vs FY 2025 Enacted
optimization, control, prognostics, and data analysis. Research emphasizes transformative advances in accelerator science and technology that lead to significant improvements in very high brightness and high current electron sources and in high intensity proton sources. In addition, research expands to include enabling capabilities for data science/AI/ML and continues for response to biological threats and to increase the diversity of the research performers.	science techniques to accelerator optimization, control, prognostics, and data analysis. Research will emphasize transformative advances in accelerator science and technology that lead to significant improvements in very high brightness and high current electron sources and in high intensity proton sources.	comprehensive and advanced accelerator-based facilities for scientific research. Funding will expand investments in data science and AI/ML methods and tools to address data and information challenges at the BES user facilities, including accelerator control and experiment automation with real time data analysis.

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

Accelerator-based x-ray light sources, accelerator-based pulsed neutron sources, reactor-based neutron sources, and nanoscale science research centers are essential user facilities that enable critical DOE mission-driven science, including research in support of next-generation energy technologies and other critical and emerging technologies (e.g., in quantum information science, microelectronics, and critical minerals) vital to U.S. economic and national security. These user facilities provide the academic, laboratory, and industrial research communities with the tools to fabricate, characterize, and develop new materials and chemical processes to advance basic and applied research across multiple scientific disciplines. Funding for the construction of new user facilities and upgrades to existing user facilities are essential to maintaining U.S. scientific leadership.

21-SC-10, Cryomodule Repair & Maintenance Facility (CRMF), SLAC

The CRMF project will provide a much-needed capability to maintain, repair, and test superconducting radiofrequency (SRF) accelerator components. These components include but are not limited to superconducting RF cavities and cryomodules that make up the new superconducting accelerator being constructed by the now complete LCLS-II project and ongoing LCLS-II-HE project, high brightness electron injectors, and superconducting undulators. The facility will provide for the full disassembly and repair of the SRF cryomodule; the ability to disassemble, clean, and reassemble the SRF cavities and cavity string; testing capabilities for the full cryomodule; and separate testing capabilities for individual SRF cavities. To accomplish this, the project requires a building of up to 21,000 gross square feet to contain the necessary equipment, tools, and fixtures, as well as a control room, clean rooms, and liquid helium distribution system. The project received CD-1, Approve Alternative Selection and Cost Range, on October 11, 2023, with a current TPC range of $70,000,000–$98,000,000. A combined CD-2/3, Approve Performance Baseline and Approve Start of Construction, is expected in 1Q FY 2026.

19-SC-14, Second Target Station (STS), ORNL

The STS project will expand SNS capabilities for neutron scattering research by exploiting 0.7 MW of the 2.8 MW SNS accelerator proton beam power enabled by the Proton Power Upgrade (PPU) project. The STS will provide high brightness, cold neutrons complementary to the first target station (FTS). Instruments will feature advanced neutron optics, optimized geometry, and high resolution, advanced detectors, enabling new research opportunities in quantum materials, materials science and engineering, chemistry and catalysis, soft matter and polymers, and biological systems. The project received CD-1, Approve Alternative Selection and Cost Range, on November 23, 2020, establishing the approved TPC range of $1,800,000,000–$3,000,000,000. CD-3A, Approve Long Lead Procurements, is expected in 3Q FY 2025.

18-SC-13, Linac Coherent Light Source-II-High Energy (LCLS-II-HE), SLAC

The LCLS-II-HE project will expand the capabilities of the LCLS to maintain U.S. leadership in ultrafast and ultrabright x-ray science. The project will increase the energy of the superconducting linac from 4 GeV to 8 GeV and thereby expand the high repetition rate operation (1 million pulses per second) into the hard x-ray regime (5-12 keV). This will transform the community's ability to interrogate and advance understanding of complex matter at the atomic scale on ultrafast time scales with elemental specificity relevant to real world systems, including quantum materials, functional materials, catalysts, and biological molecules. The project received CD-3C, Approve Long Lead Procurements and Early Limited Construction, on July 2, 2024. The project established an original TPC range of $290,000,000–$480,000,000, but due to maturing design efforts that identified additional costs across the project scope and increases in the project's contingency to address several future risks, the TPC estimate has increased to $716,000,000. The project received a combined CD-2/3, Approve Performance Baseline and Approve Start of Construction, on September 19, 2024. CD-4, Approve Start of Operations, is expected 2Q FY 2030.

18-SC-12, Advanced Light Source Upgrade ALS-U, LBNL

The ALS-U project will upgrade the existing ALS facility by replacing the existing electron storage ring with a new electron storage ring based on a multi-bend achromat lattice design, which will provide a soft x-ray source that is up to 1000 times brighter and with a significantly higher coherent flux fraction. ALS-U will leverage two decades of investments in scientific tools at the ALS by making use of the existing beamlines and infrastructure. ALS-U will ensure that the ALS facility remains a world leader in soft x-ray science. The project received CD-3, Approve Start of Construction, on November 10, 2022, with an original Total Project Cost (TPC) of $590,000,000. The ALS-U project is currently working towards rebaselining, which will establish a new TPC and schedule in 1Q FY 2026. CD-4, Approve Project Completion, is currently 4Q of FY 2029.

24-SC-10, HFIR Pressure Vessel Replacement (PVR), ORNL

The HFIR PVR project will replace the aging HFIR pressure vessel to extend facility lifetime for decades, enable resumption of 100 MW operations, and enhance isotope production and scattering research. These upgrades will maintain a domestic high-flux, steady-state neutron source for varied and critical missions. For example, in addition to the hundreds of neutron scattering users, isotope production at HFIR supports research, clinical trials and medical interventions, and federal and industrial applications, including nuclear reactor startup, homeland security, and NASA deep space missions. The project received CD-0, Approve Mission Need, on October 28, 2020, with a current preliminary Total Project Cost (TPC) range of $300,000,000–$740,000,000, updated by preliminary planning for the project. A combined CD-1, Approve Alternative Selection and Cost Range, and CD-3A, Approve Long Lead Procurements, is expected in 2Q FY 2027.

24-SC-12, NSLS-II Experimental Tools - III (NEXT-III), BNL

The NEXT-III project will provide a pathway for the construction of an additional suite of up to 12 beamlines that will be optimized to enhance the capability of NSLS-II. These beamlines will enable cutting-edge research for next-generation energy technologies, manufacturing, automated structure analysis of biological macromolecules, drug discovery, bio-preparedness, quantum materials, and quantum information science, as well as developing novel instrumentation and tools required to maintain the global competitiveness of the U.S. light sources. NEXT-III beamlines will also enable multimodal research that can facilitate growth of industrial research and provide new avenues to introduce more users to synchrotron research. The project received CD-0, Approve Mission Need, on September 30, 2022, with a preliminary TPC range of $350,000,000–$500,000,000, and CD-1, Approve Alternative Selection and Cost Range, on September 15, 2024. A combined CD-2/3, Approve Performance Baseline and Approve Start of Construction, is expected 2Q FY 2026.

Activities and Explanation of Changes

(dollars in thousands)

FY 2025 Enacted	FY 2026 Request	Explanation of Changes FY 2026 Request vs FY 2025 Enacted
Construction $233,500	**$221,343**	**-$12,157**
24-SC-10, HFIR Pressure Vessel Replacement (PVR), ORNL $6,000	$ —	-$6,000
Funding continues planning, design, R&D, analysis, engineering, and prototyping to advance design toward readiness for a combined CD-1/3A in 4Q FY 2026.	No funding is requested for the HFIR-PVR project in FY 2026.	No funding is requested.
24-SC-12, NSLS-II Experimental Tools - III (NEXT-III), BNL $5,500	$ —	-$5,500
Funding supports activities to secure CD-3A approval, expected in 3Q FY 2025, to start long lead procurements of the first group of beamlines and continue with design of the second group of beamlines.	No funding is requested for the NEXT-III project in FY 2026.	No funding is requested.
21-SC-10, Cryomodule Repair & Maintenance Facility (CRMF), SLAC $20,000	$20,000	$ —
Funding supports the continuation of activities required to secure a combined CD-2/3 approval and initiation of construction contracts, expected in 1Q FY 2026.	The Request will support the continuation of activities required to secure a combined CD-2/3 approval and initiation of construction contracts, expected in 1Q FY 2026.	Funding will advance progress on the CRMF project.
19-SC-14, Second Target Station (STS), ORNL $52,000	$52,000	$ —
Funding continues planning, R&D, design, engineering, prototyping, and testing to advance the highest-priority activities. Funding also initiates a potential long lead procurement for civil construction site preparation upon associated CD approvals.	The Request will continue activities, focusing on the highest priority accelerator and target designs in parallel with advancing long lead procurement activity for civil construction site preparation upon associated CD approvals.	Funding will advance progress on the STS project.
18-SC-13, Linac Coherent Light Source-II-High Energy (LCLS-II-HE), SLAC $100,000	$99,343	-$657
Funding supports production of the cryomodules, continues long lead	Funding will continue the construction and installation	Funding will advance progress on the LCLS-II-HE project.

(dollars in thousands)

FY 2025 Enacted	FY 2026 Request	Explanation of Changes FY 2026 Request vs FY 2025 Enacted
procurements, and begins remaining scope design efforts and initiates installation/construction contracts. Other tasks as required..	contracts, complete the pre-staging activities, and start installation activities during the year-long LCLS Dark Time in FY 2026.	
18-SC-12, Advanced Light Source Upgrade ALS-U, LBNL $50,000	$50,000	$ —
Funding supports the remaining procurements for the Accumulator and Storage Rings, installation of the Accumulator ring in the tunnel, and assembly of the Storage Ring in preparation of dark time.	The request will advance installation of the Accumulator ring in the tunnel and the beamline front end engineering and system engineering as well as begin preparation activities for the dark time Storage Ring installation.	Funding will advance progress on the ALS-U project.

