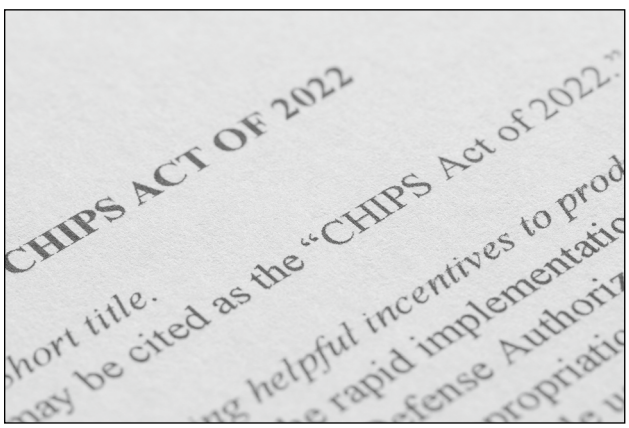
The US CHIPS and Science Act of 2022

By Michael Taylor

The Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act was signed into law by President Joe Biden on August 9, 2022. The act provides roughly USD$280B in new funding over 10 years to boost domestic research and manufacturing of semiconductors in the United States. It channels more than $52B into researching semiconductors and other scientific research over five years, with the primary aim of rebuilding (onshoring) the US semiconductor industry and countering global competitors. The bill would invest $81B in the National Science Foundation (NSF), including new money for science-technology-engineering-mathematics (STEM) education and defense against non-US intellectual property infringement, and $20B in the new Directorate for Technology, Innovation, and Partnerships, which would be tasked with deploying these technologies. It authorizes but does not appropriate $12B for the Advanced Research Projects Agency-Energy (ARPA-E). It contains annual budget increases for the Department of Energy (DOE) for other purposes including supercomputers, nuclear fusion, and particle accelerator research, and directs the Department of Commerce to establish $10B worth of research hubs in postindustrial, mostly rural economies.[1]



Credit: Tada Images.

CHIPS Act ($52.7B)

Department of Commerce Incentives Program ($39B)

The CHIPS and Science Act allocates $39B to implement the Semiconductor Initiative Financial Assistance Program. This program mandates that the Secretary of Commerce establish a program that provides financial assistance to covered entities[2] to incentivize investment in semiconductor facilities. In addition, the incentive program provides for up to $6B to be used for the cost of direct loans and loan guarantees.[3]

Advanced Microelectronics Research and Development ($11B)

The act allocates $11B to a number of programs including the National Semiconductor Technology Center (NSTC), National Advanced Packaging Manufacturing Program, and other R&D and workforce development programs. The fiscal year 2022 (FY 2022) funding includes $2B for NSTC, $2.5B for advanced packaging, and $500B for other related R&D programs. Funding for FY 2023 through FY 2026 to be used across the programs would include $2B in FY 2023, $1.3B in FY 2024, $1.1B in FY 2025, and $1.6B in FY 2026.[3]

Advanced Manufacturing Investment Credit

The CHIPS and Science Act establishes a 25% investment tax credit targeting semiconductor manufacturing investments and providing incentives for semiconductor manufacturing and includes specialized tooling equipment necessary in the manufacturing of semiconductors. The credit commences after December 21, 2022 for properties where construction starts before January 1, 2027.[3]

National Science Foundation Authorization ($81B total over 5 years; + $36B over baseline)

Invest in Strategic Translational Science ($20B)

The act allocates $20B to establish a first-of-its-kind NSF Directorate for Technology, Innovation, and Partnerships (TIP). The new NSF TIP Directorate looks to stimulate domestic development of national and economic-security critical technologies such as artificial intelligence, quantum information science and technology, advanced manufacturing, 6G communications, energy, and materials science.[3]

Grow Basic Research

The CHIPS and Science Act emphasizes supporting early-stage research in an effort to encourage innovative new ideas, including in such areas as the food-energy-water systems, sustainable chemistry, risk and resilience, clean water systems, technology and behavioral health, critical minerals, precision agriculture, and the impact of satellite constellations on NSF-funded science.[4]

Build the STEM Workforce ($13B)

