CLEAN ENERGY TECHNOLOGY

Clean Energy Technology Funding[1]

(Dollars in Millions)

	FY 2022 Actual	FY 2023 Estimate Base	Disaster Relief Supplemental Base	Disaster Relief Supplemental CHIPS and Science	FY 2023 Estimate Total	FY 2024 Request
BIO	$50.00	$55.00	-	-	$55.00	$74.50
CISE	29.28	39.50	-	-	39.50	39.50
ENG	150.00	163.00	30.00	-	193.00	229.75
MPS	123.08	123.83	-	-	123.83	123.57
OISE	17.05	7.50	-	-	7.50	12.50
OIA	0.14	-	-	-	-	-
TIP	49.20	39.95	13.12	12.52	65.59	70.69
Total	**$418.75**	**$428.78**	**$43.12**	**$12.52**	**$484.42**	**$550.51**

Overview

Energy is essential, and our future as a people and a Nation depends on our leadership in the transition to clean energy. That leadership depends on winning the research, innovation, and education race to transform the energy sector and ensuring the global competitiveness of our energy workforce. NSF will advance the clean energy future through investments in foundational research to transform energy systems and develop new energy industries; innovation and translation to move discoveries to the market and society; and education and workforce development, with a focus on preparing for the energy jobs of the future. Clean energy investments complement and align with NSF investments to advance climate change understanding, adaptation, and mitigation.

Energy production and use in the U.S. continues to grow, supporting our residential, commercial, and industrial sectors. The use of hydrogen, fusion, and renewable energy (such as solar, wind, geothermal, hydro, tidal and biomass) is enabled by new discoveries, new technologies and the translation of those discoveries and technologies to practical solutions (for example, energy conversion technologies like fuel cells, and energy distribution technologies like the smart grid). Increased energy-efficiency and energy-use management tools support the U.S. economy as industries and households transition to clean-energy solutions, while supporting increased energy demands associated with computing and communication systems. Advances in designing and producing chemicals and materials for clean energy and energy efficiency technologies, as well as electrification of the chemical industry and transportation sectors, are critical to the transition to a carbon neutral world, with reduced impacts of energy systems on the global climate. Advances in plasma science, thermoelectrics, catalysis, and semiconductors provide new opportunities for energy system transformations. Integration of advances in biotechnology and bio-inspired systems into energy research will propel discovery and applications that create new industries. Leveraging artificial intelligence and optimization across energy systems will shape the energy sector of the future. Advances in designing the next generation of computing systems will enable novel ways to not only dramatically increase energy efficiency but also incorporate clean energy technologies in the entire

computing lifecycle. Current and planned future NSF's investments across these research areas, from clean energy sources to clean energy uses (transportation, industry, cyberinfrastructure), will support U.S. leadership in the transition to clean energy.

NSF's clean energy investments span longstanding programs as well as focused solicitations. Research funding opportunities in clean energy enable partnerships of investigators in the economic and social sciences, education research, biological sciences, physical sciences, computing and information sciences, and engineering disciplines to build fundamental knowledge and overcome technological barriers. NSF continues to make long-term investments in multidisciplinary research centers through the Centers for Chemical Innovation, Expeditions in Computing, Engineering Research Centers, and Industry-University Cooperative Research Centers programs. NSF also supports research infrastructure such as the Grid-Connected Testing Infrastructure for Networked Control of Distributed Energy Resources (DERConnect).

As indicated in the National Academies of Sciences, Engineering, and Medicine reports on Accelerating Decarbonization of the U.S. Energy System[1] and The Future of Electric Power in the United States[2], bold and decisive action is urgently required to address the need for clean energy. New resources are necessary to both initiate and accelerate new discovery, insights, and translation research pathways from exploratory concepts to technological solutions. NSF-funded workshops, on topics ranging from electrochemical energy storage[3] to a zero-carbon power grid[4], have identified new research directions that can help meet this global challenge.