Basic Energy Sciences
Capital Summary

(dollars in thousands)

	Total	Prior Years	FY 2024 Enacted	FY 2025 Enacted	FY 2026 Request	FY 2026 Request vs FY 2025 Enacted
Capital Operating Expenses						
Capital Equipment	N/A	N/A	57,394	29,590	47,693	+18,103
Minor Construction Activities						
General Plant Projects	N/A	N/A	22,040	10,900	46,361	+35,461
Accelerator Improvement Projects	N/A	N/A	81,169	19,605	60,427	+40,822
Total, Capital Operating Expenses	**N/A**	**N/A**	**160,603**	**60,095**	**154,481**	**+94,386**

Capital Equipment

(dollars in thousands)

	Total	Prior Years	FY 2024 Enacted	FY 2025 Enacted	FY 2026 Request	FY 2026 Request vs FY 2025 Enacted
Capital Equipment						
Major Items of Equipment						
Scientific User Facilities (SUF)						
NSLS-II Experimental Tools-II (NEXT-II), BNL	92,283	72,283	20,000	–	–	–
NSRC Recapitalization	79,150	74,150	5,000	–	–	–
Total, MIEs	N/A	N/A	25,000	–	–	–
Total, Non-MIE Capital Equipment	N/A	N/A	32,394	29,590	47,693	+18,103
Total, Capital Equipment	**N/A**	**N/A**	**57,394**	**29,590**	**47,693**	**+18,103**

Note:

- *The Capital Equipment table includes MIEs with a Total Estimated Cost (TEC) > $10M.*

Minor Construction Activities

(dollars in thousands)

	Total	Prior Years	FY 2024 Enacted	FY 2025 Enacted	FY 2026 Request	FY 2026 Request vs FY 2025 Enacted
General Plant Projects (GPP)						
GPPs (greater than $5M and $34M or less)						
Spallation Neutron Source Sample Environmental Building	8,594	–	–	–	8,594	+8,594
HFIR Guide Hall Extension	19,900	1,400	18,500	–	–	–
HFIR Fabrication, Alignment & Manufacturing (FAM) Bldg., ORNL	1,540	–	1,540	–	–	–
Technical and Storage Space	9,528	–	–	–	9,528	+9,528
SLAC, SSRL, B120 Expansion for Beamline Upgrade	1,700	–	–	–	1,700	+1,700
SLAC, LCLS, Far Experimental Hall	25,000	–	–	–	25,000	+25,000
HFIR Helium Recovery System	539	–	–	–	539	+539
Total GPPs (greater than $5M and $34M or less)	N/A	N/A	20,040	–	45,361	+45,361
Total GPPs $5M or less	N/A	N/A	2,000	10,900	1,000	-9,900
Total, General Plant Projects (GPP)	**N/A**	**N/A**	**22,040**	**10,900**	**46,361**	**+35,461**
Accelerator Improvement Projects (AIP)						
AIPs (greater than $5M and $34M or less)						
3rd Harmonic Cavity, National Synchrotron Light Source-II	10,020	–	4,720	–	5,300	+5,300
Spallation Neutron Source Cold Box-Engineering	10,500	–	10,500	–	–	–
Cold Source Helium Refrigerator System	21,939	9,339	12,600	–	–	–
160kW Solid State Amplifier Hardware and Utilities - Phase 2 (APS)	5,967	–	5,967	–	–	–
Flexon 2nd Endstation, LBNL	8,500	–	8,500	–	–	–
New SAX/WAX Beamline, LBNL	27,140	1,890	17,750	–	7,500	+7,500
ALS Beamline Readiness	6,000	–	–	–	6,000	+6,000
ALS Front End Readiness	6,000	–	–	–	6,000	+6,000
HFIR HBRR MANTA	753	–	–	–	753	+753
HFIR HBRR MARS	1,282	–	–	–	1,282	+1,282
Total AIPs (greater than $5M and $34M or less)	N/A	N/A	60,037	–	26,835	+26,835
Total AIPs $5M or less	N/A	N/A	21,132	19,605	33,592	+13,987

(dollars in thousands)

	Total	Prior Years	FY 2024 Enacted	FY 2025 Enacted	FY 2026 Request	FY 2026 Request vs FY 2025 Enacted
Total, Accelerator Improvement Projects (AIP)	N/A	N/A	81,169	19,605	60,427	+40,822
Total, Minor Construction Activities	N/A	N/A	103,209	30,505	106,788	+76,283

Notes:

- *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.*
- *The Total funding for the HFIR Guide Hall Extension GPP project is approximately $19,900,000. This project, originally requested in FY 2021, has been delayed. Design efforts were fully funded in FY 2023 and the remaining funds were requested in FY 2024.*
- *The Total funding for the Cold Source Helium Refrigerator System (AIP) project is $12,600,000. This project, originally requested in FY 2021, was deferred until FY 2024.*
- *The Total funding for the SNS Cold Box-Engineering (AIP) project is $10,500,000. This project, originally requested in FY 2023, was deferred until FY 2024.*
- *The Total funding for the 3rd Harmonic Cavity (AIP) project is $5,300,000. This project, originally requested in FY 2024, has been deferred until FY 2026.*
- *The Total funding for the SAX/WAX Beamline (AIP) project is $9,000,000. This project, originally requested in FY 2024, has been deferred with revised scope until FY 2026.*
- *The Total funding for the NSLS-II Technical and Storage Space (GPP) project is $9,528,000. This project, originally requested in FY 2025, has been deferred until FY 2026.*
- *The SLAC B120 Expansion for Beamline Upgrade (GPP) project originally requested in FY 2025 has been delayed. Design efforts are requested in FY 2026.*
- *The Total funding for the Far Experimental Hall (GPP) project is $28,400,000. This project, originally requested in FY 2025, has been deferred until FY 2026.*
- *The Total funding for the HFIR Helium Recovery System (GPP) project is $7,440,000. Design efforts are requested in FY 2026.*
- *The Total funding for the ALS Beamline Readiness (AIP) project is $7,500,000. Design efforts will be fully funded in FY 2025 and the remaining funds are requested in FY 2026.*
- *The Total funding for the ALS Front End Readiness (AIP) project is $7,500,000. Design efforts will be fully funded in FY 2025 and the remaining funds are requested in FY 2026.*
- *The Total funding for the HFIR HBRR MANTA (AIP) project is $8,525,000. Design efforts are requested in FY 2026.*
- *The Total funding for the HFIR HBRR MARS (AIP) project is $14,855,000. Design efforts are requested in FY 2026.*

Basic Energy Sciences
Construction Projects Summary

(dollars in thousands)

	Total	Prior Years	FY 2024 Enacted	FY 2025 Enacted	FY 2026 Request	FY 2026 Request vs FY 2025 Enacted
24-SC-10, HFIR Pressure Vessel Replacement (PVR), ORNL						
Total Estimated Cost (TEC)	679,000	-	4,000	6,000	-	-6,000
Other Project Cost (OPC)	50,000	3,000	9,000	5,000	-	-5,000
Total Project Cost (TPC)	**729,000**	**3,000**	**13,000**	**11,000**	**-**	**-11,000**
24-SC-12, NSLS-II Experimental Tools - III (NEXT-III), BNL						
Total Estimated Cost (TEC)	480,000	-	2,556	5,500	-	-5,500
Other Project Cost (OPC)	20,000	1,500	4,000	4,500	-	-4,500
Total Project Cost (TPC)	**500,000**	**1,500**	**6,556**	**10,000**	**-**	**-10,000**
21-SC-10, Cryomodule Repair & Maintenance Facility (CRMF), SLAC						
Total Estimated Cost (TEC)	88,800	32,000	9,000	20,000	20,000	-
Other Project Cost (OPC)	5,700	4,700	1,000	-	-	-
Total Project Cost (TPC)	**94,500**	**36,700**	**10,000**	**20,000**	**20,000**	**-**
19-SC-14, Second Target Station (STS), ORNL						
Total Estimated Cost (TEC)	1,923,920	156,700	52,000	52,000	52,000	-
Other Project Cost (OPC)	76,080	52,845	-	-	-	-
Total Project Cost (TPC)	**2,000,000**	**209,545**	**52,000**	**52,000**	**52,000**	**-**
18-SC-11, Spallation Neutron Source Proton Power Upgrade (PPU), ORNL						
Total Estimated Cost (TEC)	257,769	242,000	15,769	-	-	-
Other Project Cost (OPC)	13,798	13,798	-	-	-	-
Total Project Cost (TPC)	**271,567**	**255,798**	**15,769**	**-**	**-**	**-**
18-SC-12, Advanced Light Source Upgrade (ALS-U), LBNL						
Total Estimated Cost (TEC)	TBD	TBD	57,300	57,000	50,000	-7,000
Other Project Cost (OPC)	28,000	28,000	-	-	-	-
Total Project Cost (TPC)	**TBD**	**TBD**	**57,300**	**57,000**	**50,000**	**-7,000**
18-SC-13, Linac Coherent Light Source-II-High Energy (LCLS-II-HE), SLAC						
Total Estimated Cost (TEC)	684,000	358,657	120,000	100,000	99,343	-657
Other Project Cost (OPC)	32,000	27,000	-	-	5,000	+5,000
Total Project Cost (TPC)	**716,000**	**385,657**	**120,000**	**100,000**	**104,343**	**+4,343**

