Advanced Reasearch Projects Agency-Energy

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Advanced Research Projects Agency - Energy
($K)

FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request
425,000	427,000	500,000

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 and energy security of the United States through the development of energy 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; and improve the resilience, reliability, and security of infrastructure to produce, deliver, and store energy. ARPA-E will ensure that the United States maintains a technological lead in developing and deploying advanced energy technologies. ARPA-E will identify and promote revolutionary advances in energy-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. The role of ARPA-E is not to duplicate DOE's basic research and applied programs but to focus on novel early-stage energy research and development (R&D) with technology applications that can be meaningfully advanced with a small investment over a defined period of time.

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 energy 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, ARPA-E has provided approximately $2.6 billion in funding to over 1,000 projects through focused programs and Open funding solicitations. 177 ARPA-E projects have attracted more than $4.9 billion in private-sector follow-on funding, 237 project teams have partnered with other agencies for further development, and 88 companies have been formed from ARPA-E projects. In addition, ARPA-E project teams have generated 4,614 peer-reviewed journal articles and received 716 patents from the U.S. Patent and Trademark Office.

In 2017, the National Academy of Sciences (NAS), in response to a congressional request, assessed ARPA-E's first six years of operation[1]. NAS reported that "There are clear indicators that ARPA-E is making progress toward achieving its statutory mission and goals, and it cannot reasonably be expected to have completely fulfilled those goals given so few years of operation and the size of its budget." The report went on to state, "Importantly, especially at this early stage, the committee found no signs that ARPA-E is failing, or on a path to failing, to deliver on its mission and goals."

In FY 2020, ARPA-E was appropriated a 16.5% year-over-year increase for its program budget and set a record of $404.2 million in funding obligated. This funding was spread over 271 projects across a wide range of technical areas. Additionally, in FY 2020 ARPA-E launched eleven Focused Programs with up to $342.5 million in total available funding. The Focused Programs fill technical whitespace that ARPA-E's talented scientific team identified, with the assistance of academia and industry. ARPA-E launched 19 Solicitations on Topics Informing New Program Areas with up to $41.25 million in total

[1] https://www.nap.edu/catalog/24778/an-assessment-of-arpa-e

funding. These are investigatory programs that pursue innovative technologies and unconventional ideas that can lead to focused ARPA-E programs in the future and also drive high-risk R&D for potentially disruptive technologies. In addition to Focused Programs and Solicitations on Topics Informing New Program Areas, ARPA-E introduced a new approach to help previously funded technology get deployed by establishing a program called SCALEUP (Seeding Critical Advances for Leading Energy technologies with Untapped Potential). 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.

Highlights and Major Changes in the FY 2022 Budget Request

In FY 2022, ARPA-E plans to release up to fifteen new funding opportunity announcements (FOAs). The FOAs will address new areas not represented in the present portfolio and develop new opportunities opened by the outcomes of previous programs.

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

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted ($)	FY 2022 Request vs FY 2021 Enacted (%)
ARPA-E Projects	390,000	392,000	463,000	+71,000	+18%
Program Direction	35,000	35,000	37,000	+2,000	+6%
Total, Advanced Research Projects Agency - Energy	**425,000**	**427,000**	**500,000**	**+73,000**	**+17%**
Federal FTEs	**64**	**64**	**64**	**+0**	**+0%**

