

# **Advanced Research Projects Agency- Energy**



## Volume 4

### Table of Contents

	Section
Appropriation Language .....	AR - 1
Overview .....	AR - 3
Funding by Site by Program .....	AR - 7
ARPA-E Projects .....	AR - 9
Transportation Systems .....	AR - 15
Stationary Power Systems .....	AR - 19
Program Direction.....	AR - 23

The Department of Energy's Congressional Budget justification is available on the Office of Chief Financial Officer, Office of Budget homepage at <http://www.cfo.doe.gov/crorg/cf30.htm>.

For the latest details on the Department of Energy's implementation of the Recovery Act, please visit:  
<http://www.energy.gov/recovery>



**Advanced Research Projects Agency - Energy**

**Proposed Appropriation Language**

*For necessary expenses in carrying out the activities authorized by section 5012 of the America COMPETES Act (Public Law 110-69), as amended, \$379,000,000, to remain available until expended: Provided, That \$34,110,000 shall be available until September 30, 2015 for program direction.*

**Explanation of Change**

No change







## Advanced Research Projects Agency - Energy (ARPA-E)

### Overview Appropriation Summary by Program\*

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Advanced Research Projects Agency – Energy Projects	253,000	256,561	344,890
Program Direction	22,000	20,122	34,110
Total, Advanced Research Projects Agency – Energy	275,000	276,683	379,000

\*FY 2013 amounts shown reflect the P.L. 112-175 continuing resolution level annualized to a full year. These amounts are shown only at the “congressional control” level and above; below that level a dash (—) is shown.

#### \*SBIR/STTR

- FY 2012 Current: SBIR: \$6,630,000 STTR: \$892,500
- FY 2013 Annualized CR: SBIR: \$6,927,136 STTR: \$897,962
- FY 2014 Request: SBIR: \$9,656,920 STTR: \$1,379,560

### Office Overview and Accomplishments

**The Advanced Research Projects Agency - Energy** (ARPA-E) mission is to support energy technology innovations that will enhance the economic and energy security of the United States through the development of transformational technologies that reduce America’s dependence on energy imports; reduce U.S. energy related emissions; improve energy efficiency across all sectors of the U.S. economy; and ensure the U.S. maintains a technological lead in the development and deployment of advanced energy technologies. ARPA-E focuses exclusively on high-impact innovations, translating science into breakthrough technologies that promise genuine transformation in the ways we generate, store, and utilize energy.

ARPA-E funds technologies that are not being supported by other parts of DOE or the private sector because of technical and financial uncertainty. ARPA-E coordinates closely with other DOE programs, the rest of the federal government, academia, and the private sector to identify “white space” where others are not making investments in innovation but that would be appropriate for ARPA-E’s support. ARPA-E’s technology acceleration model is discussed at length in the Projects section that follows.

The role of ARPA-E is to translate science into innovative breakthrough technologies that no one else is pursuing,

e.g. technologies that are defined by new learning curves (see Figure). By definition these involve new and innovative, but potentially riskier, approaches than traditional or current learning curves. But they also offer the prospect of transformational and disruptive technologies by dramatically reducing their costs-to-performance ratio.

ARPA-E’s goal is to support these approaches and to showcase them to enable further development through either the private sector or the federal government. Some of these approaches will potentially fail, but the ones that succeed could transform the energy sector and make today’s approaches obsolete. It is difficult to know which ones will fail or succeed, but all failures provide opportunities to learn and could become the basis for further innovation.