(dollars in thousands)

	Total	Prior Years	FY 2024 Enacted	FY 2025 Enacted	FY 2026 Request	FY 2026 Request vs FY 2025 Enacted
Total, Construction						
Total Estimated Cost (TEC)	N/A	N/A	260,625	233,500	221,343	-12,157
Other Project Cost (OPC)	N/A	N/A	14,000	9,500	5,000	-4,500
Total Project Cost (TPC)	N/A	N/A	274,625	243,000	226,343	-16,657

Note:

- *The current estimated TPC for the ALS-U project is $590,000. The project is currently working on a new cost and schedule analysis that will inform a new baseline TPC in FY 2026.*

Basic Energy Sciences
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 2024 Enacted	FY 2024 Current	FY 2025 Enacted	FY 2026 Request	FY 2026 Request vs FY 2025 Enacted
Scientific User Facilities - Type A					
Advanced Light Source	**106,443**	**108,443**	**118,439**	**122,111**	**+3,672**
Number of Users	1,566	1,597	1,550	750	-800
Achieved Operating Hours	–	2,845	–	–	–
Planned Operating Hours	3,051	–	2,768	1,795	-973
Advanced Photon Source	**176,091**	**178,591**	**201,758**	**208,744**	**+6,986**
Number of Users	1,835	38	2,736	4,320	+1,584
Achieved Operating Hours	–	492	–	–	–
Planned Operating Hours	2,099	–	4,774	3,930	-844
National Synchrotron Light Source II	**148,198**	**148,198**	**158,134**	**163,652**	**+5,518**
Number of Users	1,651	2,340	2,500	1,770	-730
Achieved Operating Hours	–	4,699	–	–	–
Planned Operating Hours	4,585	–	4,900	3,850	-1,050
Stanford Synchrotron Radiation Light Source	**68,002**	**68,002**	**69,000**	**78,399**	**+9,399**
Number of Users	1,848	1,796	1,900	1,525	-375
Achieved Operating Hours	–	4,253	–	–	–
Planned Operating Hours	4,639	–	5,116	4,090	-1,026
Linac Coherent Light Source	**210,400**	**217,000**	**231,534**	**232,200**	**+666**
Number of Users	916	920	1,000	830	-170
Achieved Operating Hours	–	4,005	–	–	–
Planned Operating Hours	5,947	–	7,500	4,535	-2,965
Spallation Neutron Source	**179,147**	**210,500**	**230,741**	**237,307**	**+6,566**
Number of Users	246	476	1,082	740	-342
Achieved Operating Hours	–	1,457	–	–	–
Planned Operating Hours	1,359	–	4,329	3,935	-394
High Flux Isotope Reactor	**196,016**	**165,163**	**142,626**	**147,839**	**+5,213**
Number of Users	452	612	403	415	+12
Achieved Operating Hours	–	3,511	–	–	–
Planned Operating Hours	3,733	–	2,250	2,745	+495

(dollars in thousands)

	FY 2024 Enacted	FY 2024 Current	FY 2025 Enacted	FY 2026 Request	FY 2026 Request vs FY 2025 Enacted
Scientific User Facilities - Type B					
Center for Nanoscale Materials	29,612	30,900	32,445	33,794	+1,349
Number of Users	668	842	885	780	-105
Center for Functional Nanomaterials	26,540	26,846	27,663	28,793	+1,130
Number of Users	635	719	750	660	-90
Molecular Foundry	37,491	37,403	39,273	40,906	+1,633
Number of Users	1,173	1,128	1,150	1,050	-100
Center for Nanophase Materials Sciences	29,504	29,279	30,743	32,012	+1,269
Number of Users	707	890	850	645	-205
Center for Integrated Nanotechnologies	27,733	28,720	29,106	30,265	+1,159
Number of Users	851	1,020	1,100	895	-205
Total, Facilities	1,235,177	1,249,045	1,311,462	1,356,022	+44,560
Number of Users	12,548	12,378	15,906	14,380	-1,526
Achieved Operating Hours	–	21,262	–	–	–
Planned Operating Hours	25,413	–	31,637	24,880	-6,757

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.*

Scientific Employment

	FY 2024 Enacted	FY 2025 Enacted	FY 2026 Request	FY 2026 Request vs FY 2025 Enacted
Number of Permanent Ph.Ds (FTEs)	5,930	5,530	4,060	-1,470
Number of Postdoctoral Associates (FTEs)	1,640	1,510	970	-540
Number of Graduate Students (FTEs)	2,570	2,340	1,470	-870
Number of Other Scientific Employment (FTEs)	3,710	3,520	2,860	-660
Total Scientific Employment (FTEs)	**13,850**	**12,900**	**9,360**	**-3,540**

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

21-SC-10, Cryomodule Repair & Maintenance Facility (CRMF), SLAC
SLAC National Accelerator Laboratory, SLAC
Project is for Design and Construction

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

Summary

The Cryomodule Repair and Maintenance Facility (CRMF) project will provide a much-needed capability to maintain, repair, and test superconducting radiofrequency (SRF) accelerator components. The FY 2026 Request for the CRMF project at SLAC National Accelerator Laboratory is $20,000,000 of Total Estimated Cost (TEC) funding. This project has a preliminary Total Project Cost (TPC) range of $70,000,000 to $98,000,000. This cost range encompasses the most feasible preliminary alternatives at this time. As the design of this project has matured, the current preliminary TPC estimate for this project is $94,500,000.

Significant Changes

CRMF was initiated in FY 2021. The most recent DOE Order 413.3B approved Critical Decision (CD) is CD-1, Approve Alternative Selection and Cost Range, which was approved on October 11, 2023.

FY 2024 funding supported continued building infrastructure design and advancing the technical systems design guidelines and specifications, including the SRF, controls, and cryogenics capabilities. The FY 2025 Enacted will support completion of the design of the building and conventional infrastructure and prepare the technical and procurement specifications for the building construction Request for Proposal (RFP). The cryogenic systems and procurement specifications will also be completed. The FY 2026 Request will support baselining and starting procurements, initiating the conventional facility infrastructure construction contracts. The funding will also support procurements for cryogenic system.

A Federal Project Director, certified to Level II, has been assigned to this project.

Critical Milestone History

Fiscal Year	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	CD-4
FY 2026	12/6/19	8/24/23	10/11/23	1Q FY 2026	1Q FY 2026	1Q FY 2026	1Q FY 2030

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 2025	16,400	72,400	88,800	5,700	5,700	94,500
FY 2026	20,700	68,100	88,800	5,700	5,700	94,500

Note:
- *This project has not received CD-2 approval; therefore, funding estimates are preliminary.*

2. Project Scope and Justification

Scope

The preliminary scope of the CRMF project is to construct a building equipped with clean rooms, handling tools, and fixtures to support the repair, maintenance, and testing of superconducting radiofrequency (SRF) linear accelerator (linac) components. These components may include, but are not limited to, SRF cavities and cryomodules, future capabilities for high brightness electron injectors, and superconducting undulators. The requirements will be refined as the project matures.

Justification

Through two BES construction projects at SLAC, LCLS-II (completed) and LCLS-II-HE, SC is making over a $1,800,000,000 capital investment in those projects with improved SRF linac performance to support researchers advancing the scientific discovery and technology development missions of DOE. The LCLS-II project provided a 4 GeV SRF-based linear accelerator containing 35 SRF cryomodules (CMs) to accelerate the electrons. The LCLS-II-HE project will increase the energy of the superconducting linac to 8 GeV by providing an additional 23 SRF CMs of a similar design to those installed by the LCLS-II project but operating at a higher accelerating gradient. SLAC has partnered with Fermi National Accelerator Laboratory (FNAL) and the Thomas Jefferson National Accelerator Facility (TJNAF) to provide the accelerating CMs. The specialized CM fabrication, assembly, and test capabilities are currently available at FNAL and TJNAF, but not at SLAC. Therefore, to make any repairs, SLAC must send the CMs cross country back to either FNAL or TJNAF at an increased risk of damage, cost, and schedule delays. This situation also requires that either FNAL or TJNAF have the maintenance facility capacity and trained personnel available when needed. Historically, these facilities are actively working on CMs for other SC projects, and maintenance or repairs typically require scheduling 6 to 12 months in advance.

The CRMF is designed to meet these challenges by providing SLAC with the capability to repair, maintain, and test the cryomodules and components that make up the upgraded LCLS superconducting linac.

The project is being conducted in accordance with the project management requirements in DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets*.

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 part of the approved performance baseline. The Threshold KPPs represent the minimum acceptable performance that the project must achieve. The Objective KPPs represent the desired project performance. Achievement of the Threshold KPPs will be a prerequisite for approval of CD-4, Project Completion.

