

start of full operations of the facility described in subparagraph (A) occurs before December 31, 2030.

(E) Funding

Out of funds authorized to be appropriated under subsection (k), there are authorized to be appropriated to the Secretary to carry out construction of the facility described in subparagraph (A)—

- (i) \$10,000,000 for fiscal year 2023;
- (ii) \$25,000,000 for fiscal year 2024;
- (iii) \$60,000,000 for fiscal year 2025;
- (iv) \$80,000,000 for fiscal year 2026; and
- (v) \$80,000,000 for fiscal year 2027.

(h) Accelerator and detector upgrades

The Director shall upgrade accelerator facilities and detectors, as necessary and appropriate, to increase beam power, sustain high reliability, and improve precision measurement to advance the highest priority particle physics research programs. In carrying out facility upgrades, the Director shall continue to work with international partners, when appropriate and in the United States' interest, to leverage investments and expertise in critical technologies to help build and upgrade accelerator and detector facilities in the United States.

(i) Accelerator and detector research and development

As part of the program described in subsection (b), the Director shall carry out research and development in particle beam physics, accelerator science and technology, and particle and radiation detection with relevance to the specific needs of the High Energy Physics program, in coordination with the Accelerator Research and Development program authorized under section 18648 of this title.

(j) Underground science

The Director shall—

(1) support an underground science program consistent with the missions of the Department and the scientific needs of the High Energy Physics program, including those articulated in the most recent report of the Particle Physics Project Prioritization Panel of the High Energy Physics Advisory Panel, that leverages the capabilities of relevant underground science and engineering facilities;

(2) carry out a competitive grant program to award scientists and engineers at institutions of higher education, nonprofit institutions, and National Laboratories to conduct research in underground science and engineering; and

(3) submit to the Committee on Energy and Natural Resources of the Senate and the Committee on Science, Space, and Technology of the House of Representatives a report on the inventory of underground mines in the United States that may be suitable for future development of underground science and engineering facilities and any anticipated challenges associated with repurposing, repair, facility siting, or construction.

(k) Authorization of appropriations

Out of funds authorized to be appropriated for the Office of Science in a fiscal year, there are authorized to be appropriated to the Secretary

to carry out the activities described in this section—

- (1) \$1,159,520,000 for fiscal year 2023;
- (2) \$1,289,891,200 for fiscal year 2024;
- (3) \$1,428,284,672 for fiscal year 2025;
- (4) \$1,499,881,752 for fiscal year 2026; and
- (5) \$1,554,874,657 for fiscal year 2027.

(Pub. L. 115-246, title III, § 305, Sept. 28, 2018, 132 Stat. 3147; Pub. L. 117-167, div. B, title I, § 10106, Aug. 9, 2022, 136 Stat. 1445.)

Editorial Notes

AMENDMENTS

2022—Subsecs. (b), (c). Pub. L. 117-167, § 10106(a)(2), added subsecs. (b) and (c). Former subsecs. (b) and (c) redesignated (d) and (e), respectively.

Subsec. (d). Pub. L. 117-167, § 10106(a)(1), (b), redesignated subsec. (b) as (d), struck it out, and added a new subsec. (d). Prior to amendment, text read as follows: “The Director, as practicable and in coordination with other appropriate Federal agencies as necessary, shall ensure the access of United States researchers to the most advanced accelerator facilities and research capabilities in the world, including the Large Hadron Collider.” Former subsec. (d) redesignated (f).

Subsec. (e). Pub. L. 117-167, § 10106(a)(1), redesignated subsec. (c) as (e).

Subsec. (f). Pub. L. 117-167, § 10106(a)(1), (c), redesignated subsec. (d) as (f), struck it out, and added a new subsec. (f). Prior to amendment, text read as follows: “The Director shall carry out research activities on the nature of dark energy and dark matter, which may include collaborations with the National Aeronautics and Space Administration or the National Science Foundation; or international collaborations.”

Subsecs. (g) to (k). Pub. L. 117-167, § 10106(d), added subsecs. (g) to (k).

§ 18644. Biological and environmental research

(a) Program

As part of the duties of the Director authorized under section 7139 of this title, and coordinated with the activities authorized under sections 18641 and 18642 of this title, the Director shall carry out a program of research and development in the areas of biological systems science and climate and environmental science, including subsurface science, relevant to the development of new energy technologies and to support the energy, environmental, and national security missions of the Department.

