

Advanced Research Projects Agency - Energy
(\$K)

FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request
427,000	427,000	700,150

The U.S. Department of Energy's Advanced Research Projects Agency-Energy (ARPA-E) was established by the America COMPETES Act of 2007 (Public Law 110–69), as amended. The mission of ARPA-E is to enhance the economic, climate, and energy security of the United States through the development of advanced technologies that reduce imports of energy from foreign sources; reduce energy-related emissions, including greenhouse gases; improve the energy efficiency of all economic sectors; provide transformative solutions to improve the management, clean-up, and disposal of radioactive waste and spent nuclear fuel; improve the resilience, reliability, and security of infrastructure to produce, deliver, and store energy; mitigate the causes of, reverse the impact of, adapt to, or increase resilience against climate change; and monitor, analyze, and utilize climate emissions data. ARPA-E will ensure that the United States maintains a technological lead in developing and deploying advanced technologies. ARPA-E will identify and promote revolutionary advances in energy and climate-related applied sciences, translating scientific discoveries and cutting-edge inventions into technological innovations. It will also accelerate transformational technological advances in areas where industry by itself is not likely to invest due to technical and financial uncertainty. ARPA-E focuses on novel early-stage energy and climate research and development with technology applications that can be meaningfully advanced with a small investment over a defined period of time. ARPA-E coordinates its work with DOE's basic research and applied programs and other Federal research agencies to ensure work is not duplicated.

Public Law Authorizations

P.L. 95-91, "Department of Energy Organization Act" (1977)

P.L. 109-58, "Energy Policy Act of 2005"

P.L. 110-69, "America COMPETES Act of 2007"

P.L. 111-358, "America COMPETES Reauthorization Act of 2010"

P.L. 116-260, Section 10001, "Consolidated Appropriations Act, 2021" ARPA-E Amendments

Overview

ARPA-E has established a nimble, effective management structure and developed a portfolio of technical programs that is delivering innovative, investable opportunities to the commercial sector. ARPA-E will continue to deliver value to the U.S. economy with continued emphasis on maintaining a healthy portfolio of projects. These projects cover a broad range of topics, with a growing focus on additional scale-up of the most promising projects that have demonstrated success in technical development, project management, and definition of commercial pathways.

Since its inception in 2009 through September 2021, ARPA-E has provided approximately \$2.9 billion in funding to over 1,270 projects through focused programs and open funding solicitations. A total of 183 ARPA-E projects have attracted more than \$7.6 billion in private-sector follow-on funding, 266 project teams have partnered with other agencies for further development, and 109 companies have been formed from ARPA-E projects. In addition, ARPA-E project teams have generated 4,871 peer-reviewed journal articles and received 789 patents from the U.S. Patent and Trademark Office.

Projects that receive ARPA-E support are considered "high risk" and too early for private sector support. They are subject to strict technical and commercialization milestones intended to ensure accountability and transparency that enables rapid reprioritization of Agency funds towards only the most promising technologies. This has resulted in significant commercial interest, investment, and follow-on funding in for successful technologies, amplifying the impact of the Agency's funding decisions and accelerating progress towards achieving the Agency's mission.

These efforts also support, indirectly, the President's ambitious climate goals, but there is a gap between ARPA-E's existing 'energy technology-focused' authority and what would be needed to support technology innovation to mitigate the causes of, reverse the impact of, adapt to, or increase resilience against climate change. While ARPA-E is authorized to support projects that mitigate the greenhouse gas emissions from energy users and sources, there is a need to also significantly reduce current and future greenhouse gas emissions from all sources to achieve net zero emissions by 2050.

Recommendations from the Climate Innovation Working Group – established by the President and co-chaired by the White House Office of Domestic Climate Policy, Office of Science of Technology and Policy, and Office of Management and Budget – include utilizing an “ARPA-like” model to support development of affordable, game-changing technologies that can help achieve the President’s goal of net zero economy-wide emissions by 2050 and can protect from the impacts of extreme weather events caused by climate change.

