

SCIENCE

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	FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted	
				\$	%
Office of Science					
Advanced Scientific Computing Research	1,015,000	1,015,000	1,068,741	+53,741	+5.29%
Basic Energy Sciences	2,245,000	2,245,000	2,420,439	+175,439	+7.81%
Biological and Environmental Research	753,000	753,000	903,685	+150,685	+20.01%
Fusion Energy Sciences	672,000	672,000	723,222	+51,222	+7.62%
High Energy Physics	1,046,000	1,029,065	1,122,020	+76,020	+7.27%
Nuclear Physics	713,000	629,000	739,196	+26,196	+3.67%
Isotope R&D and Production	–	84,000	97,451	+97,451	–
Accelerator R&D and Production	–	16,935	27,436	+27,436	–
Workforce Development for Teachers and Scientists	29,000	29,000	41,300	+12,300	+42.41%
Science Laboratories Infrastructure	240,000	240,000	255,000	+15,000	+6.25%
Safeguards and Security	121,000	121,000	189,510	+68,510	+56.62%
Program Direction	192,000	192,000	211,211	+19,211	+10.01%
Total, Office of Science	7,026,000	7,026,000	7,799,211	+773,211	+11.00%

Appropriation Overview

The Office of Science (SC) is the nation’s largest Federal supporter of basic research in the physical sciences and funds programs in physics, chemistry, materials science, biology, environmental science, applied mathematics, isotope research and production, accelerator research and production, and computer and computational science. The SC portfolio has two principal thrusts: direct support of scientific research and direct support of the design, development, construction, and operation of unique, open-access scientific user facilities. The SC basic research portfolio includes extramural grants and contracts supporting nearly 29,000 researchers located at over 300 institutions and the 17 DOE national laboratories, spanning all fifty states and the District of Columbia. The portfolio of 28 scientific user facilities serves nearly 34,000 users per year. SC programs invest in foundational science, including basic research for the advancement of clean energy, to transform our understanding of nature and strengthen the connection between advances in fundamental science and technology innovation.

The SC Request increases investments in Administration priorities including basic research on climate change and clean energy, artificial intelligence (AI) and machine learning (ML), and biopreparedness. SC’s Reaching a New Energy Sciences Workforce (RENEW) initiative doubles to expand targeted efforts to increase participation and retention of underrepresented groups in SC research activities. Expanded support of the RENEW initiative aims to ensure a future science workforce that is creative, innovative, and capable of meeting the nation’s needs via proactive stewardship of talent with diverse ideas and backgrounds. Also, the Request will continue support for the quantum information science (QIS) Research Centers for basic research and early-stage development in order to accelerate the advancement of QIS through vertical integration between systems, theory, hardware, and software. Additional quantum-related R&D support will focus on early-stage research associated with the first steps to establish a dedicated Quantum Network as well as research in quantum algorithms, applications, and testbeds. In FY 2023, SC initiates three new research initiatives to include Energy Earthshots; Funding for Accelerated, Inclusive Research (FAIR); and Accelerate Innovations in Emerging Technologies (Accelerate). The Request also supports ongoing investments in priority areas including microelectronics, critical materials, exascale computing, fundamental science to transform manufacturing, and accelerator science and technology. These initiatives position SC to address new research opportunities through more collaborative, cross-program efforts.

The Energy Earthshots initiative will support small group awards and larger center awards through the Energy Earthshot Research Centers (EERCs). The new EERCs will support underlying fundamental research to realize the stretch goals of the Energy Earthshots. EERCs will bring together multi-investigator, multi-disciplinary teams to address key research challenges

at the interface between basic research and applied research and development activities. EERCs will entail collaboration within the team awards involving academic, national laboratory, and industrial researchers by SC and Energy Technology Offices, establishing a new era of cross-office research cooperation.

The FAIR initiative will support a directed effort to fund clean energy, climate, and related activities at minority serving institutions (MSIs), including historically black colleges and universities (HBCUs). The goal of FAIR is to increase research capacity and support faculty at HBCUs and other MSIs by funding core research relevant to the SC mission at these institutions.

The Accelerate initiative aims to drive scientific discovery for sustainable production of new technologies across the innovation continuum, to train a STEM workforce to support industries of the future, and to meet the nation's needs for abundant clean energy, a sustainable environment, and national security. The initiative will accelerate the discovery, creation, production, and commercialization of new technologies to form the basis of future industries with public and economic impact.