(b) Biological systems

The Director shall carry out research and development activities in genomic science including fundamental research on plants and microbes to increase systems-level understanding of the complex biological systems, which may include activities—

(1) to provide a fundamental understanding of the biology of plants, fungi, and microbes as a basis for developing innovative processes for bioenergy and bioproducts and accelerate breakthroughs and new knowledge that would enable the cost-effective, sustainable production of—

- (A) advanced biofuels;
- (B) bioenergy; and
- (C) biobased materials;

(2) to conduct foundational functional systems biology research—

(A) to support expanded biosystems design research; and

(B) to understand—

- (i) fundamental genome structure; and
- (ii) phenomes, including functional genomics of gene products at genome scale;

(3) to develop biosystems designs and synthetic biology approaches for new nonfood plant-derived and microbially derived bioproducts as a basis for new bioeconomy and biotechnology applications in bioproducts production, resource recovery, recycling, and upcycling ventures;

(4) to better understand the behavior of microbiomes in the environment and the interdependencies between plants and microbes in a sustainable ecosystem;

(5) to improve fundamental understanding of plant and microbial processes impacting the global carbon cycle, including processes for removing carbon dioxide from the atmosphere, through photosynthesis and other biological processes, for sequestration, storage, and utilization;

(6) to understand the microbiome mechanisms and microbiota used to transform, immobilize, or remove contaminants from subsurface environments and that affect the cycling and disposition of carbon, nutrients, and contaminants in the environment;

(7) to develop the computational approaches and integrated platforms for open access collaborative science;

(8) to leverage tools and approaches across the Office of Science to expand research to include novel processes, methods, and science to develop bio-based chemicals, polymers, inorganic materials, including research—

(A) to advance fungal, microbial, and plant biosystems design research to advance the understanding of how CRISPR tools and other gene editing tools and technologies work in nature, in the laboratory, and in practice;

(B) to deepen genome-enabled knowledge of the roles of microbes and microbial communities, including fungi, in—

- (i) supporting plant and tree growth, productivity, performance, adaptation, and resilience in changing environmental conditions; and
- (ii) optimizing end uses of biomass;

(C) to develop biosystems design methods and tools to increase the efficiency of photosynthesis in plants; and

(D) to increase the scale and pace of characterizing the functions and physical characteristics of microbes and microbial communities to improve biosystems design;

(9) to conduct research focused on developing analysis techniques and simulation capabilities, including artificial intelligence and machine learning, on high-performance computing platforms to accelerate collaborative and reproducible systems biology research;

(10) to develop and improve new technologies for bioimaging, measurement, and characterization purposes to understand the structural, spatial, and temporal relationships of meta-

bolic processes governing phenotypic expression in plants and microbes;

(11) to conduct research focused on genotype-to-phenotype translations to develop a predictive understanding of cellular function under a variety of relevant environmental and bioenergy-related conditions;

(12) to conduct metagenomic and metadata assembly research sequencing and analysis; and

(13) to develop other relevant methods and processes as determined by the Director.

(c) Biomolecular characterization and imaging science

The Director shall carry out research and development activities in biomolecular characterization and imaging science, including development of new and integrative imaging and analysis platforms and biosensors to understand the expression, structure, and function of genome information encoded within cells and for real-time measurements in ecosystems and field sites of relevance to the mission of the Department.

(d) Limitation for research funds

The Director shall not approve new climate science-related initiatives without making a determination that such work is well-coordinated with any relevant work carried out by other Federal agencies.

(e) Low-dose radiation research program

(1) In general

The Secretary shall carry out a research program on low-dose and low dose-rate radiation to—

- (A) enhance the scientific understanding of, and reduce uncertainties associated with, the effects of exposure to low-dose and low dose-rate radiation; and
- (B) inform improved risk-assessment and risk-management methods with respect to such radiation.