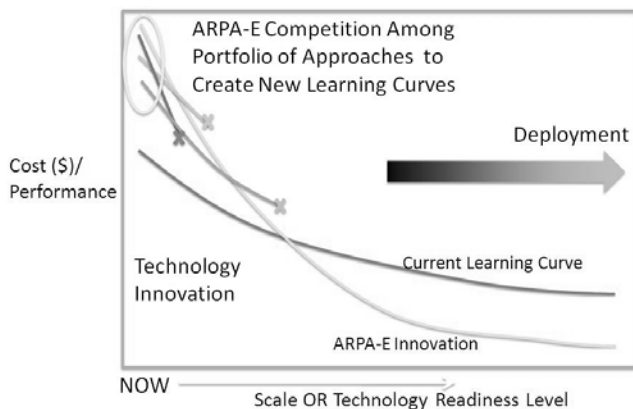


Figure: ARPA-E Innovations Create New Learning Curves

While it is too soon to know if ARPA-E projects will find commercial success, preliminary indicators of likely success do include: technical achievements, handoffs of supported technologies to other actors, follow on funding, and to a lesser degree publications and patents.

ARPA-E has already experienced several notable preliminary indicators of likely success. ARPA-E performers have made significant technical achievements in areas such as energy storage, biofuels, and power electronics.

Because ARPA-E focuses exclusively on early stage R&D, many of the projects need additional investment to build upon their technical breakthroughs and move into the marketplace. ARPA-E demands a credible path to additional funding and commercialization when launching projects and has a dedicated tech to market team to help. ARPA-E awardees are pursuing several pathways to advance their breakthroughs:

- **Public Partnerships:** ARPA-E formed a partnership with the U.S. Navy to advance research in 5 projects from the Building Energy Efficiency Through Innovative Thermodevices, or “BEETIT” program aimed at improving heating and air conditioning efficiency.
- **Encouraging New Company Formation:** University awardees have launched new companies to further develop ARPA-E funded technologies in the areas of grid scale batteries, biofuels, and efficient thermo devices. To date, eleven ARPA-E projects have generated spinoff companies and one project resulted in a company that had a successful Initial Public Offering.
- **Spurring Private Investment:** Some private companies have strategically invested in furthering and adopting

technologies that received ARPA-E support internally. Other private companies have licensed ARPA-E funded technologies that they incorporated into new product lines or larger systems. In addition, technologies from several companies that received ARPA-E awards – 17 companies (representing about \$70 million in ARPA-E investment), have attracted over \$450 million in follow-on funding to further the technologies on their pathways to the market.

ARPA-E evaluates the effectiveness of its projects by practicing an active program management that includes detailed high-impact milestones, performer site visits, quarterly report evaluation, and project terminations when goals are not being met. ARPA-E builds the milestones for its projects based upon a rigorous program definition and management process. ARPA-E conducts market analyses that shape program goals aimed at maximize the impact of new technologies, which often attracts early engagement and investment by the private sector.

Several aspects of ARPA-E’s existing technology acceleration model are in harmony with the May 2012 OMB memorandum regarding evidence based decision making. For instance, ARPA-E has worked to analyze previous funding opportunities from creation to completion and apply the best management lessons to continually improve the FOA creation, project selection, and program management process. ARPA-E, in consultation with industry and government experts, is exploring other ways in which the program can build evidence about what aspects of the ARPA-E technology acceleration model will lead to greater success over time.

Further, aspects of ARPA-E’s existing operating model are attuned to the June 2012 joint OMB/OSTP memorandum regarding Science and Technology priorities. For instance, ARPA-E promotes innovation and commercialization of the technologies it funds through the efforts of its dedicated in-house commercialization team. ARPA-E endeavors to avoid duplicating research in areas that already receive funding from the private sector.

#### **Research Coordination across DOE**

As part of its technology acceleration model, ARPA-E actively coordinates with other DOE offices and Federal agencies and others in the technical community in order to ensure that its projects do not overlap with other programs at DOE or elsewhere but instead complement them in multiple ways. ARPA-E engages these



stakeholders when it conducts workshops, establishes technical metrics for potential funding solicitations, and reviews applications.