Program Highlights

▪ Advanced Scientific Computing Research

Advanced Scientific Computing Research (ASCR) advances science and U.S. competitiveness through investments in computational research, applied mathematics, and computer science, as well as development and operation of multiple, large, high performance and leadership computing user facilities and high performance networking. The efforts prioritize basic research in applied mathematics and computer science with emphasis on the challenges of data intensive science, including AI and ML, and future computing technologies. The Request funds:

- Increased support for ASCR's Computational Partnerships with a focus on developing partnerships with the Applied Energy offices and data intensive applications, and new partnerships that broaden the impact of both exascale and data infrastructure investments.
- Final research and development activities within the Exascale Computing Project (ECP) and full scale runs to deliver project performance targets on the Nation's second exascale system, Aurora, which is projected to achieve exascale-capable systems with a five-fold improvement in true application performance over the Summit system at the Oak Ridge Leadership Computing Facility (OLCF). During FY 2023, Aurora will primarily support ECP and early science applications, as well as debugging and system stabilization efforts. Frontier, the OLCF's exascale system will begin operations and support projects selected through the Innovative and Novel Computational Impact on Theory & Experiment (INCITE) and ASCR Leadership Computing Challenge programs.
- Foundational research to improve the robustness, reliability, and transparency of Big Data and AI technologies, uncertainty quantification, and development of software and data visualization tools and continuation of an activity to deploy AI software and technologies to create an integrated computational and data infrastructure across the SC programs, scientific user facilities, and laboratories.
- Core research in applied mathematics and computer science, the Scientific Discovery through Advanced Computing (SciDAC) program, and strategic partnerships aimed at understanding the challenges that emerging technologies such as artificial Intelligence, quantum information science, and neuromorphic processors pose to DOE mission applications.
- Support for partnerships with Basic Energy Sciences, Fusion Energy Sciences, High Energy Physics, and Nuclear Physics in microelectronics, and new data and partnerships with the National Institutes of Health (NIH), as well as engagements with other agencies to improve our ability to assist in times of national emergencies.
- New activities including the FAIR initiative to expand clean energy research and capabilities at MSIs and Accelerate initiative to support fundamental research that accelerates transition from discovery science to technological innovations. Activities are also initiated to support the Department's Earthshot initiatives, which includes the establishment of Energy Earthshot Research Centers.
- Continue operations at ASCR's four scientific user facilities and continued efforts on the design of the National Energy Research Scientific Computing Center (NERSC-10) upgrade.

▪ **Basic Energy Sciences**

Basic Energy Sciences (BES) supports fundamental research to understand, predict, and ultimately control matter and energy at the electronic, atomic, and molecular levels in order to provide the foundations for new energy technologies, to mitigate the environmental impacts of energy use, and to support DOE missions in energy, environment, and national security. The Request funds:

- Core research activities to support Administration Priorities on clean energy (carbon capture, hydrogen, solar, and batteries); related topics such as critical materials/minerals and manufacturing including next-generation microelectronics; and cross-cutting priorities for biopreparedness, QIS, data science including AI/ML and related infrastructure, exascale computing, and accelerator science and technology.
- Support for universities in underrepresented regions through the DOE Established Program to Stimulate Competitive Research (EPSCoR) program, and expanded support for students at MSIs as part of the RENEW initiative.
- New activities include the FAIR initiative to expand clean energy research and capabilities at MSIs, the Accelerate initiative to support fundamental research that accelerates the transition of science to technologies, and the SC Energy Earthshot initiative in partnership with other SC programs and the DOE technology offices. New Energy Earthshot Research Centers aim to realize the stretch goals of the Energy Earthshots.
- Continued support for the Energy Frontier Research Centers, the Batteries and Energy Storage and the Fuels from Sunlight Energy Innovation Hub programs, and the computational materials and chemical sciences programs.
- Continued operation of BES scientific user facilities at 90 percent of optimal run time: five x-ray light sources, two neutron scattering sources, and five research centers for nanoscale science. Continued support for the Biopreparedness Research Virtual Environment (BRaVE) initiative to provide the tools and expertise for response to future pandemics and other national emergencies.
- Six ongoing construction projects: the Advanced Photon Source Upgrade (APS-U), the Advanced Light Source Upgrade (ALS-U), the Linac Coherent Light Source-II High Energy (LCLS-II-HE), the Proton Power Upgrade (PPU), the Second Target Station (STS), and the Cryomodule Repair and Maintenance Facility (CRMF).
- Continued support for two Major Item of Equipment (MIE) projects: the NSLS-II Experimental Tools-II (NEXT-II) for phased build-out of beamlines at NSLS-II, and the Nanoscale Science Research Centers Recapitalization project.
- Other Project Costs (OPC) to begin the planning for the NSLS-II Experimental Tools-III (NEXT-III) and the High Flux Isotope Reactor Pressure Vessel Replacement (HFIR-PVR) projects.