(2) Program components

In carrying out the program required under paragraph (1), the Secretary shall—

- (A) support and carry out the directives under section 106(b) of the American Innovation and Competitiveness Act (42 U.S.C. 6601 note), except that such section shall be treated for purposes of this subsection as applying to low dose and low-dose rate radiation research, in coordination with the Physical Science Subcommittee of the National Science and Technology Council;
- (B) identify and, to the extent possible, quantify, potential monetary and health-related impacts to Federal agencies, the general public, industry, research communities, and other users of information produced by such research program;
- (C) leverage the collective body of knowledge from existing low-dose and low dose-rate radiation research;
- (D) engage with other Federal agencies, research communities, and potential users of information produced under this section, including institutions performing or utilizing radiation research, medical physics, radiology, health physics, and emergency response measures; and

(E) support education and outreach activities to disseminate information and promote public understanding of low-dose radiation, with a focus on non-emergency situations such as medical physics, space exploration, and naturally occurring radiation.

(3) Research plan

(A) Not later than 90 days after December 27, 2020, the Secretary shall enter into an agreement with the National Academy of Sciences to develop a long-term strategic and prioritized research agenda for the program described in paragraph (2);

(B) Not later than one year after December 27, 2020, the Secretary shall transmit this research plan developed in subparagraph (A) to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Energy and Natural Resources of the Senate.

(4) GAO study

Not later than 3 years after December 27, 2020, the Comptroller General shall transmit to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Energy and Natural Resources of the Senate, a report on:

(A) an evaluation of the program activities carried out under this section;

(B) the effectiveness of the coordination and management of the program; and

(C) the implementation of the research plan outlined in paragraph (3).

(5) Definitions

In this subsection:

(A) Low-dose radiation

The term “low-dose radiation” means a radiation dose of less than 100 millisieverts.

(B) Low dose-rate radiation

The term “low dose-rate radiation” means a radiation dose rate of less than 5 millisieverts per hour.

(6) Rule of construction

Nothing in this subsection shall be construed to subject any research carried out by the Secretary for the program under this subsection to any limitations described in section 16317(e) of this title.

(7) Funding

For purposes of carrying out this subsection, the Secretary is authorized to make available from funds provided to the Biological and Environmental Research Program—

(A) \$20,000,000 for fiscal year 2021;

(B) \$20,000,000 for fiscal year 2022;

(C) \$30,000,000 for fiscal year 2023;

(D) \$40,000,000 for fiscal year 2024;

(E) \$40,000,000 for fiscal year 2025;

(F) \$50,000,000 for fiscal year 2026; and

(G) \$50,000,000 for fiscal year 2027.

(f) Low-dose radiation and space radiation research program

(1) In general

The Secretary, in consultation with the Administrator of the National Aeronautics and

Space Administration, shall carry out a basic research program on the similarities and differences between the effects of exposure to low-dose radiation on Earth, in low Earth orbit, and in the space environment.

(2) Purpose

The purpose of the program described in paragraph (1) is to accelerate breakthroughs in low-dose and low dose-rate radiation research and development as described in subsection (e) and to inform the advancement of new tools, technologies, and advanced materials needed to facilitate long-duration space exploration.

(g) Earth and environmental systems sciences activities

(1) In general

As part of the activities authorized under subsection (a), and in coordination with activities carried out under subsection (b), the Director shall coordinate with the National Oceanic and Atmospheric Administration, the National Science Foundation, the Environmental Protection Agency, the National Aeronautics and Space Administration, the Department of Agriculture, the Department of the Interior, and any other relevant agencies to carry out activities relating to Earth and environmental systems science research, which may include activities—

(A) to understand, observe, measure, and model the response of Earth’s atmosphere and biosphere to changing concentrations of greenhouse gas emissions and any associated changes in climate, including frequency and intensity of extreme weather events;

(B) to understand the coupled physical, chemical, and biological processes to transform, immobilize, remove, or move carbon, nitrogen, and other energy production-derived contaminants such as radionuclides and heavy metals, and understand the process of sequestration and transformation of these, carbon dioxide, and other relevant molecules in subsurface environments;

(C) to understand, observe, and model the cycling of water, carbon, and nutrients in terrestrial systems across spatiotemporal scales;

(D) to understand the biological, biogeochemical, and physical processes across the multiple scales that control the flux of environmentally relevant compounds between the terrestrial surface and the atmosphere; and

(E) to understand and predict interactions among natural and human systems to inform potential mitigation and adaptation options for increased concentrations of greenhouse gas emissions and any associated changes in climate.