The Administration proposes to expand ARPA-E’s scope to include R&D on climate adaptation and resilience innovations. This will enable work beyond the energy technology-focused projects necessary to achieve net zero emissions by 2050, including coordination across agencies, to meet the Administration’s goals to adapt and strengthen resilience from the most devastating impacts of climate change. The Administration looks forward to working with Congress to develop the required legislation to advance these goals. This expanded scope complements ARPA-E’s advanced energy mission and reflects the need to address additional climate change-related initiatives. Funding is requested to support the Administration’s broader climate technology agenda that will drive innovation to tackle the climate crisis while creating good paying jobs, assure the United States remains the world’s leader in climate technologies, and increase societal resilience to climate change impacts. ARPA-E will work with the other Agencies to develop transformative solutions for the climate crisis, including adaptation and resilience, and lay the foundation for future improvements in R&D across the Federal Government.

Highlights and Major Changes in the FY 2023 Budget Request

In FY 2023, ARPA-E plans to release up to 22 new funding opportunity announcements (FOAs) focused on energy and climate adaptation and resiliency (pending authorization expansion). The FOAs will address new areas not represented in the present portfolio and develop new opportunities opened by the outcomes of previous programs. The assessment process for the new programs is now underway.

**Advanced Research Projects Agency - Energy
Funding by Congressional Control (\$K)**

	FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted	
				\$	%
ARPA-E Projects	392,000	392,000	643,000	+251,000	+64%
Program Direction	35,000	35,000	57,150	+22,150	+63%
Total, Advanced Research Projects Agency - Energy	427,000	427,000	700,150	+273,150	+64%
Federal FTEs	64	64	101	+37	+58%

Future Years Energy Program

	(\$K)				
	FY 2023 Request	FY 2024	FY 2025	FY 2026	FY 2027
Advanced Research Projects Agency - Energy	700,150	716,000	733,000	749,000	767,000

Outyear Priorities and Assumptions

In the FY 2012 Consolidated Appropriations Act (P.L. 112-74), Congress directed the Department to include a future-years energy program (FYEP) in subsequent requests that reflects the proposed appropriations for five years. This FYEP shows outyear funding for each account for FY 2024 - FY 2027. The outyear funding levels use the growth rates from and match the outyear account totals published in the FY 2023 President’s Budget for both the 050 and non-050 accounts. Actual future budget request levels will be determined as part of the annual budget process.

Advanced Research Projects Agency - Energy priorities in the outyears include the following: ARPA-E will continue its focus on novel early-stage energy and climate research and development with technology applications that can be meaningfully advanced with a small investment over a defined period of time. Commensurate with the increase in appropriation, ARPA-E will increase the depth and breadth of investment in focused portfolios as well as the Agency’s investment in its Open, Seeding Critical Advances for Leading Energy Technologies with Untapped Potential (SCALEUP), Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR), and Supporting Entrepreneurial Energy Discoveries (SEED) programs.

ARPA-E Projects

Overview

ARPA-E identifies and supports revolutionary inventions and transformational energy and climate technology advances, which requires constant evolution of its programmatic focus. This is accomplished by establishing dynamic technical programs (each lasting about three years) designed to accelerate innovation in high-potential areas. The breadth of the program portfolio that has developed over ARPA-E's lifetime addresses different parts of the energy technology space from year to year.

ARPA-E has demonstrated the efficacy of its model for accelerating high-potential, novel technical approaches to existing and emerging U.S. energy and climate challenges. Program Directors, recruited for their technical expertise, leadership, and experience in energy issues, are given significant autonomy in identifying potential high-impact areas for R&D investment. ARPA-E's Program Directors work to develop their proposals in the context of both private sector and federally funded work in the technical space, and ultimately propose a program designed to accelerate research and commercial development in the topic area. As a complement to its focused technology programs, ARPA-E also supports OPEN solicitations. OPEN solicitations seek the most innovative new ideas in energy technology across the full spectrum of energy applications, allowing the Agency to support the development of important technologies that otherwise would fall outside the scope of its focused programs. OPEN solicitations were run in 2009, 2012, 2015, 2018, and 2021.