▪ **Biological and Environmental Research**

Biological and Environmental Research (BER) supports fundamental research to understand complex biological, biogeochemical, and physical principles of natural systems at scales extending from the genome of microbes and plants to the environmental and ecological processes at the scale of the planet Earth. BER's support of basic research will contribute to a future of stable, reliable, and resilient energy sources and infrastructure, that will lead to climate solutions, strengthen economic prosperity and assure environmental justice. The Request funds:

- Core research in biological systems science using approaches such as genome sequencing, secure biodesign, proteomics, metabolomics, structural biology, high-resolution imaging and characterization, including full support of the Bioenergy Research Centers. Integration of this experimental biological information into computational models for iterative testing and validation to advance a predictive understanding of biological systems for use in secure, clean, affordable, and reliable energy for adaptation to industry, as well as contributing to QIS.
- New activities including the Accelerate initiative for emerging technologies to develop sensor capabilities that scale from laboratory fabricated ecosystems to field ecosystems, research efforts on AI approaches to decrease uncertainty of climate and Earth system predictions, and FAIR initiative to expand clean energy research and capabilities at MSIs.
- Contributions to the Energy Earthshots initiative through foundational research on plant/microbiome/soil interfaces to inform enhanced soil carbon sequestration, as well as basic research on algal systems biology for removal of gaseous CO₂ from waste streams.
- Expansion of the new Urban Integrated Field Laboratories that combine modeling and observations of emerging energy technologies in urban regions, enabling the evaluation of the societal and environmental impacts of current and future energy policies.

- Full implementation of the National Virtual Climate Laboratory (NVCL) serving as a one stop portal to advance access to climate science from the DOE National Laboratories. The NVCL engagement with the science community will focus on MSIs, including HBCUs, for local to regional climate science.
 - Continued planning for a network of climate centers, affiliated with an HBCU or MSI, facilitating translation of BER investments in foundational climate research into actionable solutions for impacted communities and addressing the Administration priorities involving climate solutions and environmental justice.
 - Expanded efforts for BRaVE, a distributed framework to rapidly activate, integrate, and coordinate the expertise and research capabilities (experimental and computational) across the whole DOE National Laboratory Complex to address urgent research needs in an emerging national or international crisis.
 - Core research in earth and environmental systems science, with activities focused on scientific analysis and modeling of the sensitivity and uncertainty of Earth system predictions to atmospheric, cryospheric, oceanic, and biogeochemical processes, with continued support of the Energy Exascale Earth System Model and in support of emerging Earthshot topics.
 - Continuing operation and equipment refresh of the three BER scientific user facilities: the Joint Genome Institute, the Atmospheric Radiation Measurement (ARM) Research Facility, and the Environmental Molecular Sciences Laboratory. Initiate operations of the ARM aerial capability.
- **Fusion Energy Sciences**
- Fusion Energy Sciences (FES) supports research to understand matter at very high temperatures and densities and to build the scientific foundation needed to develop a fusion energy source. The Request is aligned with the recommendations of the recent Long-Range Plan (LRP) developed by the Fusion Energy Sciences Advisory Committee and funds:
- Research and facility operations at the DIII-D national fusion facility at 90% of the optimal run time to optimize the tokamak approach to magnetic confinement fusion.
 - The National Spherical Torus Experiment-Upgrade (NSTX-U) recovery to implement repairs and corrective actions required to obtain robust, reliable research operations at the facility as well as enhanced collaborative research at other facilities to support NSTX-U research program priorities.
 - Research opportunities for U.S. scientists at overseas superconducting tokamaks and stellarators and other international facilities with unique capabilities, enabled by U.S. hardware and intellectual contributions.
 - Continuing support for a core research portfolio to advance developments in fusion-relevant QIS and related technology.
 - Two new research activities: FAIR expands clean energy research and capabilities at MSIs and Accelerate supports fundamental research that accelerates transition from discovery science to technological innovations.
 - Following the community recommendations in the LRP, research activities in Materials, Fusion Nuclear Science, and Fusion Facilities Studies, which is focused on the design of a Fusion Pilot Plant, are enhanced.
 - Support for SciDAC in partnership with the ASCR program, research in High-Energy-Density Laboratory Plasma science including LaserNetUS, and General Plasma Science including low-temperature plasmas and microelectronics.
 - Partnerships with the private sector through the Innovation Network for Fusion Energy (INFUSE) program and initiation of a new milestone-based cost-share program.
 - The U.S. Contributions to ITER project, focusing on the highest-priority First Plasma hardware components, including the continued fabrication of the central solenoid superconducting magnet modules. Along with providing SC's share of the hardware contribution as part of Subproject 1, FES is also providing a cash contribution which supports the ITER Organization in the installation and assembling of the device.
 - An ITER Research program to continue preparations for the U.S. fusion community to take full advantage of ITER Operations after First Plasma.
 - Support for the Matter in Extreme Conditions Petawatt upgrade project at the Linac Coherent Light Source.
 - Support for the Materials-Plasma Exposure eXperiment project, which will be a world-leading facility for dedicated studies of reactor-relevant heat and particle loads on fusion materials, as it moves towards completion.
 - Initiation of research activities in inertial fusion energy.