(2) Prioritization

In carrying out the program authorized under paragraph (1), the Director shall prioritize—

(A) the development of software and algorithms to enable the productive application of environmental systems and extreme weather in climate and Earth system pre-

diction models in high-performance computing systems; and

(B) capabilities that support the Department's mission needs for energy and infrastructure security, resilience, and reliability.

(3) Environmental systems science research

(A) In general

As part of the activities described in paragraph (1), the Director shall carry out research to advance an integrated, robust, and scale-aware predictive understanding of environmental systems, including the role of hydrobiogeochemistry, from the subsurface to the top of the vegetative canopy that considers effects of seasonal to interannual variability and change.

(B) Clean water and watershed research

As part of the activities described in subparagraph (A), the Director shall—

(i) support interdisciplinary research to significantly advance our understanding of water availability, quality, and the impact of human activity and a changing climate on urban and rural watershed systems, including in freshwater environments;

(ii) consult with the Interagency Research, Development, and Demonstration Coordination Committee on the Nexus of Energy and Water for Sustainability established under section 16183 of this title on energy-water nexus research activities;

(iii) engage with representatives of research and academic institutions, non-profit organizations, State, territorial, local, and Tribal governments, and industry, who have expertise in technologies, technological innovations, or practices relating to the energy-water nexus, as applicable; and

(iv) coordinate with the National Oceanic and Atmospheric Administration, the National Science Foundation, the Environmental Protection Agency, the National Aeronautics and Space Administration, the Department of Agriculture, the Department of the Interior, and any other relevant agency.

(C) Coordination

(i) Director

The Director shall carry out activities under this paragraph in accordance with priorities established by the Secretary to support and accelerate the decontamination of relevant facilities managed by the Department.

(ii) Secretary

The Secretary shall ensure the coordination of activities of the Department, including activities under this paragraph, to support and accelerate the decontamination of relevant facilities managed by the Department.

(4) Climate and Earth modeling

As part of the activities described in paragraph (1), the Director, in collaboration with the Advanced Scientific Computing Research

program described in section 18642 of this title and other programs carried out by the Department, as applicable, and in coordination with the National Oceanic and Atmospheric Administration, the National Science Foundation, the National Aeronautics and Space Administration, and other relevant agencies, shall carry out research to develop, evaluate, and use high-resolution regional climate, global climate, Earth system, and other relevant models to inform decisions on reducing greenhouse gas emissions and the resulting impacts of a changing global climate. Such modeling shall include—

(A) integrated capabilities for modeling multisectoral interactions, including the impacts of climate policies on human systems and the interdependencies and risks at the energy-water-land nexus;

(B) greenhouse gas emissions, air quality, energy supply and demand, and other critical elements; and

(C) interaction among human and Earth systems informed by interdisciplinary research, including the economic and social sciences.

(5) Midscale funding mechanism

(A) In general

Any of the activities authorized in this subsection may be carried out, in lieu of individual research grants—

(i) by competitively selected midscale, multi-institutional research centers;

(ii) by large-scale experiments or user facilities; or

(iii) through existing facilities and systems of the Department or the National Oceanic and Atmospheric Administration.

(B) Consideration

The Biological and Environmental Research Advisory Committee shall provide recommendations to the Director on projects most suitable for the research centers described in subparagraph (A).

(6) Atmospheric Systems and Sciences Research Program

(A) In general

As part of the activities carried out under paragraph (1), the Director shall carry out a program, to be known as the "Atmospheric Systems and Sciences Research Program", to use observations to improve understanding of atmospheric processes, under which the Director, in coordination, and as appropriate, collaboration, with the National Oceanic and Atmospheric Administration and other relevant Federal agencies conducting research under the topics described in this subparagraph, shall conduct research relating to—

(i) better understanding the atmosphere and the interaction of the atmosphere with the surface of the Earth;

(ii) understanding sources of uncertainty in Earth system models, including with respect to the interdependence of clouds, atmospheric aerosols, radiation processes, and precipitation;

(iii) understanding the radiative balance and hydrological cycle of Earth;

(iv) demonstrating the improved predictability of regional and global atmospheric models due to improved process-level understanding;

(v) atmospheric regimes with large uncertainties in earth system prediction, aerosol processes, warm boundary-layer processes, convective processes, and high-latitude processes;

(vi) reduced uncertainty and improved simulation capability of earth system models of the atmospheric system in a holistic, comprehensive fashion; and

(vii) understanding and modeling representation of priority research areas, including aerosol, warm boundary layer, convective, and high-latitude processes.