Selection of project awards within each program occurs by a rigorous process of proposal review. Selection criteria include the transformative character of the technology, the potential impact of the technology on ARPA-E's energy missions as defined in its authorizing statute, and the potential for the project to yield commercial applications that benefit U.S. economic and energy security. Within these criteria the most highly rated proposals are selected for award negotiations. The majority of the funded projects involve more than one institution, and the lead institutions are distributed among universities, businesses, federally funded R&D centers (FFRDCs), and non-profit organizations.

The resulting portfolio of alumni and active R&D projects (shown below) broadly covers the U.S. energy technology landscape, from transportation fuels and energy storage, through residential, commercial and manufacturing efficiency to the storage, distribution and generation of electrical power. The programs are designed to deliver value given a targeted investment over a defined period of time. The projects are structured in a portfolio funding approach to 'de-risk' areas of technological opportunity by supporting multiple high-potential approaches to the program goals to the point where their relative value for further applications can be determined. This allows the most effective approaches to emerge based on their technical performance and potential. Under ARPA-E's rigorous project management process, project teams work to quarterly milestones for both technical and commercialization goals.

	ELECTRICITY GENERATION & DELIVERY	EFFICIENCY	TRANSPORTATION
Active	ONWARDS (new) SHARKS BETHE GAMOW	HESTIA (new) REMEDY FLECCS REPAIR	ECOSYNBIO ULTIMATE
	PERFORM GEMINA ATLANTIS DAYS	DIFFERENTIATE BREAKERS HITEMMP SENSOR	ASCEND REEACH SMARTFARM
	MEITNER INTEGRATE IONICS GRID DATA	CIRCUITS PNDIODES ENLITENED ROOTS	MARINER REFUEL NEXTCAR
	NODES MOSAIC GENSETS ALPHA	SHIELD ARID MONITOR DELTA	TERRA REMOTE RANGE
	CHARGES REBELS FOCUS SOLAR ADEPT	SWITCHES METALS	TRANSNET AMPED MOVE
HEATS GENI GRIDS IMPACCT	REACT BEEIT ADEPT	PETRO ELECTROFUELS BEEST	
+ OPEN 2009, 2012, 2015, 2018, & 2021 Solicitations + Seedlings, Competitions, Complementary Exploratory Topics + SCALEUP 2019 & 2021			

FOA Acronym	Definition
Electricity Generation and Delivery – Active	
ALPHA	Accelerating Low-Cost Plasma Heating and Assembly
ATLANTIS	Aerodynamic Turbines Lighter and Afloat with Nautical Technologies and Integrated Servo-control
BETHE	Breakthroughs Enabling THERmonuclear-fusion Energy
CHARGES	Cycling Hardware to Analyze and Ready Grid-Scale Electricity Storage
DAYS	Duration Addition to electricity Storage
GAMOW	Galvanizing Advances in Market-Aligned Fusion for an Overabundance of Watts
GEMINA	Generating Electricity Managed by Intelligent Nuclear Assets
GENSETS	Generators for Small Electrical and Thermal Systems
GRID DATA	Generating Realistic Information for the Development of Distribution and Transmission Algorithms
INTEGRATE	Innovative Natural-gas Technologies for Efficiency Gain in Reliable and Affordable Thermochemical Electricity-generation
IONICS	Integration and Optimization of Novel Ion-Conducting Solids
MEITNER	Modeling-Enhanced Innovations Trailblazing Nuclear Energy Reinvigoration
MOSAIC	Micro-scale Optimized Solar-cell Arrays with Integrated Concentration
NODES	Network Optimized Distributed Energy Systems
ONWARDS	Optimizing Nuclear Waste and Advanced Reactor Disposal Systems
PERFORM	Performance-based Energy Resource Feedback, Optimization, and Risk Management
SHARKS	Submarine Hydrokinetic And Riverine Kilo-megawatt Systems
Electricity Generation and Delivery – Alumni	
CHARGES	Cycling Hardware to Analyze and Ready Grid-Scale Electricity Storage
FOCUS	Full-Spectrum Optimized Conversion and Utilization of Sunlight
GENI	Green Electricity Network Integration
GRIDS	Grid-Scale Rampable Intermittent Dispatchable Storage
HEATS	High Energy Advanced Thermal Storage
IMPACCT	Innovative Materials and Processes for Advanced Carbon Capture Technologies