Goals

Clean Energy Technology investments at NSF are designed to identify and support transformative research to advance U.S. leadership in the clean energy transition. Goals include:

- *Support fundamental research* in science and engineering to change paradigms and spawn innovations in clean energy supply, distribution, and use;
- *S*upport *convergent research engaging teams* of scientists and engineers to address interconnected problems inspired by the need to reshape the energy sector and related emerging industries;
- *Develop energy research infrastructure*, as well as the associated computing and communications infrastructure, necessary to generate fundamental knowledge and technologies for clean energy;
- *Translate innovations* through unique funding opportunities and partnerships that foster co-design, co-creation, piloting, and prototyping*;* and
- *Develop the clean energy workforce of the future* by attracting, inspiring, educating, training, and reskilling/upskilling diverse individuals, from K-12 to college and industry.

[1] https://nap.nationalacademies.org/catalog/25932/accelerating-decarbonization-of-the-us-energy-system
[2] https://nap.nationalacademies.org/catalog/25968/the-future-of-electric-power-in-the-united-states
[3] https://nsf.gov/awardsearch/showAward?AWD_ID=1942226
[4] https://nsf.gov/awardsearch/showAward?AWD_ID=2218933

FY 2024 Investments

The cross-NSF investments in Clean Energy Technology in FY 2024 support high-risk, high-reward research ideas across the science and engineering spectrum that create broad new understanding and innovations to support energy efficiency, enhance sustainability, adapt to and mitigate climate change, spawn new industries, and support translation and partnerships for innovation, as well as education and workforce development.

Fundamental and Convergent Research*:*
NSF will invest in fundamental, convergent clean-energy technology research to support: improvements in generation, capture, conversion, storage, and distribution of electricity and fuels; advancements in renewable clean-energy sources, including off-shore wind, hydrogen and fuel cells; development of new net-zero fuels and chemicals; more efficient energy usage; as well as research related to infrastructure and systems, such as industrial heat, decarbonization technologies, and interconnected natural, human-built, and social systems. NSF will invest in research related to behavioral economic, equity and regional drivers in design and implementation of clean energy technologies, as well as the human-technology interface. NSF will also invest in collaboration activities to advance grand challenges in clean energy frontiers.

Energy Research Infrastructure:
Investments in energy research infrastructure will allow for the creation of more energy-efficient energy systems, from capture and generation to distribution, for industry, transportation, buildings, and other uses. Investments in computing and communication research infrastructure will enable the creation of more efficient and sustainable hardware, software, and systems for computing and communication—a significant and growing component of U.S. electricity consumption. Energy research infrastructure investments will also afford piloting and prototyping of research-based solutions.

Innovation and Translation:
NSF accelerates the translation of research results to the market and society, catalyzing a broad spectrum of advanced energy technologies and systems. NSF speeds translation of fundamental discoveries in clean energy into technologies and systems through its Centers for Chemical Innovation, Expeditions in Computing, Engineering Research Centers, Materials Research Science and Engineering Centers, Materials Innovation Platforms, and Industry-University Cooperative Research Centers, as well as through the NSF Lab-to-Market Platform comprising Partnerships for Innovation, NSF Innovation Corps, and the Small Business Innovation Research and Small Business Technology Transfer programs. In FY 2024, NSF will add Biofoundries to the set of programs that fosters innovation and translation of biobased clean energy technologies. In addition, NSF partners and coordinates with federally supported Manufacturing USA Institutes, and with other agencies such as the Department of Energy and the Department of Defense to transition fundamental clean energy technology research further towards application.

Education and Workforce Development:
To prepare a diverse clean energy workforce across the Nation, NSF invests in the Advanced Technological Education, NSF Research Traineeship, Faculty Early Career Development, Research Experiences for Undergraduates Sites and Supplements, and Research Experiences for Teachers in Engineering and Computer Science programs, as well as clean energy technology education in

research projects and education research and development projects. NSF support for Non-Academic Research Internships for Graduate Students (INTERN) provides students with relevant experience beyond academia, including in government and industry settings. The Innovative Technology Experiences for Students and Teachers (ITEST) program provides support for projects that involve K-12 students in innovative use of technologies, including those related to clean energy. In addition, EDU has a suite of programs that support the underlying knowledge STEM education and workforce development from preK-12 to professional learning and in both formal and informal contexts.