ARPA-E works in close coordination with program offices on its “borders” – DOE’s basic science and applied research offices – to avoid duplicative research and ensure a balanced research portfolio across the DOE. ARPA-E utilizes the close coordination and collaboration to identify ripe opportunities for ARPA-E investment. This coordination serves to inform all parties of each other’s ongoing research activities and to facilitate the transition of successful ARPA-E projects to other DOE offices or elsewhere.

#### **Research Coordination across the Federal Government**

ARPA-E is coordinating with the Department of Defense (DOD) in two instances under the DOD/DOE MOU signed in July 2010. First, ARPA-E developed the Advanced Management and Protection of Energy-storage Devices (AMPED) program to increase the performance of energy storage systems in conjunction with DOD and in support of DOD’s Hybrid Energy Storage Module program. Second, up to four of ARPA-E’s Building Energy Efficiency Through Innovative Thermo-devices (BEETIT) performers will be advanced and continued through the Naval Facilities Engineering Command Navy Expeditionary Technology Transition (NAVFAC NETT) Program.

ARPA-E has also developed its biofuel programs in close consultation with the Department of Agriculture (USDA), specifically focused on regulations, research goals, and USDA’s biological knowledge base. Further, ARPA-E is coordinating research activities with the Department of Transportation.

ARPA-E has interagency agreements with several entities to serve as third-party laboratory test facilities for ARPA-E performer technologies. ARPA-E and the National Institute of Standards and Technology (NIST) established a national Facility for Adsorbent Characterization and Testing (FACT) to characterize and validate sorbent materials synthesized by DOE funded research and development programs and specifically to support the research programs funded by ARPA-E. The Naval Surface Warfare Center (Crane) is testing batteries developed under the Batteries for Electrical Energy Storage in Transportation (BEEST) program.

ARPA-E also has funded the Naval Postgraduate School (NPS) and the Naval Facilities Engineering Command Expeditionary Warfare Center (NAVFAC EXWC) to provide technical consulting services in areas including

the development, testing, evaluation, and operational deployment of lithium-ion battery systems integrated with advanced battery management systems. ARPA-E recently announced a partnership with the National

Science Foundation’s Innovation Corps program (I-Corps) which seeks to foster the commercialization of government-funded technology research. The program includes an intensive six-week program. Five project teams ARPA-E recommended for the program were selected to participate in the upcoming I-Corps program.

Finally, ARPA-E has developed a technical seminar series with the Department of State to better inform them on the status of various energy technologies.

#### **Alignment to Strategic Plan**

Through its work, ARPA-E contributes to the achievement of the Department’s strategic goal, “**Transform our Energy Systems:** Catalyze the timely, material, and efficient transformation of the nation’s energy system and secure U.S. leadership in clean energy technologies.”

The Department’s May 2011 Strategic Plan outlines the objective to which ARPA-E aligns its activities: Discover the New Solutions We Need. The Strategic Plan identifies four targeted outcomes to achieving these objectives, and ARPA-E is responsible for supporting Strategic Plan outcomes through its budget request. The targeted outcomes are:

- Catalyze by the development of transformative and potentially disruptive energy technologies;
- Drive the transition of high-impact energy innovations toward market adoption;
- Contribute to the advancement of U.S. leadership and global competitiveness in energy innovation;
- Build itself as an innovative, highly effective, and sustainable organization.

#### **Goal/Program Alignment Summary**

	GOAL: Fulfill statutory mission
ARPA-E Projects	100%
Program Direction	100%
Total, ARPA-E	100%



**Strategic Plan and Performance Measures**

<b>Performance Goal (Measure)</b>	<b>Award Funding</b> - Cumulative percentage of award funding committed 45 days after award selections are announced		
<b>Fiscal Year</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>
<b>Target</b>	70 %	70 %	70 %
<b>Result</b>	(70%)		
<b>Endpoint Target</b>	No endpoint - continuous measure of efficiency in awarding funds		

<b>Performance Goal (Measure)</b>	<b>Follow-on Funding</b> - Cumulative percentage of follow-on funding from other federal and private organizations		
<b>Fiscal Year</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>
<b>Target</b>	15 %	20 %	20 %
<b>Result</b>	Met		
<b>Endpoint Target</b>	No endpoint - continuous measure of encouraging follow-on funding		

Please see Annual Performance Plan/Report (APPR) for a full list of measures and targets.