FOA Acronym	Definition
REBELS	Reliable Electricity Based on ELectrochemical Systems
Solar ADEPT	Solar Agile Delivery of Electrical Power Technology
Efficiency – Active	
ARID	Advanced Research In Dry cooling
BREAKERS	Building Reliable Electronics to Achieve Kilovolt Effective Ratings Safely
CIRCUITS	Creating Innovative and Reliable Circuits Using Inventive Topologies and Semiconductors
DELTA	Delivering Efficient Local Thermal Amenities
DIFFERENTIATE	Design Intelligence Fostering Formidable Energy Reduction and Enabling Novel Totally Impactful Advanced Technology Enhancements
ENLITENED	ENergy-efficient Light-wave Integrated Technology Enabling Networks that Enhance Dataprocessing
FLECCS	FLExible Carbon Capture and Storage (FLECCS)
HESTIA	Harnessing Emissions into Structures Taking Inputs from the Atmosphere
HITEMMP	High Intensity Thermal Exchange through Materials, and Manufacturing Processes
MONITOR	Methane Observation Networks with Innovative Technology to Obtain Reductions
PNDIODES	Power Nitride Doping Innovation Offers Devices Enabling SWITCHES
REMEDY	Reducing Emissions of Methane Every Day of the Year
REPAIR	Rapid Encapsulation of Pipelines Avoiding Intensive Replacement
ROOTS	Rhizosphere Observations Optimizing Terrestrial Sequestration
SENSOR	Saving Energy Nationwide in Structures with Occupancy Recognition
SHIELD	Single-Pane Highly Insulating Efficient Lucid Designs
Efficiency – Alumni	
ADEPT	Agile Delivery of Electrical Power Technology
BEETIT	Building Energy Efficiency Through Innovative Thermodevices
METALS	Modern Electro/Thermochemical Advances in Light Metals Systems
REACT	Rare Earth Alternatives in Critical Technologies
SWITCHES	Strategies for Wide Bandgap, Inexpensive Transistors for Controlling High-Efficiency Systems
Transportation – Active	
ASCEND	Aviation-class Synergistically Cooled Electric-motors with iNtegrated Drives
ECOSynBio	Energy and Carbon Optimized Synthesis for the Bioeconomy
MARINER	Macroalgae Research Inspiring Novel Energy Resources
NEXTCAR	Next-Generation Energy Technologies for Connected and Automated On-Road Vehicles
RANGE	Robust Affordable Next Generation Energy Storage Systems
REEACH	Range Extenders for Electric aviation with Low Carbon and High Efficiency
REFUEL	Renewable Energy to Fuels Through Utilization of Energy-Dense Liquids
REMOTE	Reducing Emissions using Methanotrophic Organisms for Transportation Energy
SMARTFARM	Systems for Monitoring and Analytics for Renewable Transportation Fuels from Agricultural Resources and Management
TERRA	Transportation Energy Resources from Renewable Agriculture
ULTIMATE	Ultrahigh Temperature Impervious Materials Advancing Turbine Efficiency
Transportation – Alumni	
AMPED	Advanced Management and Protection of Energy Storage Devices
BEEST	Batteries for Electrical Energy Storage in Transportation
ElectroFuels	Microorganisms for Liquid Transportation Fuel
MOVE	Methane Opportunities for Vehicular Energy
PETRO	Plants Engineered to Replace Oil
TRANSNET	Traveler Response Architecture using Novel Signaling for Network Efficiency in Transportation

One significant component of ARPA-E’s mission is accelerating the economic impact of U.S. investments in energy and climate R&D, and advancing the commercialization readiness of successful projects (depth of investment) is essential to

achieving this goal. Developing the pathway to commercial applications is an intrinsic component of all projects, and project teams are required to conduct activities such as develop a detailed techno-economic analysis, market research, intellectual property protection, and engagement with potential customers and investors. As project teams demonstrate success, ARPA-E's Technology-to-Market Advisors and Program Directors work closely with the teams to help identify pathways toward commercial deployment. Many of ARPA-E's alumni projects have been able to obtain follow-on funding from private investors, state agencies and/or federal programs, and ARPA-E's maturing portfolio is offering increasing opportunities for commercialization of ARPA-E funded technologies.