▪ **High Energy Physics**

High Energy Physics (HEP) supports research to understand how the universe works at its most fundamental level, enabling the discovery of the most elementary constituents of matter and energy, the probing of the interactions among them, and the exploration of the basic nature of space and time. The Request provides support to foster a diverse, highly skilled, American workforce, to build R&D capacity, to spur technology innovation, and to conduct world-leading R&D. The Request funds:

- Core research activities, with emphasis on the physics of the Higgs boson, neutrinos, dark matter, and dark energy; exploring the unknown; and enabling early and visible scientific results from HEP project investments.
- QIS co-development of quantum information, theory, and technology with core research activities, and pursuit of new capabilities in sensing, simulation, and computing.
- Two new research activities: FAIR to expand high energy physics research and capabilities at MSIs and Accelerate to support fundamental research that accelerates transition from discovery science to technological innovations.
- AI/ML to tackle the challenges of managing increasingly high volumes and complexity of HEP data.
- Advanced computing to ensure broad access to exascale computing resources to HEP researchers via the internet and remote virtual platforms.
- Multi-disciplinary microelectronics research, including sensor materials, devices, and advances in front-end electronics.
- In coordination with the Accelerator R&D and Production program, mid- to long-term accelerator science and technology to maintain a world-leading position in key accelerator technologies, including high-field magnets, superconducting radiofrequency cavities, and high-power lasers; and new focus areas of scientific research to accelerate innovations in emerging technologies.
- The Fermilab Accelerator Complex and the Facility for Advanced Accelerator Experimental Tests II (FACET-II) continue operations at 87 and 91 percent of optimal, respectively.
- Continuing support for the Fermi National Accelerator Laboratory (FNAL)-hosted line-item construction projects: Long Baseline Neutrino Facility/Deep Underground Neutrino Experiment (LBNF/DUNE), Proton Improvement Plan II (PIP-II), and Muon to Electron Conversion Experiment (Mu2e); and five Major Item of Equipment (MIE) projects: Accelerator Controls Operations Research Network (ACORN), Cosmic Microwave Background Stage 4 (CMB-S4), High Luminosity Large Hadron Collider (HL-LHC) Accelerator Upgrade Project, and the HL-LHC ATLAS and CMS Detector Upgrade Projects.