Capability	Threshold	Objective
Disassembly, repair, and re-assembly of a 1.3 gigahertz (GHz) cryomodule	Install CM assembly tooling and ISO 4 Cleanroom	Same as threshold
1.3 GHz cavity qualification tests in CM	One 7 kilowatt (kW) Solid State Amplifier (SSA) installed with controls and safety systems operational	Eight 7kW SSA installed
High-pressure-rinsing (HPR) of 1.3 GHz cavity	Installation of High-Pressure Rinse and ultrapure water systems	Same as threshold
Cryogenic cooling	Delivery of sufficient 4.5 kelvin (K) liquid Helium (LHe) to sustain 100W of heat load at 2 K for 8 hours	Delivery of sufficient 4.5 Kelvin LHe to sustain 250W of heat load at 2 K for 8 hours
Infrastructure	18,000 GSF building	21,750 GSF building
Infrastructure for testing of 1.3 GHz cavity & cryomodule	Shielded enclosure and 880 GSF dedicated area for vertical test stand equipment and construction of two vertical pits	Same as threshold
Area for SRF-related equipment	Space for ISO 4 cleanroom and CM assembly workstations	Additional space for future SRF shielded enclosure

3. Financial Schedule

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Estimated Cost (TEC)				
Design (TEC)				
Prior Years	3,600	3,600	—	—
Prior Years - IRA Supp.	300	300	—	—
FY 2024	7,800	7,800	—	5,953
FY 2025	4,700	4,700	4,400	3,347
FY 2026	4,300	4,300	7,000	—
Total, Design (TEC)	**20,700**	**20,700**	**11,400**	**9,300**
Construction (TEC)				
Prior Years	8,400	8,400	—	—
Prior Years - IRA Supp.	19,700	19,700	—	—
FY 2024	1,200	1,200	—	—
FY 2025	15,300	15,300	200	—
FY 2026	15,700	15,700	19,300	10,700
Outyears	7,800	7,800	37,900	—
Total, Construction (TEC)	**68,100**	**68,100**	**57,400**	**10,700**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Estimated Cost (TEC)				
Total Estimated Cost (TEC)				
Prior Years	12,000	12,000	—	—
Prior Years - IRA Supp.	20,000	20,000	—	—
FY 2024	9,000	9,000	—	5,953
FY 2025	20,000	20,000	4,600	3,347
FY 2026	20,000	20,000	26,300	10,700
Outyears	7,800	7,800	37,900	—
Total, Total Estimated Cost (TEC)	**88,800**	**88,800**	**68,800**	**20,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Other Project Cost (OPC)				
Prior Years	4,000	4,000	2,961	700
Prior Years - IRA Supp.	700	700	–	–
FY 2024	1,000	1,000	128	–
Outyears	–	–	1,911	–
Total, Other Project Cost (OPC)	**5,700**	**5,700**	**5,000**	**700**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Project Cost (TPC)				
Prior Years	16,000	16,000	2,961	700
Prior Years - IRA Supp.	20,700	20,700	–	–
FY 2024	10,000	10,000	128	5,953
FY 2025	20,000	20,000	4,600	3,347
FY 2026	20,000	20,000	26,300	10,700
Outyears	7,800	7,800	39,811	–
Total, TPC	**94,500**	**94,500**	**73,800**	**20,700**

4. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design	17,000	12,500	N/A
Design - Contingency	3,700	3,900	N/A
Total, Design (TEC)	**20,700**	**16,400**	N/A
Construction	31,700	31,700	N/A
Equipment	22,600	24,200	N/A
Construction - Contingency	13,800	16,500	N/A
Total, Construction (TEC)	**68,100**	**72,400**	N/A
Total, TEC	**88,800**	**88,800**	N/A
Contingency, TEC	*17,500*	*20,400*	*N/A*
Other Project Cost (OPC)			
Conceptual Planning	500	500	N/A
Conceptual Design	2,800	2,800	N/A
Start-up	1,200	1,200	N/A
OPC - Contingency	1,200	1,200	N/A
Total, Except D&D (OPC)	**5,700**	**5,700**	N/A
Total, OPC	**5,700**	**5,700**	N/A
Contingency, OPC	*1,200*	*1,200*	*N/A*
Total, TPC	**94,500**	**94,500**	N/A
Total, Contingency (TEC+OPC)	***18,700***	***21,600***	*N/A*

5. Schedule of Appropriations Requests

(dollars in thousands)

Fiscal Year	Type	Prior Years	FY 2024	FY 2025	FY 2026	Outyears	Total
FY 2025	TEC	32,000	9,000	20,000	—	27,800	88,800
	OPC	4,700	1,000	—	—	—	5,700
	TPC	36,700	10,000	20,000	—	27,800	94,500
FY 2026	TEC	32,000	9,000	20,000	20,000	7,800	88,800
	OPC	4,700	1,000	—	—	—	5,700
	TPC	36,700	10,000	20,000	20,000	7,800	94,500

Note:
- *This project has not received CD-2 approval; therefore, funding estimates are preliminary.*

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	1Q FY 2030
Expected Useful Life	25 years
Expected Future Start of D&D of this capital asset	1Q FY 2055

Related Funding Requirements
(dollars in thousands)

	Annual Costs		Life Cycle Costs	
	Previous Total Estimate	Current Total Estimate	Previous Total Estimate	Current Total Estimate
Operations, Maintenance and Repair	5,500	5,500	137,500	137,500

7. D&D Information

At this stage of project planning and development, SC is planning to construct a new building up to 21,750 gross square feet as part of this project.

	Square Feet
New area being constructed by this project at SLAC	21,750
Area of D&D in this project at SLAC	—
Area at SLAC to be transferred, sold, and/or D&D outside the project, including area previously "banked"	21,750
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"	—
Total area eliminated	—

8. Acquisition Approach

The CRMF Project will be sited at SLAC and is being acquired under the existing DOE M&O contract with Stanford University. SLAC has delivered several large construction projects and research facilities and has the requisite expertise to successfully deliver CRMF. SLAC, with support from partner laboratory expert staff, will complete the design of the technical systems. The acquisition of the CRMF building will be based on the design-bid-build methodology. Selected subcontracted vendors, pre-qualified with the necessary capabilities, will fabricate the technical equipment. SLAC will competitively bid and award all contracts based on best value to the government.

SC and the M&O will draw from the lessons learned from other SC projects and other similar facilities in planning and executing the CRMF project. SC will evaluate the M&O contractor's performance through the annual laboratory performance appraisal process.

19-SC-14, Second Target Station (STS), ORNL
Oak Ridge National Laboratory, ORNL
Project is for Design and Construction

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

Summary

The STS project will design and build a new, very high brightness cold[j] neutron scattering capability to maintain U.S. competitiveness in providing world-leading neutron scattering user facilities. STS will offer unique beamlines to advance our understanding of the fundamental aspects of the natural world. The FY 2026 Request for the STS project is $52,000,000 of Total Estimated Cost (TEC) funding. This project has a preliminary Total Project Cost (TPC) range of $1,800,000,000 to $3,000,000,000. This cost range encompasses the most feasible preliminary alternatives. The current preliminary TPC estimate is $2,000,000,000 based on the most current revised scope, notional funding profile, and schedule.

Significant Changes

STS was initiated in FY 2019. The most recent DOE Order 413.3B approved Critical Decision (CD) is CD-1, Approve Alternative Selection and Cost Range, which was approved on November 23, 2020. CD-3A, Approve Long Lead Procurements (LLPs), is expected in 3Q FY 2025. The project continues to face schedule and cost challenges due to increasing construction costs in the local market and has worked diligently to mitigate the overall cost and schedule risk impacts by value engineering and addressing the Key Performance Parameter (KPP) and scope optimization required by the mission need. The preliminary notional TPC point estimate is $2,000,000,000, assumes a more favorable funding profile than presented at a June 2024 peer review, and is subject to change with adjustments in the annual funding levels.

FY 2024 funding enabled the project to optimize planning around a TPC and funding profile that prioritized the design of the accelerator optics, target assembly, moderator reflector assembly, and conventional facilities. The FY 2025 Enacted will support continued planning, R&D, design, engineering, prototyping, and testing to advance the highest priority activities with emphasis on key project scope for the target vessel, shielding, moderator, and conventional facilities. The science case will be more fully developed to specify the currently inaccessible grand challenges that the new capabilities can address, and the instrument suite will be redefined to support the refined science case. Civil construction site preparation is planned to start in 3Q FY 2025. The FY 2026 Request will progress toward the scientific instrument selection and advance the efforts initiated in FY 2025, including but not limited to planning, R&D, design, engineering, prototyping, and testing to advance the highest priority activities and completing the target monolith, accelerator, and bunker designs in preparation for a combined CD-2/3. The technical scope will advance in parallel with the remaining civil construction site preparation.

A Federal Project Director, certified to level III, has been assigned to this project.

[j] Neutrons can be described based on their wavelength and energy. Cold neutrons have lower energy (below 25 meV) and longer wavelengths (>0.2 nm) than thermal neutrons. Cold neutrons are best for characterizing materials with large atomic/molecular structures, such as polymers, biological materials, and magnetic materials. The wavelength of cold neutrons is similar to the activation energies for many solid-state excitations, molecular relaxations, and dynamic processes.

Critical Milestone History

Fiscal Year	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	CD-4
FY 2026	1/7/09	4/30/21	11/23/20	1Q FY 2027	4Q FY 2029	1Q FY 2027	4Q FY 2039

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.

Fiscal Year	Performance Baseline Validation	CD-3A
FY 2026	1Q FY 2027	3Q FY 2025

CD-3A – Approve Long-Lead Procurements for the Construction Management/General Contractor (CM/GC) to perform site preparation for conventional civil construction.