Despite the level of technology 'de-risking' projects from the focused and OPEN solicitations achieved, ARPA-E determined that in some areas, further de-risking was necessary to validate technologies at a scale pertinent to investment. To this end, in FY 2020, ARPA-E instituted a new solicitation called SCALEUP. SCALEUP is designed to fund successful technologies that were previously funded by ARPA-E for which the proof-of-concept R&D challenges have been addressed, and which can progress toward real-world impact through scaling. An enduring challenge to ARPA-E's mission is that even technologies that achieve substantial technical advancement under ARPA-E support are at risk of being stranded in their development path once ARPA-E funding ends. Experience across ARPA-E's diverse energy portfolios, and with a wide range of investors, indicates that pre-commercial "scaling" projects are critical to establishing that performance and cost parameters can be met in practice for these very early stage technologies. Success in these scaling projects would enable industry, investors, and partners to justify substantial commitments of financial resources, personnel, production facilities, and materials to develop promising ARPA-E technologies into early commercial products.

In FY 2023, ARPA-E plans to release up to 22 new FOAs, including additional investment in SCALEUP. The FOAs will address new areas not represented in the present portfolio and develop new opportunities opened by the outcomes of previous programs. The assessment process for the new programs is now underway as described below.

Potential technology areas for up to 22 focused programs in FY 2023:

ARPA-E is developing programs for transformational research across a wide range of energy and climate technologies, and applications including:

- Energy-related topics may include: Grid resilience, reliability, flexibility, and operation; advanced nuclear or fusion technologies; disruptive storage for transportation and/or grid; carbon neutral or negative fuels; and decarbonization and/or greenhouse gas (GHG) capture.
- Climate-related topics may include: Climate sensors and monitoring for dramatically improved GHG detection, climate analysis, and severe event prediction; carbon neutral/negative agricultural production and general land, freshwater, and ocean use; prevention of GHG emissions from land sources; carbon neutral waste and recycling; and resilient infrastructure to protect against climate-related severe events.

ARPA-E plans to release another SCALEUP FOA in FY 2023 in order to continue the push toward commercialization for previous extremely early-stage ARPA-E programs and to continue the focus on ensuring manufacturing in the U.S.

ARPA-E will also continue its stand-alone SBIR/STTR program to provide additional support to small businesses beyond the significant number of awards to small businesses via ARPA-E's standard non-SBIR/STTR solicitations. ARPA-E plans to release SBIR/STTR funding through its annual SEED program, as well as focused FOAs targeted for SBIR/STTR awards.

**ARPA-E Projects
Funding (\$K)**

ARPA-E Projects:

ARPA-E Projects:

Total, ARPA-E Projects

FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted
392,000	392,000	643,000	+251,000
392,000	392,000	643,000	+251,000

SBIR/STTR

- FY 2021 Enacted: \$14,308 total (SBIR \$12,544 / STTR \$1,764)
- FY 2022 Annualized CR: \$14,308 total (SBIR \$12,544 / STTR \$1,764)
- FY 2023 Request: \$23,470 total (SBIR \$20,576 / STTR \$2,894)

ARPA-E Projects
Explanation of Major Changes (\$K)

FY 2023 Request vs FY 2021 Enacted

ARPA-E Projects: The FY 2023 Congressional Request proposes an additional \$251 million above the FY 2021 Enacted. At the increased appropriation, ARPA-E will fund up to 22 focused programs, another SCALEUP FOA, its stand-alone SBIR/STTR program, and annual SEED program.