(B) Activities

In carrying out the Atmospheric Systems and Sciences Research Program, the Director shall, in coordination, and as appropriate, in collaboration, with other relevant Federal agencies—

(i) collect data and conduct research to advance atmospheric and Earth system modeling capabilities;

(ii) develop or participate in existing or future integrated, scalable test-beds that—

(I) incorporate process-level understanding of the life cycles of aerosols, clouds, and precipitation; and

(II) can be incorporated into other models;

(iii) improve data, analysis, and prediction systems in marine, littoral, terrestrial, and arctic environments, including those environments sensitive to changes in the climate, relating to the energy and science mission of the Department; and

(iv) support the development of technologies relating to—

(I) more accurate cloud, aerosol, and other atmospheric sensors;

(II) observing sensor networks; and

(III) computational predictive modeling.

(C) Use of Atmospheric Radiation Measurement Program facilities and infrastructure

To support the Atmospheric Systems and Sciences Research Program and, in coordination, and as appropriate, in collaboration, with the National Oceanic and Atmospheric Administration and other relevant Federal agencies, to improve fundamental understanding of the physical and chemical processes that impact the formation, life cycle, and radiative impacts of cloud and aerosol particles, atmospheric processes, and surface or subsurface phenomena, the Director shall use the facilities and infrastructure of the Atmospheric Radiation Measurement User Facility, the Global Monitoring Laboratory of the National Oceanic and Atmospheric Administration, or other Earth and Environmental Systems User Facilities—

(i) to provide support to environmental scientists by collecting high-quality and

well-characterized in-situ, remote-sensing, and aircraft observations of—

(I) the microphysical properties of clouds and atmospheric aerosols;

(II) the coincident and highly detailed dynamical and thermodynamic properties of the atmospheric environment that contains those clouds and aerosols;

(III) the properties of precipitation;

(IV) the properties of radiation and the background environment; and

(V) the properties of surface or subsurface phenomena;

(ii) to carry out laboratory studies and ground-based and airborne field campaigns to target specific atmospheric and surface or subsurface processes relating to the energy and science mission of the Department in different locations and across a range of environments, including by developing technologies to assist in advancing predictive capabilities;

(iii) to build data sets that can be incorporated into atmospheric models; and

(iv) to enhance observations by using modeling and simulations that test the accuracy of climate model parameterizations.

(h) Biological and environmental research user facilities

(1) In general

The Director shall carry out a program for the development, construction, operation, and maintenance of user facilities to enhance the collection and analysis of observational data related to complex biological, climate, and environmental systems.

(2) Selection

(A) In general

The Director shall select user facilities under paragraph (1) on a competitive, merit-reviewed basis.

(B) Applicants

In selecting user facilities under paragraph (1), the Director shall consider applications from the National Laboratories, institutions of higher education, multi-institutional collaborations, and other appropriate entities.

(3) Facility requirements

To the maximum extent practicable, the user facilities developed, constructed, operated, or maintained under paragraph (1) shall include—

(A) distributed field research and observation platforms for understanding earth system processes;

(B) analytical techniques, instruments, and modeling resources, including high-throughput molecular phenotyping, for understanding and predicting the functional processes of biological and environmental systems;

(C) integrated high-throughput sequencing, advanced bioanalytic techniques, DNA design and synthesis, metabolomics, and computational analysis; and

(D) such other facilities as the Director considers appropriate, consistent with section 7139 of this title.

(4) Existing facilities

In carrying out the program established under paragraph (1), the Director is encouraged to evaluate the capabilities of existing user facilities and, to the maximum extent practicable, invest in modernization of those capabilities to address emerging research priorities.