The act authorizes $13B in funding over five years for STEM education, including scholarships, fellowships, and traineeships to develop workers in critical fields, including to establish an artificial intelligence scholarship-for-service program, a national network for microelectronics education, and cybersecurity workforce development programs.[5]

Building Broad-Based Research Opportunities

Under the CHIPS and Science Act, Established Program to Stimulate Competitive Research (EPSCoR), jurisdictions can receive 20% of funding in key accounts by FY 2029. This should encourage funding growth in NSF research activities for universities across the country, including investments in minority serving institutions and emerging research institutions.[6]

Major Research Equipment and Facilities Construction Funding

The act increases the NSF's Major Research Equipment and Facilities Construction account from its current budget of about $250M to a sustained level of around $370M by FY 2025. This account funds both large construction projects and a few mid-scale projects.[6]

NSF Mid-scale Programs

The CHIPS and Science Act recommends that NSF's agency-wide Mid-scale Research Infrastructure programs be raised to $180M in FY 2027. The programs fund equipment and facilities with total costs ranging from $6M to about $100M.[6]

Department of Commerce Technology Hubs ($11B total over 5 years; + $11B over baseline)

Build Regional Innovation ($10B)

The Department of Commerce is directed to establish 20 geographically distributed "regional technology hubs." The focus of these hubs will be on technology development, job creation, and expanding US innovation capacity. With regional innovation a major component of the CHIPS and Science Act, a number of programs will be created or expanded, attempting to develop industry clusters and stimulate knowledge-based industries by leveraging universities, federal laboratories, and the private sector.[6]

These regional innovation programs are to be administered through the Department of Commerce and the National Institute of Standards and Technology (NIST), along with NSF. These initiatives are supplemented by other provisions in the act, for example those seeking to increase research funding for EPSCoR states and to strengthen research institutions in rural areas.[6]

National Institute of Standards and Technology Authorization ($9B total, + $4B over baseline)

Support Critical Technology Research and Standards

The CHIPS and Science Act advances research and standards development for industries of the future, including quantum information science, artificial intelligence, cybersecurity, advanced communications technologies, and semiconductors.[6]

> According to NIST, standards allow technology to work seamlessly and establish trust so that markets can operate smoothly. They provide a common language to measure and evaluate performance, make interoperability of components made by different companies possible, and protect consumers by ensuring safety, durability, and market equity.[7]

Strengthen Small Manufacturers ($2B)

The act provides for a threefold increase in funding for the Manufacturing Extension Partnership (MEP), to support small- and medium-sized manufacturers with cybersecurity, workforce training, and supply chain resiliency.[8]

Combat Supply Chain Disruption ($131M)

The CHIPS and Science Act seeks to use the MEP to create a National Supply Chain Database for helping businesses with supplier scouting and minimizing supply chain disruptions.[8]

Grow Manufacturing USA ($829M)

The act assists in the setting up of new competitively awarded manufacturing research institutes having expanded capacity for education and workforce development.[8]

Promote Competitiveness in International Standards

The CHIPS and Science Act increases interagency coordination and information exchange activities as a way to support private sector engagement and guarantee effective federal participation in the development and use of international standards.[8]

NIST Reactor Facility

The act requires NIST to develop a plan within 30 months for the eventual replacement of the nuclear reactor it operates at its Center for Neutron Research in Maryland. This facility is one of three main facilities in the country for neutron-scattering research. Although this reactor is 55 years old and currently shut down following a radiation incident attributed to operator error, NIST anticipates still continuing to operate it for several years.[9]

Department of Energy Provisions

Basic Energy Sciences

The CHIPS and Science Act authorizes a research and development program in basic energy sciences, including materials science and engineering, chemical sciences, and prioritizes R&D in sustainable chemistry. It reauthorizes R&D activities related to artificial photosynthesis and electricity

storage, directs research in foundational nuclear science, establishes a carbon materials science initiative, and establishes a carbon dioxide sequestration research and geologic computing initiative.[10]