Project Cost History

(dollars in thousands)

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Except D&D	OPC, Total	TPC
FY 2025	290,700	1,854,300	2,145,000	97,000	97,000	2,242,000
FY 2026	263,520	1,660,400	1,923,920	76,080	76,080	2,000,000

Note:
- *This project has not received CD-2 approval; therefore, funding estimates are preliminary.*

2. Project Scope and Justification

Scope

The STS project will design and build the new cold neutron scattering facility that comprises four primary elements: the neutron target and moderators; the accelerator systems; the instruments; and the conventional facilities. Costs for acceptance testing, integrated testing, and initial commissioning to demonstrate achievement of the KPPs are included in the STS scope. STS will be located in unoccupied space east of the existing SNS First Target Station (FTS). The project requires approximately 220,000 square feet of new buildings, making conventional facility construction a major contributor to project costs. The conventional facilities have been consolidated and the footprint reduced to lower the construction cost and shorten the schedule.

Justification

BES supports a diverse portfolio of large-scale user facilities including two neutron scattering facilities, the HFIR and the SNS, with the SNS FTS providing the world's brightest pulsed neutron scattering capability for thermal neutrons.[k] Currently, the U.S. lacks domestic capacity for research with lower energy, longer wavelength cold

[k] Thermal neutrons have higher energy (at and above 25 meV) and shorter wavelengths (<0.2 nm) than cold neutrons. The wavelength of thermal neutrons is similar to the interatomic distances in materials, making them ideal for engineering materials, imaging, and determination of crystal structures.

neutrons. Filling this gap is critical to maintaining U.S. competitiveness in world-leading neutron scattering research. The STS project will design and build a new, very high brightness, cold neutron source. The STS will provide unique beamlines with unmatched capabilities that will address major scientific challenges currently difficult or impossible to conduct at existing facilities. This includes unlocking breakthroughs in quantum materials, biomaterials, soft matter and polymers, materials under extreme condition and in non-equilibrium environments, advancing the development of materials into devices, and enhancing manufacturing, all of which are enabling for U.S. energy dominance.

STS will have a very high-density proton beam produced by the SNS proton linac directed to strike a solid tungsten target. The produced neutron beam illuminates compact moderators that will feed experimental beamlines. The neutron moderator system is geometrically optimized to deliver higher peak brightness of cold neutrons. The STS project will exploit 0.7 MW of the 2.8 MW accelerator proton beam power enabled by the PPU project. STS is designed to operate at 15 pulses/second simultaneously with FTS by using one out of every four proton pulses to produce cold neutron beams. FTS will operate at 45 pulses/second. An initial set of world-class instruments to support the refined science case will feature advanced neutron optics, optimized geometry, and high resolution, advanced detectors, enabling new research opportunities and unprecedented levels of performance.

The project is being conducted in accordance with the project management requirements in DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets*.

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. The Objective KPPs represent the desired project performance. Achievement of the Threshold KPPs will be a prerequisite for approval of CD-4, Project Completion.

Performance Measure	Threshold	Objective
Demonstrate independent control of the proton beam on the two target stations	Operate beam to FTS at 45 pulses/s, with no beam to STS. Operate beam to STS at 15 pulses/s, with no beam to FTS. Operate with beam to both target stations 45 pulses/s at FTS and 15 pulses/s at STS.	Operate beam to FTS at 45 pulses/s, with no beam to STS. Operate beam to STS at 15 pulses/s, with no beam to FTS. Operate with beam to both target stations 45 pulses/s at FTS and 15 pulses/s at STS.
Demonstrate proton beam power on STS at 15 Hz with FTS at 2MW at 45 pulses/s	100 kW beam power	700 kW beam power
Measure STS neutron brightness	peak brightness of 2×10^{13}n/cm^2/sr/Å/s at 5 Å	peak brightness of 2×10^{14}n/cm^2/sr/Å/s at 5 Å
Beamlines transitioned to operations	3 beamlines successfully passed the integrated functional testing per the transition to operations parameters acceptance criteria.	≥ 3 beamlines successfully passed the integrated functional testing per the transition to operations parameters acceptance criteria.

3. Financial Schedule

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Estimated Cost (TEC)				
Design (TEC)				
Prior Years	114,000	114,000	50,442	31,728
Prior Years - IRA Supp.	42,700	42,700	—	—
FY 2024	37,000	37,000	34,032	10,972
FY 2025	17,000	17,000	64,165	—
FY 2026	26,000	26,000	33,678	—
Outyears	26,820	26,820	38,503	—
Total, Design (TEC)	**263,520**	**263,520**	**220,820**	**42,700**
Construction (TEC)				
FY 2024	15,000	15,000	—	—
FY 2025	35,000	35,000	8,665	—
FY 2026	26,000	26,000	40,000	—
Outyears	1,584,400	1,584,400	1,611,735	—
Total, Construction (TEC)	**1,660,400**	**1,660,400**	**1,660,400**	**—**
Total Estimated Cost (TEC)				
Prior Years	114,000	114,000	50,442	31,728
Prior Years - IRA Supp.	42,700	42,700	—	—
FY 2024	52,000	52,000	34,032	10,972
FY 2025	52,000	52,000	72,830	—
FY 2026	52,000	52,000	73,678	—
Outyears	1,611,220	1,611,220	1,650,238	—
Total, Total Estimated Cost (TEC)	**1,923,920**	**1,923,920**	**1,881,220**	**42,700**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Other Project Cost (OPC)			
Prior Years	52,845	52,845	47,272
FY 2024	–	–	3,141
FY 2025	–	–	2,432
FY 2026	–	–	3,000
Outyears	23,235	23,235	20,235

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Other Project Cost (OPC)			
Total, Other Project Cost (OPC)	76,080	76,080	76,080

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Project Cost (TPC)				
Prior Years	166,845	166,845	97,714	31,728
Prior Years - IRA Supp.	42,700	42,700	–	–
FY 2024	52,000	52,000	37,173	10,972
FY 2025	52,000	52,000	75,262	–
FY 2026	52,000	52,000	76,678	–
Outyears	1,634,455	1,634,455	1,670,473	–
Total, TPC	2,000,000	2,000,000	1,957,300	42,700

4. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design	248,220	250,700	N/A
Design - Contingency	28,300	40,000	N/A
Total, Design (TEC)	276,520	290,700	N/A
Construction	1,128,120	1,299,300	N/A
Construction - Contingency	519,280	555,000	N/A
Total, Construction (TEC)	1,647,400	1,854,300	N/A
Total, TEC	1,923,920	2,145,000	N/A
Contingency, TEC	*547,580*	*595,000*	*N/A*
Other Project Cost (OPC)			
R&D	5,632	20,000	N/A
Conceptual Design	36,644	26,000	N/A
Start-up	18,588	32,000	N/A
OPC - Contingency	15,216	19,000	N/A
Total, Except D&D (OPC)	76,080	97,000	N/A
Total, OPC	76,080	97,000	N/A
Contingency, OPC	*15,216*	*19,000*	*N/A*

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total, TPC	2,000,000	2,242,000	N/A
Total, Contingency (TEC+OPC)	*562,796*	*614,000*	*N/A*

5. Schedule of Appropriations Requests

(dollars in thousands)

Fiscal Year	Type	Prior Years	FY 2024	FY 2025	FY 2026	Outyears	Total
FY 2025	TEC	156,700	52,000	52,000	—	1,884,300	2,145,000
	OPC	52,845	—	—	—	44,155	97,000
	TPC	209,545	52,000	52,000	—	1,928,455	2,242,000
FY 2026	TEC	156,700	52,000	52,000	52,000	1,611,220	1,923,920
	OPC	52,845	—	—	—	23,235	76,080
	TPC	209,545	52,000	52,000	52,000	1,634,455	2,000,000

Note:
- *This project has not received CD-2 approval; therefore, funding estimates are preliminary.*

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	4Q FY 2039
Expected Useful Life	25 years
Expected Future Start of D&D of this capital asset	4Q FY 2064

Related Funding Requirements
(dollars in thousands)

	Annual Costs		Life Cycle Costs	
	Previous Total Estimate	Current Total Estimate	Previous Total Estimate	Current Total Estimate
Operations, Maintenance and Repair	59,000	59,000	1,475,000	1,475,000

The numbers presented are the incremental operations and maintenance costs above the existing SNS facility without escalation. The estimate will be updated and additional details will be provided after CD-2, Approve Performance Baseline.

7. D&D Information

The new area being constructed in this project will not replace existing facilities.

	Square Feet
New area being constructed by this project at ORNL	~170,000
Area of D&D in this project at ORNL	—
Area at ORNL to be transferred, sold, and/or D&D outside the project, including area previously "banked"	~170,000
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"	—
Total area eliminated	—

8. Acquisition Approach

Based on the DOE determination at CD-1, ORNL is acquiring the STS project under the existing DOE M&O contract.

The M&O contractor prepared a Conceptual Design Report for the STS project and identified key design activities, requirements, and high-risk subsystem components to reduce cost and schedule risk to the project and expedite the startup. The necessary project management systems are fully up to date, operating, and are maintained as an ORNL-wide resource.

ORNL will design and procure the key technical subsystem components. Some technical system designs will require research and development activities. Preliminary cost estimates for most of these systems are based on SNS operating experience and vendor estimates, while some first-of-a-kind systems are based on expert judgement. Vendors and/or partner labs with the necessary capabilities will fabricate the technical equipment. ORNL will competitively bid and award all subcontracts based on best value to the government. SC will evaluate the M&O contractor's performance through the annual laboratory performance appraisal process.

SC and the M&O will draw from lessons learned from other SC projects and other similar facilities in planning and executing the STS project.