(5) Earth and environmental systems sciences user facilities

In carrying out the program established under paragraph (1), the Director shall operate at least 1 user facility to advance the collection, validation, and analysis of atmospheric data, including through activities—

(A) to advance knowledge of the Earth and environmental systems and improve model representations; and

(B) to measure the impact of atmospheric gases, aerosols, and clouds on the Earth and environmental systems.

(6) Microbial molecular phenotyping capability project**(A) In general**

The Secretary shall provide for the expansion of the Environmental Molecular Sciences Laboratory, or subsequent facility successor, to advance high-throughput microbial plant and molecular phenotyping capability to accelerate discovery of new protein functions and metabolic pathways in microbial systems.

(B) Capabilities

In carrying out subparagraph (A), the Secretary shall ensure the following capabilities:

(i) Coupled high-throughput autonomous experimental and multimodal analytical capabilities.

(ii) Direct integration of automated multiomics analyses, biomolecular and cellular imaging, and functional biological assays with high-throughput microbial culturing and cultivation capabilities at timescales relevant to biological processes under natural and perturbed environmental conditions.

(C) Data coordination

In carrying out subparagraph (A), the Secretary shall ensure integration and coordination with existing data platforms and user facilities of the Department.

(D) Start of operations

Subject to the availability of appropriations, the Secretary shall begin carrying out subparagraph (A) not later than September 29, 2027.

(E) Funding

Of the funds authorized to be appropriated under subsection (k) for a fiscal year, there are authorized to be appropriated to the Secretary to carry out this paragraph—

- (i) \$550,000 for fiscal year 2023;
- (ii) \$29,000,000 for fiscal year 2024;
- (iii) \$32,000,000 for fiscal year 2025;
- (iv) \$30,500,000 for fiscal year 2026; and

(v) \$27,500,000 for fiscal year 2027.

(7) User facilities integration and collaboration program**(A) In general**

The Director shall support a program of collaboration between user facilities to encourage and enable researchers to more readily integrate the tools, expertise, resources, and capabilities of multiple Office of Science user facilities (as described in subsection (d) of section 7139 of this title) to further research and advance emerging technologies.

(B) Activities

The program shall advance the integration of automation, robotics, computational biology, bioinformatics, biosensing, cellular platforms and other relevant emerging technologies as determined by the Director to enhance productivity and scientific impact of user facilities.

(8) Coordination

In carrying out the program authorized under paragraph (1), the Director shall ensure that the Office of Science coordinates with—

(A) the National Oceanic Atmospheric Administration, the Environmental Protection Agency, the National Aeronautics and Space Administration, the Department of Agriculture, the Department of the Interior, and any other relevant Federal agency on the collection, validation, and analysis of atmospheric data; and

(B) relevant stakeholders, including institutions of higher education, nonprofit research institutions, industry, State, territorial, local, and Tribal governments, and other appropriate entities to ensure access to the best available relevant atmospheric and historical weather data.

(i) Terrestrial-aquatic interface research initiative**(1) In general**

The Director shall carry out a research program to enhance the understanding of terrestrial-aquatic interface. In carrying out the program, the Director shall prioritize efforts to enhance the collection of observational data, and shall develop models to analyze the natural and human processes that interact in littoral zones.

(2) Littoral data collection system

The Director shall establish an integrated system of geographically diverse field research sites in order to improve the scientific understanding and predictability of the major land water interfaces of the United States through improved data quantity and quality, including in—

- (A) the Great Lakes region;
- (B) the Pacific coast;
- (C) the Atlantic coast;
- (D) the Arctic;
- (E) the Gulf coast; and
- (F) the coasts of United States territories and freely associated States.

(3) Existing infrastructure

In carrying out the programs and establishing the field research sites under para-

graphs (1) and (2), the Secretary shall leverage existing research and development infrastructure supported by the Department, including the Department's existing marine and coastal research lab.

(4) Coordination

For the purposes of carrying out the programs and establishing the field research sites under paragraphs (1) and (2), the Secretary may enter into agreements with Federal departments and agencies with complementary capabilities, including the National Oceanic and Atmospheric Administration and any other relevant Federal agency as appropriate.

(5) Report

Not earlier than 2 years after August 9, 2022, the Director shall provide to the Committee on Science, Space, and Technology, the Committee on Natural Resources, and the Committee on Appropriations of the House of Representatives, and the Committee on Energy and Natural Resources and the Committee on Appropriations of the Senate, a report examining whether the system described in paragraph (2) should be established as a National User Facility within the Department or as a research facility within another Federal agency.