The act recommends Congress immediately increase the annual US contribution to the International Thermonuclear Experimental Reactor fusion facility to around $400M. This additional funding far exceeds the current level of about $240M. The act and DOE itself look to increase funding for the Long-Baseline Neutrino Facility/Deep Underground Neutrino Experiment project to about $300M by FY 2025, up from the current annual budget of $180M. The CHIPS and Science Act recommends increased funding for a cryomodule maintenance facility at the SLAC National Accelerator Laboratory.[11]

New Mid-scale Program

The CHIPS and Science Act instructs the DOE Office of Science to establish its own mid-scale program for funding equipment costing between $1M and $20M, with a target total budget of $150M per year. Equipment acquired through the program would be installed at user facilities, with a focus on fostering partnerships with minority-serving institutions and institutions in EPSCoR jurisdictions and rural areas.[11]

Advanced Scientific Computing Research

The act builds on the National Quantum Initiative Act of 2018 in a number of ways. One such provision directs DOE to create a "quantum network infrastructure R&D program" with a funding target of $100M per year. Because this program is to be managed within DOE's advanced scientific computing research program, this effort seeks to build on DOE's ongoing work with industry and university partners to establish quantum communications links between its 17 national laboratories. The CHIPS and Science Act also establishes a "Quantum User Expansion for Science and Technology" Program within DOE to provide researchers access to quantum computing infrastructure, with a funding target starting at $30M and rising to more than $36M by FY 2027.[11]

Fusion Energy Research

The CHIPS and Science Act calls for the establishment of a Material Plasma Exposure Experiment Facility capable of meeting the research needs for testing of fusion materials. The act further provides for upgrades to meet research needs for understanding physical and chemical changes to plasmas at fundamental time scales, and for new regimes of dense materials physics, astrophysics, planetary physics, and short-pulse laser–plasma interactions.[11]

In an effort to augment the scope of DOE's Fusion Energy Sciences Program, the CHIPS and Science Act directs the program to support at least two "national teams" to develop conceptual designs and technology roadmaps for a fusion power plant. This effort has an initial target budget of $35M, increasing to $80M in FY 2026. The act recommends additionally that Congress immediately expand the fusion program's overall annual budget from its current level of $713M to a sustained level of more than $1B.[11]

High Energy Physics Program

The CHIPS and Science Act sets up a program in elementary particle physics and associated advanced technology research and development. This program includes the use of high-energy accelerators and advanced detectors to create and study the interactions. Within its High Energy Physics Program, DOE is directed to establish a competitive grant program for "underground science" and to submit an inventory to Congress, of mines in the United States that may be suitable for scientific use. Within DOE's High Energy Physics Program, the act further recommends increased funding for the 21-telescope Cosmic Microwave Background Stage 4 project to $80M in FY 2026. The intention here is to begin operations no later than the end of 2030.[11]

Nuclear Physics

The act establishes a program in nuclear physics and recommends budget authorization levels for building a Facility for Rare Isotope Beams and the Electron–Ion Collider. DOE's Electron–Ion Collider and Spallation Neutron Source Second Target Station projects have only been receiving adequate funding to support early work. The act foresees the budgets of each project topping out at around $300M in FY 2026.[11]

Accelerator R&D

The CHIPS and Science Act supports DOE's creation of an Accelerator R&D and Production program within the Office of Science and further recommends its budget be increased from its current $18M level to $24M in FY 2027. This program looks to encourage private–public partnerships to develop, demonstrate, and enable the commercial applications of such technologies, supports associated workforce development activities, and establishes access to accelerator design and engineering resources.[11]

Isotope Development and Production

The act creates a program to produce isotopes for research, medical, industrial, and related purposes, advance isotope production methods and techniques, and to make sure production activities do not compete with private industry. The act additionally sets up an isotope demonstration subprogram to foster the development and commercial demonstration of critical stable or radioactive isotope production at existing commercial nuclear power plants. The act supports DOE's creation of a standalone Isotope R&D and Production program and proposes immediately expanding its budget from $82M to $176M, increasing its funding up to $216M in FY 2025.[11]