\*2013 targets represent DOE's FY 2013 Budget Request to Congress. FY 2013 target updates can be found in the upcoming FY 2012-2014 Annual Performance Plan & Report.



**Advanced Research Projects Agency - Energy (ARPA-E)**  
**Funding by Site by Program**

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Washington Headquarters			
Advanced Research Projects Agency – Energy (ARPA-E)	275,000	276,683	379,000
Total, Washington Headquarters	275,000	276,683	379,000
Total, Advanced Research Projects Agency – Energy (ARPA-E)	275,000	276,683	379,000

\*FY 2013 amounts shown reflect the P.L. 112 175 continuing resolution level annualized to a full year. These amounts are shown only at the “congressional control” level and above; below that level a dash (—) is shown.







**ARPA-E Projects  
Funding Profile by Subprogram and Activities\***

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
ARPA-E Projects			
Projects	253,000	----	344,890
Total, ARPA-E Projects	253,000	256,561	344,890

\*FY 2013 amounts shown reflect the P.L. 112 175 continuing resolution level annualized to a full year. These amounts are shown only at the “congressional control” level and above; below that level a dash (—) is shown.

**\* SBIR/STTR**

- FY 2012 Current: SBIR: \$6,630,000 STTR: \$892,500
- FY 2013 Annualized CR: SBIR: \$6,927,136 STTR: \$897,962
- FY 2014 Request: SBIR: \$9,656,920 STTR: \$1,379,560

**Comparable Funding Profile by Subprogram and Activities**

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
ARPA-E Projects			
Transportation Systems*	138,250	---	196,587
Stationary Power Systems*	114,750	---	148,303
Total, ARPA-E Projects	253,000	256,561	344,890

\*Because the Transportation Systems and Stationary Power Systems thrusts were new for the FY 2013 Congressional Justification, a comparable funding profile is provided to show estimates for how the FY 2012 funds are split between the Transportation Systems or Stationary Power Systems thrusts.

**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 Reauth. Act of 2010”

**Overview**

ARPA-E Projects will identify and promote early-stage research projects that have the promise to make revolutionary advances in applications of energy science, translate scientific discoveries and cutting-edge inventions into technological innovations, and accelerate transformational technological advances in areas that the private sector by itself will not support because of technical and financial risk and uncertainty.

ARPA-E programs generally fall into two categories:

- New Areas of Science and Technology—for example, the goal of ARPA-E’s current Electrofuels program is to produce biofuels in a new way from non-photosynthetic autotrophic bacteria. This first-of-kind program is emblematic of ARPA-E and, if successful, could create an entirely new industry.
- Next Generation of Technology—for example, ARPA-E’s current program called Batteries for Electrical Energy Storage in Transportation, or BEEST. While DOE’s applied energy activities and most outside R&D is focused on lithium batteries, ARPA-E is looking for other battery chemistries that, if successful, would yield batteries that are less expensive and provide



longer range and storage capabilities than today's approaches.

ARPA-E will continue to employ a project management hierarchy of thrust-portfolio-program-project. ARPA-E will continue to have two primary thrusts: Transportation Systems and Stationary Power Systems. These two broad thematic strategic thrusts and their attendant portfolios and programs are explored more deeply in the Transportation Systems and Stationary Power Systems sections that follow.

#### **Program Accomplishments and Milestones**

During FY 2012 ARPA-E enjoyed several notable program accomplishments and milestones as detailed below.