ARPA-E Projects

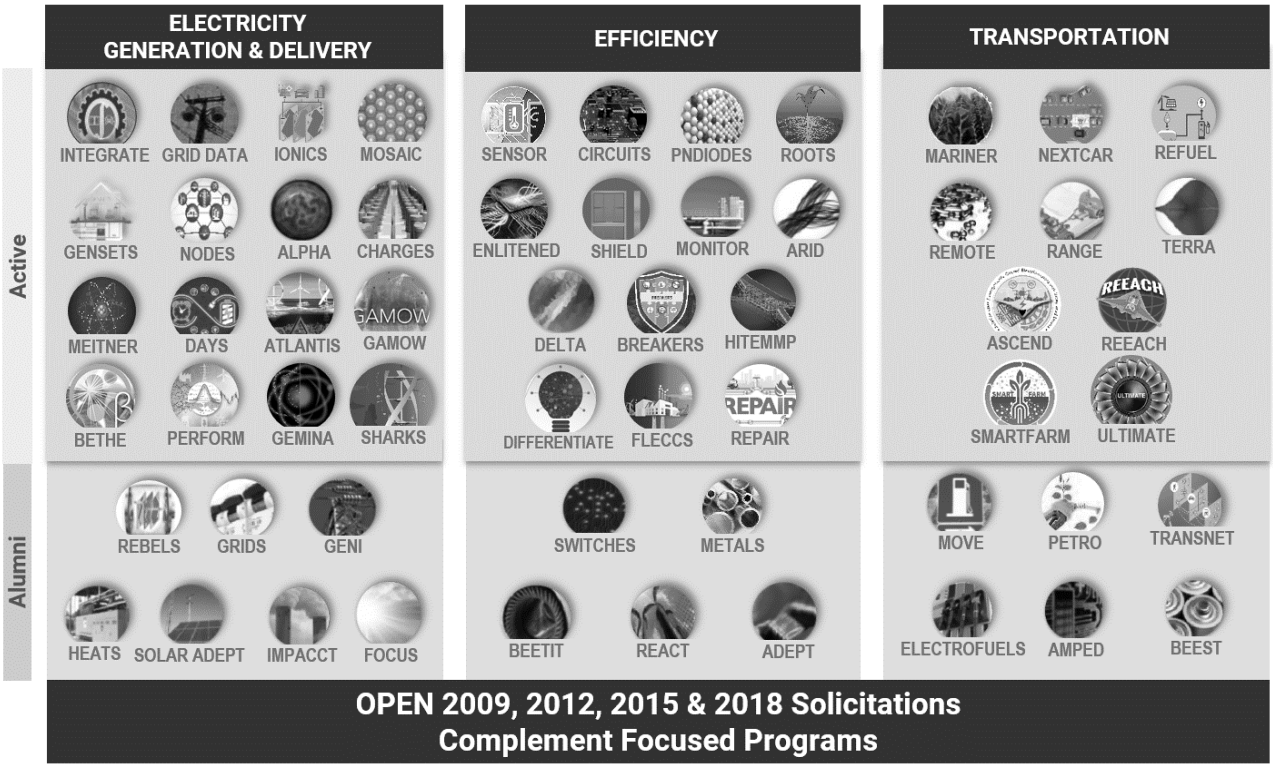
Overview

ARPA-E identifies and supports revolutionary energy inventions and transformational energy 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 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.



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
PERFORM	Performance-based Energy Resource Feedback, Optimization, and Risk Management
SHARKS	Submarine Hydrokinetic And Riverine Kilo-megawatt Systems
Electricity Generation and Delivery – Alumni	
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
REBELS	Reliable Electricity Based on ELectrochemical Systems
Solar ADEPT	Solar Agile Delivery of Electrical Power Technology

FOA Acronym	Definition
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)
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
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
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 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 2022, ARPA-E plans to release up to fifteen 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 fifteen focused programs in FY 2022:
ARPA-E is developing programs for transformational research across a wide range of energy technologies, and applications including:

- Materials for carbon-neutral or carbon-negative buildings: Novel technologies could enable buildings to be transformed into carbon sinks to reduce their embodied emissions, and potentially make future buildings carbon neutral or even carbon negative. If successful, these technologies would have a significant impact on energy usage and provide a valuable pathway for carbon sequestration. This focus area entails novel materials derived from feedstocks including forestry and other purpose-grown raw materials, agricultural residues, as well as direct use of greenhouse gases (e.g., carbon dioxide, methane). Attaining this vision requires radical new developments in building materials and manufacturing methods. Comprehensive and robust life-cycle analyses and carbon accounting, along with permanency of storage and end-of-life design, will also be necessary.