High-Intensity Laser Research Initiative

The CHIPS and Science Act authorizes the creation of a high-intensity laser research initiative[12] to advance laser

technologies relevant to future facility needs in discovery science and to support a user network of academic and national laboratory high-intensity laser facilities. The act directs DOE's Office of Science to stand up a high-intensity laser research initiative drawing from across all of its program offices. The act recommends Congress provide initial funding of $50M, increasing to $250M per year in FY 2027. The CHIPS and Science Act proposes a faster increase in funding for SLAC's new x-ray free electron laser, the Linac Coherent Light Source II. The act aims for a funding level of $135M in FY 2025, with the goal of commencing operations by the end of 2026.[13]

Helium Conservation

The CHIPS and Science Act establishes a program to reduce the use of helium among DOE grantees and facilities by encouraging recycling and reuse. The act also directs DOE and NSF to fund the purchase, installation, and repair of helium recycling equipment. As far as the DOE part of this effort, DOE will be permitted to renew its program for periods of up to five years and may use it to fund projects at its own facilities and those operated by grant recipients. The DOE program will also support R&D on alternatives to helium. As for the NSF part, it will be of unlimited duration and will receive funding through the Major Research Instrumentation Program. The act does not set a target budget for either effort.[13]

Established Program to Stimulate Competitive Research

The act increases the authorized scope and funding for DOE's EPSCoR program over five years; increases transparency and accountability of the program; and expands the ways DOE can support research capabilities in eligible states including with undergraduate scholarships, grants to support early-career faculty and staff, and funding to expand research capacity in key technology areas and partnerships with National Labs and industry.[14]

Regional Innovation

The CHIPS and Science Act amends the Energy Independence and Security Act of 2007 to authorize a Regional Clean Energy Innovation Program at DOE to create regional partnerships that promote the economic development of diverse geographic areas of the United States by supporting clean energy innovation.[15]

Foundation of Energy Security and Innovation

The act creates a Foundation for Energy Security and Innovation (FESI) for the DOE to engage with the private sector to raise funds that support the creation, development, and commercialization of innovative technologies that address tomorrow's energy challenges. Functions of FESI will include the following.

FESI will facilitate public–private partnerships to commercialize research and technology as well as administer prize competitions that engage the private sector to invest in commercial solutions to big problems.

FESI will organize events, briefings, and symposia to create a neutral space for partners to share ideas and engage the public.

FESI will support education and training of new researchers in energy through awards, grants, and fellowships.[16]

As a 501(c)(3) organization, FESI will have the flexibility to engage with various private sector sources for funds and attract new nontraditional partners.

Micro Act

The CHIPS and Science Act calls on DOE to establish a dedicated research program focused on research, development, and demonstration of next-generation microelectronics. Eligible research areas within this program include materials and chemical sciences, novel microchip designs and diverse computing architectures, integrated sensing, photonic integration and packaging, cybersecurity through design, and advancements in next-generation microelectronics manufacturing, among others.[17]

In order to ensure that all research activities support commercial technology transfers, the Secretary of Energy, in coordination with the Director of the Office of Technology Transitions and in consultation with the private sector, shall:

(a) support translational research and transfer of microelectronics technologies; and (b) identify emerging research and development needs of industry and government for the benefit of United States economic competitiveness.

Further, in order to carry out the workforce development program, the Secretary shall:

(a) ensure workforce development through existing authorities and mechanisms available to the Department, including internships, fellowships, individual investigator grants, and other activities the Secretary determines appropriate; and (b) in consultation with the National Science Foundation, as appropriate, ensure education and outreach activities—

> (i) to disseminate information and promote understanding of microelectronics and related fields among students at elementary school, secondary school, high school, undergraduate, and graduate levels; and
> (ii) that may include educational programming with an emphasis on experiential and project-based learning.[17]

The act calls upon DOE to develop four Microelectronics Science Research Centers, each funded at up to $25M annually, to be located at national laboratories, universities, nonprofit or commercial research entities, or consortiums to carry out research activities focused on addressing the foundational challenges in design, development, characterization, prototyping, demonstration, and fabrication of microelectronics. These research centers are required to support technology transfer and workforce development initiatives targeting the private sector, and to coordinate with other federal programs focused on microelectronics R&D.[18]

National Nuclear University Research Infrastructure Reinvestment

The CHIPS and Science Act amends the Energy Policy Act of 2005 to improve collaboration between relevant nuclear energy university stakeholders and to maintain and upgrade existing university research reactor infrastructure. The act authorizes $55M for each of FYs 2023 through 2027 for these activities.[18]