(6) Interoperability

(A) In general

The Director shall ensure that activities carried out under paragraphs (1) and (2), including observation, data collection, monitoring, and model development and enhancements, are interoperable and may be integrated with existing related systems at the National Oceanic and Atmospheric Administration and other relevant Federal agencies, as practicable.

(B) Resources

In carrying out subparagraph (A), in support of interoperability, as practicable, the Director may make available to other Federal agencies high performance computing resources.

(C) NOAA

The National Oceanic and Atmospheric Administration shall integrate the data collected under the programs carried out under paragraphs (1) and (2) into relevant data systems and models, as practicable.

(j) Engineered ecosystems initiative

(1) In general

The Secretary shall establish within the Biological and Environmental Research program an initiative focused on the development of engineered ecosystems through the application of artificial intelligence, novel sensing capabilities, and other emerging technologies.

(2) Interagency coordination

The Secretary shall coordinate with the Director of the National Science Foundation, the Administrator of the National Oceanic and Atmospheric Administration, the Director of the U.S. Geological Survey, the Secretary of Agriculture, and other relevant officials to avoid

duplication of research and observational activities and to ensure that activities carried out under the initiative established under paragraph (1) are complimentary to activities being undertaken by other agencies.

(3) Report

Not later than 180 days after August 9, 2022, the Secretary shall submit to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Energy and Natural Resources of the Senate a report on the activity authorized under this subsection.

(k) Authorization of appropriations

Out of funds authorized to be appropriated for the Office of Science in a fiscal year, there are authorized to be appropriated to the Secretary to carry out the activities described in this section—

- (1) \$885,420,000 for fiscal year 2023;
- (2) \$946,745,200 for fiscal year 2024;
- (3) \$1,001,149,912 for fiscal year 2025;
- (4) \$1,068,818,907 for fiscal year 2026; and
- (5) \$1,129,948,041 for fiscal year 2027.

(l) Definitions

In this section:

(1) Advanced biofuel

The term “advanced biofuel” has the meaning given the term in section 8101 of title 7.

(2) Bioenergy

The term “bioenergy” means energy derived from biofuels.

(3) Biomass

The term “biomass” has the meaning given the term in section 15852(b) of this title.

(4) Bioproduct

The term “bioproduct” has the meaning given the term “biobased product” in section 8101 of title 7.

(Pub. L. 115–246, title III, §306, Sept. 28, 2018, 132 Stat. 3148; Pub. L. 116–260, div. Z, title XI, §11001, Dec. 27, 2020, 134 Stat. 2610; Pub. L. 117–167, div. B, title I, §10103(a)–(d), Aug. 9, 2022, 136 Stat. 1420–1423.)

Editorial Notes

REFERENCES IN TEXT

Section 106(b) of the American Innovation and Competitiveness Act (42 U.S.C. 6601 note), referred to in subsec. (e)(2)(A), is section 106(b) of Pub. L. 114–329, title I, Jan. 6, 2017, 130 Stat. 2986, which is set out in a note under section 6601 of this title.

AMENDMENTS

2022—Subsecs. (a) to (c). Pub. L. 117–167, §10103(a)(3), added subsecs. (a) to (c) and struck out former subsec. (a) which related to research and development activities of complex biological systems. Former subsecs. (b) and (c) redesignated (d) and (e), respectively.

Subsec. (c)(5) to (8). Pub. L. 117–167, §10103(a)(1), prior to redesignation of subsec. (c) as (e), redesignated pars. (6) to (8) as (5) to (7), respectively.

Subsecs. (d), (e). Pub. L. 117–167, §10103(a)(2), redesignated subsecs. (b) and (c) as (d) and (e), respectively. Former subsec. (d) redesignated (f).

Subsec. (e)(7)(E) to (G). Pub. L. 117–167, §10103(b), which directed amendment of subsec. (e)(8) by adding

subpars. (E) to (G), was executed by making the addition to subsec. (e)(7) to reflect the probable intent of Congress and the successive redesignations of subsec. (c)(8) as (c)(7) and then (e)(7) by Pub. L. 117-167, §10103(a)(1), (2). See notes above.