- Technologies to dramatically reduce high-level nuclear waste: The realization of safe, economical nuclear energy is a critical component for multiple ARPA-E mission areas. Addressing urgent needs for the disposal of existing nuclear waste via novel technologies and processes that eliminate inherent risks, regarding both safety and security, is a key element of this focus. New technologies are required such as modular separations and processing systems which could economically, safely, and securely reduce by an order of magnitude the amount of high-level waste in spent nuclear fuel. Technologies developed in this area may prove beneficial for waste from commercial nuclear reactors, from emerging advanced reactor concepts, or from other sources.

- Advanced battery electrodes and conductors for high capacity and rapid charge: New, disruptive pathways to develop the next generation of batteries are crucial to formulate now to achieve U.S. leadership in this highly competitive area. This focus area seeks to develop battery systems that can withstand extremely fast charging, have a much higher capacity at lower weight, or utilize abundant, easily-sourced materials – all well beyond the capability of current generation Li-ion, or even emerging solid-state Li-metal batteries. Such attributes could enable broad adoption of electrified transportation applications, including electric vehicles and electrified aviation.

- Grid resilience, reliability, and flexibility: The needs for the future grid are rapidly evolving with increased levels of renewable power, the proliferation of distributed energy resources (DERs), and the strains and disruptions of extreme weather. These needs are extremely challenging, as the infrastructure for the future grid will still be highly dependent on legacy systems that are decades, or in some cases over a century, old. This presents a tremendous challenge to integrate new technologies within an old system in the face of rapidly changing requirements. In this focus area, ARPA-

E is developing technologies that flexibly utilize grid resources – new and old – through approaches in topology and power flow optimization, integration of DERs into transmission-level operations, and microgrids. These approaches may enhance legacy grid operation systems in the near-term, and seek to provide a path to the fully flexible, resilient, and reliable grid system of the future.

- Advanced Fusion Approaches and Energy Applications: Fusion energy is one of a very few potential baseload, low-carbon energy sources that could scale to global proportions. It is an important technology option to develop given this large-scale potential, and if successful, could provide a long-term sustainable energy solution for humanity. Most fusion research today focuses on the Deuterium-Tritium (D-T) thermonuclear reaction, which is the most scientifically mature and accessible path to fusion power, however this is still decades away. There are many other fuel options that, while less scientifically mature than D-T, could offer significant system advantages with far lower levels of neutron production and resultant radiological waste, along with novel power conversion approaches.

- SCALEUP: Expanding the SCALEUP program both in scope and funding level 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 Supporting Entrepreneurial Energy Discoveries (SEED) program as well as focused FOAs targeted for SBIR/STTR awards.

ARPA-E Projects
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
ARPA-E Projects:				
Transportation Systems	195,000	196,000	231,500	+35,500
Stationary Power Systems	195,000	196,000	231,500	+35,500
Total, ARPA-E Projects	**390,000**	**392,000**	**463,000**	**+71,000**

SBIR/STTR

- FY 2020 Enacted: $14,235 total (SBIR $12,480 / STTR $1,755)
- FY 2021 Enacted: $14,308 total (SBIR $12,544 / STTR $1,764)
- FY 2022 Request: $16,900 total (SBIR $14,816 / STTR $2,084)

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

	FY 2022 Request vs FY 2021 Enacted
Transportation Systems: The FY 2022 Congressional Request proposes an additional $71 million above the FY 2021 Enacted. ARPA-E will continue to invest roughly half of its mission funding in transportation systems.	**+35,500**
Stationary Power Systems: The FY 2022 Congressional Request proposes an additional $71 million above the FY 2021 Enacted. ARPA-E will continue to invest roughly half of its mission funding in stationary power systems	**+35,500**
Total, ARPA-E Projects	**+71,000**