▪ **Nuclear Physics**

Nuclear Physics (NP) supports research to discover, explore, and understand all forms of nuclear matter. The Request funds:

- High priority world-class nuclear physics research and core competencies in quantum chromodynamics, nuclei and nuclear structure and astrophysics, and fundamental symmetries at universities and laboratories.
- Operations of all NP user facilities at 90% optimal including: the Relativistic Heavy Ion Collider; the 12 GeV Continuous Electron Beam Accelerator Facility (CEBAF); the Argonne Tandem Linac Accelerator System; and the first full year of operations at the newly constructed Facility for Rare Isotope Beams (FRIB).
- Support for QIS research efforts to enable precision NP measurements, development of quantum sensors based on atomic-nuclear interactions, and development of quantum computing algorithms, in support of the National Quantum Initiative.
- Expanded support of the RENEW initiative to ensure future nuclear physics workforce that is creative, innovative, and capable of meeting the nation's needs via proactive stewardship of talent with diverse ideas and backgrounds.
- Initiatives in microelectronics and AI/ML to achieve groundbreaking advances in these fields related to Nuclear Physics.
- Two new initiatives: FAIR to expand nuclear physics research and capabilities at MSIs, and Accelerate to research how imaging advances within nuclear physics can apply to other fields.
- Continued support for R&D and design activities for the Electron Ion Collider, which will be America's only collider for scientific research and will play a critical role in maintaining U.S. leadership in nuclear science and accelerator R&D.
- Continued support for fabrication of new NP scientific equipment: the Gamma-Ray Energy Tracking Array MIE, which will enable the provisioning of advanced, high resolution gamma ray detection capabilities for FRIB; the High Resolution Spectrometer (HRS) to study fast neutron beams at FRIB; the Ton-scale Neutrinoless Double Beta Decay

MIE to determine whether the neutrino is its own antiparticle; and the Measurement of a Lepton-Lepton Electroweak Reaction (MOLLER), which will measure the parity-violating asymmetry in electron-electron scattering with the 12 GeV CEBAF machine.

▪ **Isotope R&D and Production**

Isotope R&D and Production ensures robust supply chains of critical radioactive and stable isotopes for the Nation that no domestic entity has the infrastructure or core competency to produce. Isotopes underpin emerging technology, innovation, and a suite of research and applications that are fundamental to the Nation's prosperity, and scientific and technical leadership. The DOE Isotope Program (DOE IP) reduces the Nation's dependence on foreign supplies of key isotopes. The Request funds:

- Research activities to support Administration and national priorities on advanced manufacturing (innovative targetry, robotics, automation, and enrichment technologies); clean energy (isotopes for environmental research, low activation materials for reactors, and enriched isotopes for more economical reactor operations); transformative technology for producing pure isotopes for QIS; the use of AI/ML for effective operations of transformative approaches to isotope production; the promotion of National Preparedness by mitigating single point failures in domestic supply chains (radioisotope processing); the strengthening of synergies between the DOE IP and the NIH with the targeted support of translational research for development and production of necessary isotopes to advance clinical trials for cancer and infectious disease; and support for investments at specific institutions in disadvantaged areas in order to promote environmental justice through place-based science and the provision of technical jobs and capabilities associated with isotope research and production.
- High impact R&D activities at universities and national laboratories to develop innovative, cutting-edge isotope production and processing technologies for novel isotopes, and research to advance isotope harvesting capabilities and expertise at FRIB, and advanced processing capabilities at the University of Missouri Research Reactor (MURR).
- The Isotope Traineeship Program, as part of RENEW, to train the next generation of researchers in innovative isotope production and processing technology.
- Mission readiness of the growing portfolio of stable and radio-isotope production and processing sites at national laboratories and universities. Capabilities include accelerators, reactors, gas centrifuge, electromagnetic ion separation, and extraction of isotopes from waste streams and legacy materials. Collections from stakeholders support the actual production costs of the isotope.
- Support for National Isotope Development Center activities to interface with the fast-growing stakeholder community and rapidly expanding isotope portfolio.
- Continuing design and long-lead activities for the Stable Isotope Production and Research Center to mitigate U.S. dependence on foreign sources of enriched stable isotopes for research and applications. Commissioning and fabrication activities for the Stable Isotope Production Facility MIE.
- Continuing research and design for the proposed next generation Radioisotope Processing Facility (RPF) at ORNL to make available novel isotopes and mitigate single point failures in domestic supply chains.