Subsec. (f). Pub. L. 117-167, §10103(a)(2), (c), redesignated subsec. (d) as (f) and amended it generally. Prior to amendment, text read as follows: “The Secretary of Energy, shall continue and strengthen collaboration with the Administrator of the National Aeronautics and Space Administration on basic research to understand the effects and risks of human exposure to ionizing radiation in low Earth orbit, and in the space environment.”

Subsecs. (g) to (k). Pub. L. 117-167, §10103(d), added subsecs. (g) to (k).

Subsec. (l). Pub. L. 117-167, §10103(a)(4), added subsec. (l).

2020—Subsec. (c). Pub. L. 116-260, §11001(a), amended subsec. (c) generally. Prior to amendment, subsec. (c) related to the establishment and purpose of a low-dose radiation research program.

Subsec. (d). Pub. L. 116-260, §11001(b), added subsec. (d).

§ 18645. Fusion energy

(a) Program

As part of the activities authorized under section 7139 of this title and section 16312 of this title, the Director shall carry out a fusion energy sciences research and enabling technology development program to effectively address the scientific and engineering challenges to building a cost competitive fusion power plant and to support the development of a competitive fusion power industry in the United States. As part of this program, the Director shall carry out research activities to expand the fundamental understandings of plasma and matter at very high temperatures and densities for fusion applications and for other engineering and plasma science applications.

(b) Fusion materials research and development

(1) In general

As part of the activities authorized in section 16318 of this title—

(A) the Director, in coordination with the Assistant Secretary for Nuclear Energy of the Department, shall carry out research and development activities to identify, characterize, and demonstrate materials that can endure the neutron, plasma, and heat fluxes expected in a fusion power system; and

(B) the Director shall provide an assessment of—

(i) the need for one or more facilities that can examine and test potential fusion and next generation fission materials and other enabling technologies relevant to the development of fusion power; and

(ii) whether a single new facility that substantially addresses magnetic fusion and next generation fission materials research needs is feasible, in conjunction with the expected capabilities of facilities operational as of September 28, 2018.

(2) Authorization of appropriations

Out of funds authorized to be appropriated under subsection (q),¹ there is authorized to be

appropriated to the Secretary to carry out activities described in paragraph (1) \$50,000,000 for each of fiscal years 2023 through 2027.

(c) Tokamak research and development

The Director shall support research and development activities and facility operations to optimize the tokamak approach to fusion energy.

(d) Inertial fusion research and development

(1) In general

The Director shall carry out a program of research and technology development in inertial fusion for energy applications, including ion beam, laser, and pulsed power fusion systems.

(2) Activities

As part of the program described in paragraph (1), the Director shall support activities at and partnerships with universities and the National Laboratories to—

(A) develop novel target designs;

(B) support modeling of various inertial fusion energy concepts and systems;

(C) develop diagnostic tools; and

(D) improve inertial fusion energy driver technologies.

(3) Authorization of appropriations

Out of funds authorized to be appropriated under subsection (q),¹ there are authorized to be appropriated to the Secretary to carry out the activities described in this subsection \$25,000,000 for each of fiscal years 2021 through 2027.

(e) Alternative and enabling concepts

(1) In general

The Director shall support research and development activities and facility operations at institutions of higher education, National Laboratories, and private facilities in the United States for a portfolio of alternative and enabling fusion energy concepts that may provide solutions to significant challenges to the establishment of a commercial magnetic fusion power plant, prioritized based on the ability of the United States to play a leadership role in the international fusion research community.

(2) Activities

Fusion energy concepts and activities explored under paragraph (1) may include—

(A) alternative fusion energy concepts, including—

(i) advanced stellarator concepts;

(ii) non-tokamak confinement configurations operating at low magnetic fields;

(iii) magnetized target fusion energy concepts; or

(iv) other promising fusion energy concepts identified by the Director;

(B) enabling fusion technology development activities, including—

(i) high magnetic field approaches facilitated by high temperature superconductors;

(ii) liquid metals to address issues associated with fusion plasma interactions with the inner wall of the encasing device; and

¹ So in original. Probably should be “subsection (r).”. See References in Text note below.