+251,000

Total, ARPA-E Projects

+251,000

**Program Direction – Appropriations Request
Funding (\$K)**

	FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted
Washington Headquarters				
Salaries and Benefits	11,810	11,810	18,879	+7,069
Travel	400	400	2,000	+1,600
Support Services	16,432	16,432	26,246	+9,814
Other Related Expenses	6,358	6,358	10,025	+3,667
Total, Program Direction	35,000	35,000	57,150	+22,150
Federal FTEs	64	64	101	+37
Support Services				
Technical Support	5,751	5,751	9,186	+3,435
Management Support	10,681	10,681	17,060	+6,379
Total, Support Services	16,432	16,432	26,246	+9,814
Other Related Expenses				
Working Capital Fund	4,123	4,123	6,732	+2,609
Energy Information Technology Services (EITS)	1,588	1,588	2,593	+1,005
Other Services	647	647	700	+53
Total, Other Related Expenses	6,358	6,358	10,025	+3,667

Program Direction

Activities and Explanation of Changes

FY 2021 Enacted	FY 2023 Request	Explanation of Changes FY 2023 Request vs FY 2021 Enacted
Program Direction \$35,000,000	\$57,150,000	+ \$22,150,000
Salaries and Benefits		
At the FY 2021 Enacted level, ARPA-E anticipates supporting up to 64 Federal FTEs.	At the FY 2023 Request level, ARPA-E anticipates needing up to 101 Federal FTEs. Salaries and benefits will increase from the FY 2021 Enacted level commensurate with the overall Projects and Program Direction appropriations. Additional Program Directors, Tech to Market, and Operations staff will be added in FY 2023 to support ARPA-E's growing portfolio and expanded climate mission.	+ \$7,069,000: The increase from the FY 2021 Enacted level supports an additional 37 FTEs in support of ARPA-E's expanded climate mission.
Travel		
At the FY 2021 Enacted level, ARPA-E Program Directors and Technology-to-Market advisers will visit performers as part of ARPA-E's hands-on engagement, which is the primary component of ARPA-E travel. The number of site visits will be commensurate with the number of ongoing projects.	At the FY 2023 Request level, ARPA-E Program Directors and Technology-to-Market advisers will visit performers regularly as part of ARPA-E's hands-on engagement. The number of site visits will be commensurate with the number of ongoing projects. FY 2023 Travel is expected to return to pre-COVID levels.	+ \$1,600,000: Travel will increase as new projects initiate and ARPA-E Program Directors and Technology-to-Market advisers visit performers as part of ARPA-E's hands-on engagement. FY 2023 is expected to return to pre-COVID levels and increase four times over the FY 2021 level.
Support Services		
At the FY 2021 Enacted level, ARPA-E anticipates continuing the use of support service contractors to support ARPA-E federal staff in the management and oversight of projects and other required functions. The level of support is commensurate to the number of ongoing and anticipated projects.	At the FY 2023 Request level, ARPA-E anticipates continuing the use of support service contractors to support ARPA-E federal staff in the management and oversight of projects and other required functions. The level of support is commensurate with the number of ongoing and anticipated projects.	+ \$9,814,000: Support services will increase from FY 2021 levels as ARPA-E continues management and oversight of its growing portfolio and expanded climate mission.
Other Related Expenses		
The FY 2021 Enacted level for other related expenses primarily consists of Working Capital Fund and Energy Information Technology support costs, which are commensurate with the level of FTEs and support services requested.	The FY 2023 Request level for other related expenses primarily consists of Working Capital Fund and Information Technology support costs, which are commensurate with the level of FTEs and support services requested.	+ \$3,667,000: IT and WCF costs are expected to increase proportionally with the overall increase in Program Direction budget and costs associated with additional staffing.

**Advanced Research Projects Agency - Energy
Research and Development (\$K)**

	FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted
Basic	0	0	0	0
Applied	213,500	213,500	350,075	+136,575
Development	213,500	213,500	350,075	+136,575
Subtotal, R&D	427,000	427,000	700,150	+273,150
Equipment	0	0	0	0
Construction	0	0	0	0
Total, R&D	427,000	427,000	700,150	+273,150

**Advanced Research Projects Agency - Energy
Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) (\$K)**

	FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request
ARPA-E Projects			
SBIR	12,544	12,544	20,576
STTR	1,764	1,764	2,894
Total, SBIR/STTR	14,308	14,308	23,470

- FY 2021 Enacted: \$14,308 total (SBIR \$12,544 / STTR \$1,764)
- FY 2022 Annualized CR: \$14,308 total (SBIR \$12,544 / STTR \$1,764)
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