▪ **Accelerator R&D and Production**

Accelerator R&D and Production (ARDAP) supports cross-cutting basic R&D in accelerator science and technology, access to unique SC accelerator R&D infrastructure, workforce development, and public-private partnerships to advance new technologies for use in SC's scientific facilities and in commercial products. The Request funds:

- Innovative R&D and deployment of accelerator technology, formation of topically-focused multi-institutional collaborations for accelerator R&D, and workforce development.
- Operation of the Brookhaven National Laboratory Accelerator Test Facility (ATF) at 94 percent of optimal.
- Accelerator market sector analysis and R&D partnerships to develop advanced superconducting wire and cable, superconducting accelerators, and advanced radiofrequency power sources for accelerators.
- The FAIR initiative to expand research and capabilities in accelerator R&D and production at MSIs.

▪ **Workforce Development for Teachers and Scientists**

Workforce Development for Teachers and Scientists (WDTs) ensures that DOE has a sustained pipeline of science, technology, engineering, and mathematics (STEM) workforce. Accomplishing this goal depends on continued support for hands-on research and workforce training opportunities via undergraduate internships, graduate thesis research, and visiting faculty research appointments at DOE national laboratories and strengthening the connection to a STEM

identity. As part of the RENEW initiative, WDTS expands outreach and training opportunities to students and faculty from MSIs and individuals from underrepresented, underserved groups.

▪ **Science Laboratories Infrastructure**

Science Laboratories Infrastructure (SLI) sustains mission-ready infrastructure and safe and environmentally responsible operations by providing the infrastructure necessary to support leading edge research at the ten SC DOE national laboratories. The SLI Program is focused on both replacing the over 50 year old basic infrastructure at the SC national laboratories in support of the Science Mission, and assuring that new infrastructure provides for the critical needs of future science initiatives and world class user facilities. A principal element of the SLI Program is to provide for a renewal of utilities at all SC national laboratories to address the extraordinary challenges to SC laboratory operations, particularly as they relate to climate resilience. The SLI utility projects address climate resilience in three important ways: (1) improvements in operational efficiency that will significantly reduce the energy usage of the laboratory operations; (2) reduction of the release of greenhouse gases; and (3) direct investments needed to support the success of the science initiatives that will help the country address the challenges of climate change. The Request funds:

- Eleven ongoing construction projects: the Critical Utilities Rehabilitation Project at Brookhaven National Laboratory (BNL); the Seismic and Safety Modernization project, the Linear Assets Modernization Project, and the Biological and Environmental Program Integration Center (BioEPIC) at Lawrence Berkeley National Laboratory (LBNL); the CEBAF Renovation and Expansion at TJNAF; the Critical Utilities Infrastructure Revitalization project and Large Scale Collaboration Center at SLAC National Accelerator Laboratory (SLAC); the Argonne Utilities Upgrade at Argonne National Laboratory (ANL); the Utilities Infrastructure Project and the Integrated Engineering Research Center at Fermi National Accelerator Laboratory (FNAL); and the Princeton Plasma Innovation Center and Critical Infrastructure Recovery & Renewal project at Princeton Plasma Physics Laboratory (PPPL).
- Three projects are being paused as SC focuses on supporting the large number of ongoing projects: the Ames Infrastructure Modernization project at Ames Laboratory, the Critical Infrastructure Modernization Project at ORNL, and the Thomas Jefferson Infrastructure Improvements project at TJNAF. These projects will resume in future years.
- General purpose infrastructure projects that will upgrade critical core infrastructure and utility needs; and support for Payment in Lieu of Taxes, nuclear facilities at ORNL, and landlord responsibilities at the Oak Ridge Reservation.

▪ **Safeguards and Security**

Safeguards and Security (S&S) program maintains security measures to protect personnel and assets in an environment of open scientific research. The Request funds:

- Increased funding for implementation of the Department's Design Based Threat to address modernization of physical access control systems at site entry points, buildings, and select internal facility locations.
- Continued security operations for all remaining S&S elements.

▪ **Program Direction**

Program Direction (PD) supports the skilled and motivated Federal workforce that plans, develops, and oversees SC investments in world-leading basic research and scientific user facilities, and provides critical oversight to ten of DOE's national laboratories. The Request funds Salaries and Benefits, Travel, Support Services, Other Related Expenses, and Working Capital Fund requirements.