18-SC-13, Linac Coherent Light Source-II-High Energy (LCLS-II-HE), SLAC
SLAC National Accelerator Laboratory, SLAC
Project is for Design and Construction

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

Summary

The LCLS-II-HE project will expand the capabilities of the LCLS to maintain U.S. leadership in ultrafast and ultrabright x-ray science. The project will increase the energy of the superconducting linac from 4 GeV to 8 GeV and thereby expand the high repetition rate operation (one million pulses per second) into the hard x-ray regime (5-12 keV). The FY 2026 Request for the LCLS-II-HE project is $99,343,000 of Total Estimated Cost (TEC) funding and $5,000,000 of Other Project Cost (OPC) funding. The Total Project Cost established at the combined CD-2/3 is $716,000,000.

Significant Changes

The LCLS-II-HE project was initiated in FY 2019. The most recent DOE Order 413.3B approved Critical Decision (CD) is a combined CD-2/3, Approve Performance Baseline/Approve Start of Construction, which was approved on September 19, 2024. The phased long-lead procurements were enabled by the investment of the Inflation Reduction Act (IRA) funds. CD-4 is projected for 2Q FY 2030.

FY 2024 funding supported continued engineering, R&D, and injector gun prototyping; and initiated CD-3C long-lead procurements of cryogenic system components and early construction of vertical transfer line penetration through the linac structure for delivery of cryogens, and cryogenic distribution system and controls instruments required for installation during the year-long down time. The FY 2025 Enacted will continue engineering, R&D, and prototyping and support continued R&D for the superconducting radiofrequency electron gun; cryomodule and solid state amplifier production and delivery; continued CD-3C procurements advancing the cryogenic systems, and the low-emittance injector beamline and related infrastructure; and construction/installation contracts. The FY 2026 Request will continue the construction and installation contracts, including the infrastructure systems for cryogenic transfer lines, water, mechanical and electrical; complete the experimental hutch design; complete the pre-staging activities; and start installation activities during the year-long LCLS downtime.

A Federal Project Director, certified to Level IV, has been assigned to this project.

Critical Milestone History

Fiscal Year	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	CD-4
FY 2026	12/15/16	3/23/18	9/21/18	09/19/24	1Q FY 2026	09/19/24	2Q FY 2030

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.

Fiscal Year	Performance Baseline Validation	CD-3A	CD-3B	CD-3C
FY 2026	09/19/24	5/12/20	1/27/23	7/2/24

CD-3A – Approve Long-Lead Procurements for cryomodule associated parts and equipment.
CD-3B – Approve Long-Lead Procurements for SRF Injector cryogenic systems, Cryo Distribution Box, Optics for Experimental Systems, Controls Systems.
CD-3C – Approve Long-Lead Procurements of cryogenic system distribution and controls, beamline optics, and Early Limited Construction including drilling vertical penetration into the accelerator housing for delivery of cryogens into the tunnel.

Project Cost History

(dollars in thousands)

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Except D&D	OPC, Total	TPC
FY 2025	59,000	619,000	678,000	32,000	32,000	710,000
FY 2026	68,000	616,000	684,000	32,000	32,000	716,000

2. Project Scope and Justification

Scope

The LCLS-II-HE project's scope increases the superconducting linac energy from 4 GeV to 8 GeV by installing additional cryomodules in the first kilometer of the existing linac tunnel. The electron beam, generated by a superconducting electron source, will be transported to the existing undulator hall to extend the x-ray energy to 12 keV and beyond. The project will also modify or upgrade existing infrastructure (process cooling water, power, electrical) in the last sector of the linac tunnel and the x-ray transport, optics, and diagnostics system. It will provide new or upgraded instrumentation to augment existing and planned capabilities.

Justification

International developments in X-ray facilities will challenge LCLS's world leadership position. The Shanghai Advanced Research Institute XFEL in Shanghai, China, called SHINE, will match the high pulse rate for continuous operation and have double the electron energy enabled by the LCLS-II project, which allows production of shorter (i.e., harder) x-ray wavelength pulses compared to LCLS. The European X-ray Free Electron Laser (XFEL) at DESY in Hamburg, Germany has a higher electron energy than LCLS, and recent plans could extend the European XFEL from a pulsed operation mode to continuous operation. The continuous operation improves the stability of the electron beam and provides uniformly spaced pulses of x-rays or, if desired, the ability to customize the sequence of x-ray pulses provided to experiments to optimize the measurements being made. The European XFEL began operations in 2017, and SHINE is expected to begin in 2025. Both of these facilities will create a profound capability gap compared to LCLS.

In the face of this challenge to U.S. scientific leadership, extending the energy reach of x-rays beyond the upper limit of the current LCLS superconducting linac (5 keV) is a high priority. This expanded range to 12 keV will allow U.S. researchers to access x-ray wavelengths as short as one Ångstrom and probe earth-abundant elements for novel catalysts used for electricity, fuel, and chemical production. It also allows the study of strong spin-orbit coupling that underpins many aspects of quantum materials, and it reaches the biologically important selenium k-edge, used for protein crystallography.

The ability to observe and understand the structural dynamics of complex matter at the atomic scale, at ultrafast time scales, and in operational environments is critical to the nation's R&D enterprise and ability to develop the

new advanced materials for new energy technologies. To achieve this objective, DOE needs a hard x-ray source capable of producing high energy ultrafast bursts with full spatial and temporal coherence at high repetition rates. This capability cannot be provided by any existing or planned light source.

The LCLS-II project was completed successfully in October 2023 and began operation in November 2023. The LCLS-II project was the first step to address the capability gap described above. With this upgrade, LCLS is currently the premier XFEL facility in the world at photon energies ranging from 200 eV up to approximately 5 keV. The cryomodule technology is a major advancement from prior designs that will allow continuous operation up to 1 MHz.

The cryomodule design for the LCLS-II project has consistently performed beyond expectations, providing the technical basis to double the electron beam energy. The LCLS-II-HE project adds the additional acceleration capacity necessary to double the electron beam energy from 4 GeV to 8 GeV. Calculations have indicated that an 8 GeV linac will deliver a hard x-ray photon beam with peak energy of ~12.8 keV, which will meet the mission need.

The LCLS-II-HE upgrade will provide world leading experimental capabilities for the U.S. research community by extending the x-ray energy from 5 keV to 12 keV and beyond.

The project is being conducted in accordance with the project management requirements in DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets*.

Key Performance Parameters (KPPs)

The threshold KPPs approved at CD-2 represent the minimum acceptable performance that the project must achieve. The Objective KPPs represent the desired project performance. Achievement of the Threshold KPPs will be a prerequisite for approval of CD-4, Project Completion.

Performance Measure	Threshold	Objective
Superconducting linac electron beam energy	7 GeV	≥ 8 GeV
Electron bunch repetition rate	93 kHz	929 kHz
Superconducting linac charge per bunch	0.02 nC	0.1 nC
Photon beam energy range	250 to 8,000 eV	250 to 12,800 eV
High repetition rate capable, hard X-ray end stations	≥ 1	≥ 2
FEL photon quantity (10^{-3} BW)	$5x10^{8}$ @ 8 keV (10x spontaneous)	10^{10} @ 12.8 keV (20 mJ)

3. Financial Schedule

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Estimated Cost (TEC)				
Design (TEC)				
Prior Years	52,000	52,000	39,691	—
FY 2024	16,000	16,000	24,800	—
FY 2025	—	—	3,509	—

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Estimated Cost (TEC)				
Total, Design (TEC)	**68,000**	**68,000**	**68,000**	**—**
Construction (TEC)				
Prior Years	216,657	216,657	142,590	11,171
Prior Years - IRA Supp.	90,000	90,000	—	—
FY 2024	104,000	104,000	39,475	41,564
FY 2025	100,000	100,000	118,401	37,265
FY 2026	99,343	99,343	155,000	—
Outyears	6,000	6,000	70,534	—
Total, Construction (TEC)	**616,000**	**616,000**	**526,000**	**90,000**
Total Estimated Cost (TEC)				
Prior Years	268,657	268,657	182,281	11,171
Prior Years - IRA Supp.	90,000	90,000	—	—
FY 2024	120,000	120,000	64,275	41,564
FY 2025	100,000	100,000	121,910	37,265
FY 2026	99,343	99,343	155,000	—
Outyears	6,000	6,000	70,534	—
Total, Total Estimated Cost (TEC)	**684,000**	**684,000**	**594,000**	**90,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Other Project Cost (OPC)				
Prior Years	21,000	21,000	16,104	–
Prior Years - IRA Supp.	6,000	6,000	–	–
FY 2024	–	–	88	2,200
FY 2025	–	–	600	900
FY 2026	5,000	5,000	5,742	2,900
Outyears	–	–	3,466	–
Total, Other Project Cost (OPC)	**32,000**	**32,000**	**26,000**	**6,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Project Cost (TPC)				
Prior Years	289,657	289,657	198,385	11,171
Prior Years - IRA Supp.	96,000	96,000	–	–
FY 2024	120,000	120,000	64,363	43,764
FY 2025	100,000	100,000	122,510	38,165
FY 2026	104,343	104,343	160,742	2,900
Outyears	6,000	6,000	74,000	–
Total, TPC	**716,000**	**716,000**	**620,000**	**96,000**

Note:

– *In FY 2021, the Office of Science reprogrammed $19,343,211.24 of prior year funds from this project to support the LCLS-II project at SLAC. The Prior Year Budget Authority in the table above reflects this reprogramming. Also in FY 2021, a total of $10,000,000 in current year and prior year funding was reprogrammed to the LCLS-II-HE project and additional funds are included in the outyears to maintain the project profile.*

4. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design	65,000	55,500	N/A
Design - Contingency	3,000	3,500	N/A
Total, Design (TEC)	**68,000**	**59,000**	N/A
Construction	268,000	262,000	N/A
Site Preparation	2,000	2,000	N/A
Equipment	236,000	236,000	N/A
Construction - Contingency	110,000	119,000	N/A
Total, Construction (TEC)	**616,000**	**619,000**	N/A
Total, TEC	**684,000**	**678,000**	N/A
Contingency, TEC	*113,000*	*122,500*	*N/A*
Other Project Cost (OPC)			
R&D	5,000	10,000	N/A
Conceptual Planning	1,000	1,000	N/A
Conceptual Design	12,000	8,000	N/A
Start-up	8,000	7,000	N/A
OPC - Contingency	6,000	6,000	N/A
Total, Except D&D (OPC)	**32,000**	**32,000**	N/A
Total, OPC	**32,000**	**32,000**	N/A

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Contingency, OPC	*6,000*	*6,000*	*N/A*
Total, TPC	716,000	710,000	N/A
Total, Contingency (TEC+OPC)	*119,000*	*128,500*	*N/A*

5. Schedule of Appropriations Requests

(dollars in thousands)

Fiscal Year	Type	Prior Years	FY 2024	FY 2025	FY 2026	Outyears	Total
FY 2025	TEC	358,657	120,000	100,000	—	99,343	678,000
	OPC	27,000	—	—	—	5,000	32,000
	TPC	385,657	120,000	100,000	—	104,343	710,000
FY 2026	TEC	358,657	120,000	100,000	99,343	6,000	684,000
	OPC	27,000	—	—	5,000	—	32,000
	TPC	385,657	120,000	100,000	104,343	6,000	716,000

Note:

– *In FY 2021, the Office of Science reprogrammed $19,343,211.24 of prior year funds from this project to support the LCLS-II project at SLAC. The Prior Year Budget Authority in the table above reflects this reprogramming. Also in FY 2021, a total of $10,000,000 in current year and prior year funding was reprogrammed to the LCLS-II-HE project and additional funds are included in the outyears to maintain the project profile.*

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	2Q FY 2030
Expected Useful Life	25 years
Expected Future Start of D&D of this capital asset	2Q FY 2055

Related Funding Requirements
(dollars in thousands)

	Annual Costs		Life Cycle Costs	
	Previous Total Estimate	Current Total Estimate	Previous Total Estimate	Current Total Estimate
Operations, Maintenance and Repair	21,500	21,500	537,500	537,500

The numbers presented are the incremental operations and maintenance costs above the LCLS-II facility without escalation. The estimate will be updated and additional details will be provided after CD-2, Approve Project Performance Baseline.

7. D&D Information

At this stage of project planning and development, SC anticipates no new area will be constructed for this project.

8. Acquisition Approach

Based on the DOE determination at CD-1, SLAC is acquiring the LCLS-II-HE project under the existing DOE M&O contract.

SLAC has completed the requirements for baselining the project and LCLS-II-HE has received CD-2/3 approval. The necessary project management systems are fully operating and are maintained as a SLAC-wide resource.

SLAC is partnering with other laboratories for design and procurement of key technical subsystem components. Technical system designs require research and development activities. Preliminary cost estimates for these systems are based on actual costs from the LCLS-II project and other similar facilities, to the extent practicable. The M&O contractor is fully exploiting recent cost data in planning and budgeting for the project. SLAC or partner laboratory staff will complete the design of the technical systems. SLAC or subcontracted vendors with the necessary capabilities will fabricate the technical equipment. All subcontracts will be competitively bid and awarded based on best value to the government. SC will evaluate the M&O contractor's performance through the annual laboratory performance appraisal process.

SC and the M&O will draw from lessons learned from the LCLS-II project and other similar facilities in planning and executing the LCLS-II-HE project.

18-SC-12, Advanced Light Source Upgrade (ALS-U), LBNL
Lawrence Berkeley National Laboratory, LBNL
Project is for Design and Construction

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

Summary

The FY 2026 Request for the ALS-U project is $50,000,000 of Total Estimated Cost (TEC) funding. The project has a Total Project Cost (TPC) of $590,000,000. Since the TPC was established at CD-2, Approve Performance Baseline, on April 2, 2021, the project has experienced significant cost and schedule escalation because of factors both external and internal to the project. As a result, the Department is preparing for a rebaseline of the project, which is currently planned for 1Q FY 2026.

Significant Changes

The ALS-U was initiated in FY 2018. The most recent DOE Order 413.3B approved Critical Decision (CD) is CD-3, Approve Start of Construction, approved on November 10, 2022. This Construction Project Data Sheet (CPDS) is an update of the FY 2024 CPDS and does not include a new start for FY 2026.

An independent project review (IPR) carried out by the DOE Office of Project Assessment in November 2023 identified significant challenges impacting project performance. Following an internal laboratory assessment and subsequent external Director's review, the lab concluded that the project was on a trajectory to exceed its current baseline. The analysis identified multiple issues which have been validated by a root cause analysis. The project is currently working on a detailed bottom-up cost and schedule analysis that will inform with confidence the expected revised baseline in 1Q FY 2026.

FY 2024 and FY 2025 funding support advancing the remaining procurements for the Accumulator Ring and the Storage Ring. The FY 2026 Request will advance installation of the cable plant and Accumulator Ring in the tunnel and advances the beamline front end engineering and system engineering. The first raft and sector mockup will advance as necessary precursors for pre-staging and assembly of the Storage Ring rafts and components as the vacuum systems, magnets, and diagnostics instruments are received, in preparation for the dark time Storage Ring installation. The FY 2026 Request will allow the lab to continue progressing toward project completion.

A FPD certified to Level II has been assigned to this project, with Level III certification in progress.

Critical Milestone History

Fiscal Year	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	CD-4	Re-baseline
FY 2026	9/27/16	4/30/18	9/21/18	4/2/21*	11/10/22	11/10/22	4Q FY 2029	1Q 2026

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.

Fiscal Year	Performance Baseline Validation	CD-3A
FY 2026	4/2/21	12/19/19

CD-3A – Approve Long-Lead Procurements includes Accumulator Ring equipment on the critical path necessary for installation.

*Note: The ALS-U project is currently working towards a rebaseline in FY 2026 that will establish a new cost and schedule estimate. The current cost and schedule estimates shown are those established at CD-2.

Project Cost History

(dollars in thousands)

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Except D&D	OPC, Total	TPC
FY 2026	134,340	427,660	562,000	28,000	28,000	590,000

Note:

- *The ALS-U project is currently working towards a rebaseline in FY 2026 that will establish a new cost and schedule estimate. The current cost and schedule estimates shown are those established at CD-2.*

2. Project Scope and Justification

Scope

The ALS-U project will upgrade the existing ALS facility by replacing the existing electron storage ring with a new electron storage ring based on a multi-bend achromat (MBA) lattice design to provide a soft x-ray source that is orders of magnitude brighter—a 10-1000 times increase in brightness over the current ALS—and to provide a significantly higher fraction of coherent light in the soft x-ray region (approximately 50-2,000 electronvolts [eV]) than is currently available at ALS. The project will replace the existing triple-bend achromat storage ring with a new, high-performance storage ring based on a nine-bend achromat design. In addition, the project will add a low-emittance, full-energy accumulator ring to the existing tunnel inner shield wall to enable on- and off-axis, swap-out injection and extraction into and from the new storage ring using fast kicker magnets. The new source will require upgrading x-ray optics on existing beamlines with some beamlines being realigned or relocated. The project adds two new undulator beamlines that are optimized for the novel science made possible by the beam's new high coherent flux. The project intends to reuse the existing building, utilities, electron gun, linac, and booster synchrotron equipment currently at ALS. Prior to CD-2, the scope was increased to include radiation shielding and safety-mandated seismic structural upgrades to the ALS facility. With an aggressive accelerator design, ALS-U will provide the highest coherent flux of any existing or planned storage ring facility worldwide, up to a photon energy of about 3.5 keV. This range covers the entire soft x-ray regime.

Justification

At this time, our ability to observe and understand materials and material phenomena in real-time and as they emerge and evolve is limited. Soft x-rays (approximately 50 to 2,000 eV) are ideally suited for revealing the chemical, electronic, and magnetic properties of materials, as well as the chemical reactions that underpin these properties. This knowledge is crucial for the design and control of new advanced materials that address the challenges of new energy technologies.

Existing storage ring light sources lack a key attribute that would revolutionize x-ray science: stable, nearly continuous soft x-rays with high brightness and high coherent flux—that is, smooth, well organized soft x-ray wave fronts. Such a stable, high brightness, high coherent flux source would enable 3D imaging with nanometer

resolution and the measurement of spontaneous nanoscale motion with nanosecond resolution—all with electronic structure sensitivity.