Advanced Nuclear Research Infrastructure Enhancement Subprogram

The CHIPS and Science Act further amends the Energy Policy Act of 2005 to establish a new university infrastructure subprogram that seeks to advance the development of nuclear technologies. This is accomplished by constructing not more than four new research reactors and establishing new nuclear science and engineering facilities. DOE's Office of Nuclear Energy will support this construction of up to four research reactors with an initial total annual funding target of $45M that increases to $140M by FY 2027. In addition, the office is mandated to support consortia that expand access to reactor facilities for research and training purposes, along with overhauls of existing reactors focused on R&D in "advanced nuclear technology" or on conversions to low-enriched uranium fuel. The act authorizes a total of $390M over FYs 2023 through 2027 for these activities.[18]

Applied Laboratories Infrastructure Restoration and Modernization

The CHIPS and Science Act authorizes funding for deferred maintenance, critical infrastructure needs, and modernization activities across National Laboratories for each of FYs 2023 through 2027. The act recommends that Congress appropriate $640M per year through FY 2027 for modernization and maintenance projects at the National Renewable Energy Laboratory, the National Energy Technology Laboratory, Idaho National Laboratory, and Savannah River National Laboratory. An additional $160M per year is recommended for such projects at Los Alamos, Lawrence Livermore, and Sandia National Laboratories. In addition, the act recommends that Congress increase DOE's Science Laboratories Infrastructure account from its current level of $291M to $550M through FY 2027.[18]

Department of Energy Research, Development, and Demonstration Activities

The act authorizes funding for research, development, and demonstration aligned with the 10 technology areas in the applied energy offices. In the Office of Energy Efficiency & Renewable Energy, funds are designated for building technologies, sustainable transportation, advanced manufacturing, industrial emissions reduction technology, advanced materials, and renewable power research, development, and demonstration. In the Office of Electricity, funds are authorized for grid modernization research, development, and demonstration. In the Office of Nuclear Energy, funds are designated for advanced materials research, development, and demonstration. In the Office of Environmental Management, funds are authorized for artificial intelligence and information technologies. In the Office of Fossil Energy and Carbon Management, funds are designated for clean industrial technologies, alternative fuels, and carbon removal research, development, and demonstration. Finally, funds are also set aside for the ARPA-E.[18]

Fission for the Future

The CHIPS and Science Act instructs the Secretary of Energy to establish a program to provide federal financial assistance to eligible entities to support the research, development, and demonstration of advanced nuclear reactors. It further directs the Secretary to use a competitive, merit-based review process in awarding these funds.[18]

Materials Research Database

The act directs DOE to support a "web-based platform to develop and provide access to a database of computed information on known and predicted materials properties and computational tools," with a target annual budget of $10M. In carrying out this task, the Director of the DOE's Office of Science shall:

(a) conduct cooperative research among National Laboratories, industry, academia, and other research institutions to advance understanding, prediction, and manipulation of materials and facilitate the design of novel materials;
(b) develop and maintain data infrastructure at user facilities that generate data to collect, analyze, label, and otherwise prepare the data for inclusion in the database;
(c) leverage existing high performance computing systems to conduct high throughput calculations, and develop computational and data mining algorithms for the prediction of materials properties;
(d) strengthen the foundation for new technologies and advanced manufacturing; and
(e) drive the development of advanced materials for applications that span the Department's missions in energy, environment, and national security.[18]

Endnotes

1. https://www.whitehouse.gov/briefing-room/statements-releases/2022/08/25/fact-sheet-president-biden-signs-executive-order-to-implement-the-chips-and-science-act-of-2022/d; and https://www.whitehouse.gov/briefing-room/statements-releases/2022/08/09/fact-sheet-chips-and-science-act-will-lower-costs-create-jobs-strengthen-supply-chains-and-counter-china/

2. A covered entity is a nonprofit entity, a private sector entity, a consortium of private sector entities, or a consortium of nonprofit, public, and private sector entities with a demonstrated ability to substantially finance, construct, expand, or modernize a facil-

ity relating to fabrication, assembly, testing, advanced packaging, or production of semiconductors, materials used to manufacture semiconductors, or semiconductor manufacturing equipment. In general, the recipient should be the single, private-sector, domestic legal entity that will receive the CHIPS Incentives directly from the Department of Energy.