Program Direction – Appropriations Request
Funding ($K)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
Washington Headquarters				
Salaries and Benefits	11,500	11,810	12,129	+319
Travel	1,750	400	1,600	+1,200
Support Services	16,000	16,432	16,876	+444
Other Related Expenses	5,750	6,358	6,395	+37
Total, Program Direction	**35,000**	**35,000**	**37,000**	**+2,000**
Federal FTEs	**64**	**64**	**64**	**0**
Support Services				
Technical Support	5,600	5,751	5,907	+156
Management Support	10,400	10,681	10,969	+288
Total, Support Services	**16,000**	**16,432**	**16,876**	**+444**
Other Related Expenses				
Working Capital Fund	3,773	4,123	4,123	0
Energy Information Technology Services (EITS)	1,588	1,588	1,667	+79
Other Services	389	647	605	-42
Total, Other Related Expenses	**5,750**	**6,358**	**6,395**	**+37**

Program Direction

Activities and Explanation of Changes

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
Program Direction $35,000,000	**$37,000,000**	**+ $2,000,000**
Salaries and Benefits		
At the FY 2021 Enacted level, ARPA-E anticipates supporting up to 64 Federal FTEs.	At the FY 2022 Request level, ARPA-E anticipates needing up to 64 Federal FTEs. It is assumed that S&B will escalate 2.7% from the FY 2021 Enacted level. Additional Program Directors and Tech to Market staff will be added in FY22 to support ARPA-E's growing portfolio but overall FTE utilization is expected to remain level as some ARPA-E staff will split time with ARPA-C to facilitate the establishment of ARPA-C.	+ $319,000: Increase in cost due to FTE cost escalation.
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 2022 Request level, ARPA-E Program Directors and Technology-to-Market advisers will visit performers regularly 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. FY 2022 Travel is expected to return to pre-COVID levels.	+ $1,200,000: 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 2022 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 2022 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.	+ $444,000: Increase from FY 2021 levels as ARPA-E continues management and oversight of its growing portfolio.

FY 2021 Enacted	FY 2022 Request	Explanation of Changes FY 2022 Request vs FY 2021 Enacted
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 2022 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.	+ $37,000: IT costs are expected to increase up to 5% in FY 2022 due to enterprise-wide data center migrations, Office 365 upgrades, IT modernization, VTC upgrades, and Security Operations Center maturity. It is assumed that WCF costs will remain flat in FY 2022.

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

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request	FY 2022 Request vs FY 2021 Enacted
Basic	0	0	0	0
Applied	195,000	196,000	231,500	+35,500
Development	195,000	196,000	231,500	+35,500
Subtotal, R&D	390,000	392,000	463,000	+71,000
Equipment	0	0	0	0
Construction	0	0	0	0
Total, R&D	**390,000**	**392,000**	**463,000**	**+71,000**

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

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request
ARPA-E Projects			
SBIR	12,480	12,544	14,816
STTR	1,755	1,764	1,764
Total, SBIR/STTR	**14,235**	**14,308**	**16,900**

- FY 2020 Enacted: $14,235 total (SBIR $12,480 / STTR $1,755)
- FY 2021 Enacted: $14,308 total (SBIR $12,544 / STTR $1,764)
- FY 2022 Request: $16,900 total (SBIR 14,816 / STTR $2,084)

DEPARTMENT OF ENERGY

Funding by Site

TAS_0337 - Advanced Research Projects Agency - Energy BY2022

(Dollars in Thousands)

	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request Detail
Washington Headquarters			
ARPA-E Projects	390,000	392,000	463,000
Program Direction - ARPA-E	35,000	35,000	37,000
Total Washington Headquarters	**425,000**	**427,000**	**500,000**
Total Funding by Site for TAS_0337 - Advanced Research Projects Agency - Energy	**425,000**	**427,000**	**500,000**