Currently, BES operates advanced ring-based light sources that produce soft x-rays. The NSLS-II, commissioned in 2015, is the brightest soft x-ray source in the U.S. The ALS, completed in 1993, is competitive with NSLS-II for x-rays below 200 eV but not above that. NSLS-II is somewhat lower in brightness than the new Swedish light source, MAX-IV, which began user operations in 2017 and represents the first use of a MBA lattice design in a light source facility. Neither NSLS-II nor ALS make use of the newer MBA lattice design. Switzerland's SLS-2 (an MBA-based design in the planning stage) will be a brighter soft x-ray light source than both NSLS-II and MAX-IV when it is built and brought into operation. These international light sources, and those that follow, will present a significant challenge to the U.S. light source community to provide competitive x-ray sources to domestic users. Neither NSLS-II nor ALS soft x-ray light sources possess sufficient brightness or coherent flux to provide the capability to meet the mission need in their current configurations.

BES is currently supporting two major light source upgrade projects, the APS-U and LCLS-II. These two projects will upgrade existing x-ray facilities in the U.S. and will provide significant increases in brightness and coherent flux. These upgrades will not address the specific research needs that demand stable, nearly continuous soft x-rays with high brightness and high coherence.

APS-U, which is under construction at ANL, will deploy the MBA lattice design optimized for its higher 6 GeV electron energy and to produce higher energy (hard) x-rays in the range of 10-100 keV. Because the ring will be optimized for high energy, the soft x-ray light it produces will not be sufficiently bright to meet the research needs described above.

LCLS-II, which is under construction at SLAC, is a high repetition rate (up to 1 MHz) free electron laser (FEL) designed to produce high brightness, coherent x-rays, but in extremely short bursts rather than as a nearly continuous beam. Storage rings offer higher stability than FELs. In addition, there is a need for a facility that can support a larger number of concurrent experiments than is possible with LCLS-II in its current configuration. This is critical for serving the large and expanding soft x-ray research community. LCLS-II will not meet this mission need.

The existing ALS is a 1.9 GeV storage ring operating at 500 milliamps (mA) of beam current. It is optimized to produce intense beams of soft x-rays, which offer spectroscopic contrast, nanometer-scale resolution, and broad temporal sensitivity. The ALS facility includes an accelerator complex and photon delivery system that can provide the foundations for an upgrade that will achieve world-leading soft x-ray coherent flux. The existing ALS provides a ready-made foundation, including conventional facilities, a $500,000,000 scientific infrastructure investment and a vibrant user community of over 2,500 users per year already attuned to the potential scientific opportunities an upgrade offers. The facility also includes extensive (up to 40) simultaneously operating beamlines and instrumentation, an experimental hall, computing resources, ancillary laboratories, offices, and related infrastructure that will be heavily utilized in an upgrade scenario. Furthermore, the upgrade leverages the ALS staff, who are experts in the scientific and technical aspects of the proposed upgrade.

In summary, the capabilities at our existing x-ray light source facilities are insufficient to develop the next generation of tools that combine high resolution spatial imaging together with precise energy resolving spectroscopic techniques in the soft x-ray range. To enable these cutting-edge experimental techniques, ALS-U is designed and being constructed to be a world-leading facility in soft x-ray science by delivering ultra-bright source of light in soft x-ray regime with high coherent x-ray flux required to resolve nanometer-scale features and interactions, and to allow the real-time observation and understanding of materials and phenomena as they emerge and evolve. Developing such a light source will ensure the U.S. has the tools to maintain its leadership in soft x-ray science and will significantly accelerate the advancement of the fundamental sciences that underlie a broad range of emerging and future energy applications.

The project is being conducted in accordance with the project management requirements in DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets.*

Key Performance Parameters (KPPs)

The Threshold KPPs approved at CD-2 represent the minimum acceptable performance that the project must achieve. The Objective KPPs represent the desired project performance. Achievement of the Threshold KPPs will be a prerequisite for approval of CD-4, Project Completion.

Performance Measure	Threshold	Objective
Storage Ring Energy	≥ 1.9 GeV	2.0 GeV
Beam Current	> 25 mA	500 mA
Horizontal Emittance	< 150 pm-rad	< 85 pm-rad
Brightness @ 1 keV[a]	> 2 x 10^{19}	≥ 2 x 10^{21}
New MBA Beamlines	2	≥ 2

[a] Units = photons/sec/0.1% BW/mm2/mrad2

3. Financial Schedule

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Estimated Cost (TEC)				
Design (TEC)				
Prior Years	134,340	134,340	128,340	–
FY 2024			2,132	–
FY 2025	–	–	3,365	–
FY 2026	–	–	503	–
Outyears	–	–	–	–
Total, Design (TEC)	**134,340**	**134,340**	**134,340**	**–**
Construction (TEC)				
Prior Years	363,360	363,360	56,215	48,314
Prior Years - IRA Supp.	96,600	96,600	–	4
FY 2024	57,300	57,300	108,121	22,580
FY 2025	57,000		183	1,566
FY 2026	50,000	107,000	TBD	
Outyears	TBD	TBD	TBD	24,136
Total, Construction (TEC)	**TBD**	**TBD**	**TBD**	**TBD**
Total Estimated Cost (TEC)				
Prior Years	497,700	497,700	184,555	48,314
Prior Years - IRA Supp.	96,600	96,600	–	4
FY 2024	57,300	57,300	108,121	22,580
FY 2025	57,000		60,548	1,566

FY 2026	50,000	107,000	TBD	
Outyears	TBD	TBD	TBD	24,136
Total, TEC	**TBD**	**TBD**	**TBD**	**TBD**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Other Project Cost (OPC)				
Prior Years	28,000	28,000	23,560	–
Outyears	–	–	4,440	–
Total, OPC	**28,000**	**28,000**	**28,000**	**–**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Project Cost (TPC)				
Prior Years	525,700	525,700	208,115	48,314
Prior Years - IRA Supp.	96,600	96,600	–	4
FY 2024	57,300	57,300	108,121	22,580
FY 2025	57,000		60,548	1,566
FY 2026	50,000	107,000	TBD	
Outyears	TBD	TBD	TBD	24,136
Total, TPC	**TBD**	**TBD**	**TBD**	**TBD**

Note:

- *The ALS-U project is currently working towards a rebaseline in FY 2026 that will establish a new cost and schedule estimate. The current cost and schedule estimates shown are those established at CD-2.*

4. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design	117,778	101,098	92,967
Design - Contingency	16,562	33,242	38,778
Total, Design (TEC)	**134,340**	**134,340**	**131,745**
Construction	159,338	150,093	142,165
Equipment	172,938	171,743	161,449
Construction - Contingency	95,384	105,824	126,641

Total, Construction (TEC)	**427,660**	**427,660**	**430,255**
Total, TEC	**562,000**	**562,000**	**562,000**
Contingency, TEC	*111,946*	*139,066*	*165,419*
Other Project Cost (OPC)			
R&D	N/A	4,971	8,241
Conceptual Planning	10,261	2,000	2,000
Conceptual Design	14,100	12,100	12,100
Start-up	1,000	2,000	2,000
OPC - Contingency	2,639	6,929	3,659
Total, Except D&D (OPC)	**28,000**	**28,000**	**28,000**
Total, OPC	**28,000**	**28,000**	**28,000**
Contingency, OPC	*2,639*	*6,929*	*3,659*
Total, TPC	**TBD**	**TBD**	**TBD**
Total, Contingency (TEC+OPC)	***114,585***	***145,995***	***169,078***

Note:

- *The ALS-U project is currently working towards a rebaseline in FY 2026 that will establish a new cost and schedule estimate. The current cost and schedule estimates shown are those established at CD-2.*

5. Schedule of Appropriations Requests

(dollars in thousands)

Fiscal Year	Type	Prior Years	Prior Years IRA Supp.	FY 2024	FY 2025	FY 2026	Outyears	Total
FY 2025	TEC	497,700	96,600	57,300	57,000	—	TBD	TBD
	OPC	28,000	—	—	—	—	—	28,000
	TPC	525,700	96,600	57,300	57,000	—	TBD	TBD
FY 2026	TEC	497,700	96,600	57,300	57,000	50,000	TBD	TBD
	OPC	28,000	—	—	—	—	—	28,000
	TPC	525,700	96,600	57,300	57,000	50,000	TBD	TBD

Note:

- *The ALS-U project is currently working towards a rebaseline in FY 2026 that will establish a new cost and schedule estimate. The current cost and schedule estimates shown are those established at CD-2.*

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	4Q FY 2029
Expected Useful Life	25 years
Expected Future Start of D&D of this capital asset	4Q FY 2054

Related Funding Requirements
(dollars in thousands)

	Annual Costs		Life Cycle Costs	
	Previous Total Estimate	Current Total Estimate	Previous Total Estimate	Current Total Estimate
Operations, Maintenance and Repair	71,500	71,500	2,597,500	2,597,500

7. D&D Information

At this stage of project planning and development, SC anticipates that there will be no new area being constructed in the construction project.

8. Acquisition Approach

Based on the DOE determination at CD-1, LBNL is acquiring the ALS-U project under the existing DOE Management and Operations (M&O) contract.

The ALS-U project identified key design activities, requirements, and high-risk subsystem components to reduce cost and schedule risk to the project and expedite the startup. The necessary project management systems are fully up-to-date, operating, and are maintained as a LBNL-wide resource.

LBNL has partnered with BNL for design and procurement of all required power supplies. Technical system designs required research and development and prototyping activities that are now near completion. Cost estimates for the remaining work have been updated by acquiring recent vendor quotes as part of CD-3 approval. All subcontracts are being competitively bid and awarded based on best value to the government. The M&O contractor's performance is being evaluated through the annual laboratory performance appraisal process.

Lessons learned from other SC projects and other similar facilities are being exploited fully in planning and executing ALS-U.