3. https://www.bennet.senate.gov/public/_cache/files/4/0/40919cb4-ff63-4434-8ae2-897a4a026b30/7BCDD84F555A6B85BEC800514F1D3AFD.chips-and-science-act-of-2022-section-by-section.pdf
4. https://www.vanhollen.senate.gov/imo/media/doc/CHIPS%20and%20Science%20Act%20of%202022%20Summary.pdf
5. https://www.commerce.senate.gov/services/files/60905CE3-7D54-465C-B1CC-A2D1FFF6B335
6. https://www.bennet.senate.gov/public/_cache/files/4/0/40919cb4-ff63-4434-8ae2-897a4a026b30/7BCDD84F555A6B85BEC800514F1D3AFD.chips-and-science-act-of-2022-section-by-section.pdf
7. https://www.nist.gov/services-resources/standards-and-measurements
8. https://www.bennet.senate.gov/public/_cache/files/4/0/40919cb4-ff63-4434-8ae2-897a4a026b30/7BCDD84F555A6B85BEC800514F1D3AFD.chips-and-science-act-of-2022-section-by-section.pdf
9. https://www.bennet.senate.gov/public/_cache/files/4/0/40919cb4-ff63-4434-8ae2-897a4a026b30/7BCDD84F555A6B85BEC800514F1D3AFD.chips-and-science-act-of-2022-section-by-section.pdf; and https://www.aip.org/fyi/2023/research-infrastructure-initiatives-chips-and-science-act
10. https://www.energy.senate.gov/services/files/9B8E79B1-8CBD-4510-B080-8F748FDC7331
11. https://www.bennet.senate.gov/public/_cache/files/4/0/40919cb4-ff63-4434-8ae2-897a4a026b30/7BCDD84F555A6B85BEC800514F1D3AFD.chips-and-science-act-of-2022-section-by-section.pdf
12. According to the law, we are talking about 1 terawatt (TW) of power in ultrafast pulses, up to the petawatt (PW) range.
13. https://www.bennet.senate.gov/public/_cache/files/4/0/40919cb4-ff63-4434-8ae2-897a4a026b30/7BCDD84F555A6B85BEC800514F1D3AFD.chips-and-science-act-of-2022-section-by-section.pdf
14. https://www.bennet.senate.gov/public/_cache/files/4/0/40919cb4-ff63-4434-8ae2-897a4a026b30/7BCDD84F555A6B85BEC800514F1D3AFD.chips-and-science-act-of-2022-section-by-section.pdf; and for information on grants and how to apply, please use this link—https://science.osti.gov/bes/epscor/How-to-Apply
15. https://www.bennet.senate.gov/public/_cache/files/4/0/40919cb4-ff63-4434-8ae2-897a4a026b30/7BCDD84F555A6B85BEC800514F1D3AFD.chips-and-science-act-of-2022-section-by-section.pdf
16. https://www.bennet.senate.gov/public/_cache/files/4/0/40919cb4-ff63-4434-8ae2-897a4a026b30/7BCDD84F555A6B85BEC800514F1D3AFD.chips-and-science-act-of-2022-section-by-section.pdf; https://www.coons.senate.gov/imo/media/doc/SUMMARY%20117th%20Partnerships%20for%20Energy%20Security%20and%20Innovation%20Act.pdf; and https://www.energy.gov/articles/doe-launches-foundation-energy-security-and-innovation
17. https://www.bennet.senate.gov/public/_cache/files/4/0/40919cb4-ff63-4434-8ae2-897a4a026b30/7BCDD84F555A6B85BEC800514F1D3AFD.chips-and-science-act-of-2022-section-by-section.pdf
18. https://www.bennet.senate.gov/public/_cache/files/4/0/40919cb4-ff63-4434-8ae2-897a4a026b30/7BCDD84F555A6B85BEC800514F1D3AFD.chips-and-science-act-of-2022-section-by-section.pdf