- **Batteries:** An ARPA-E awardee announced the world record in energy density at 400 Wh/kg for a rechargeable lithium-ion battery, doubling the capacity of today's batteries. This advance could cut battery costs by half, perhaps enabling electric cars with comparable range and cost as gasoline-powered cars.
- **Power Electronics:** An ARPA-E awardee has had early success in developing a 1 MW transistor the size of a human fingernail made of silicon carbide. If successful, the higher frequencies enabled by the transistor would allow for a much smaller transformer itself. A 1000 kVA transformer could then shrink from 8,000 pounds to only 100 pounds; it would require fewer materials and could be deployed closer to end users. This would greatly reduce costs and increase reliability for the electric grid.
- **Biofuels:** An ARPA-E awardee succeeded in engineering microbes that use hydrogen and carbon dioxide to make liquid transportation fuel. Further, this was done without sunlight and has the potential to be 10 times more efficient than current photosynthetic biofuels.
- **Grid Scale Storage:** An ARPA-E awardee developed a near-isothermal compressed air energy storage system that prevents air from heating up during compression and cooling down during expansion. When integrated with renewable energy generation, such as a wind farm, this technology would allow intermittent energy to be stored as compressed air in salt caverns or pressurized tanks. Unlike conventional compressed air energy storage, no gas is burned to convert the stored high-pressure air back into electricity. The result of this breakthrough is an ultra-efficient, fully shapeable, 100 percent renewable, and carbon-free power product.

Also in FY 2012, ARPA-E issued Funding Opportunity Announcements (FOAs) totaling about \$225 million to develop two new focused program areas, fund a stand-alone SBIR/STTR program, and an Open FOA that could spark critical breakthrough technologies.

- **Methane Opportunities for Vehicular Energy (MOVE):** This program seeks to fund the development of transformational technologies that reduce the barriers to mass adoption of natural gas use in vehicles. Of particular interest are technologies that enable at-home refueling and low-cost, high energy density on-board storage for natural gas vehicles. Under MOVE, ARPA-E awarded almost \$27 million to 13 projects.
- **Advanced Management and Protection of Energy-storage Devices (AMPED):** AMPED aims to maximize performance, safety, and lifetime of existing and future battery chemistries through system-level innovations, distinct from the many efforts aimed at underlying battery materials. The AMPED program's focus on advances in internal state sensing, modeling and diagnostics will dramatically improve and provide new innovation in battery management systems. These innovations will help reduce costs and improve the performance of next generation energy storage systems for plug-in electric and hybrid-electric vehicles as well as grid storage. Under AMPED, ARPA-E awarded over \$30 million to 14 projects.
- **Energy Storage SBIR/STTR Funding Opportunity Announcement (FOA):** ARPA-E solicited projects to be performed under the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs authorized pursuant to Section 9 of the Small Business Act (15 U.S.C. § 638). ARPA-E is funding the research of transformational technologies that reduce the barriers to mass adoption of electrical energy storage for stationary and transportation applications. Under its SBIR/STTR program, ARPA-E awarded almost \$13 million to 7 projects.
- **Open Funding Opportunity Announcement (FOA; OPEN FOA 2012):** To address the challenges of the rapidly evolving global energy market, ARPA-E seeks to support transformational research in all areas of energy technology, including energy generation, storage, transmission, and use in both the transportation and stationary power sectors. OPEN 2012 projects cut across 11 technology areas: advanced fuels, advanced vehicle design and materials, building efficiency, carbon capture, grid modernization, renewable power, stationary power



generation, tidal power, as well as stationary, thermal, and transportation energy storage. Under OPEN 2012, ARPA-E awarded over \$130 million to 66 projects.

To date in FY 2013, ARPA-E has issued one FOA and plans to issue five to eight additional FOAs. All additional FOA topics are pre-decisional.

- **Robust, Affordable, Next-Generation EV-Storage (RANGE)**: This program seeks to fund the development of transformational electrochemical energy storage technologies that will accelerate widespread electric vehicle adoption by dramatically improving their driving range, cost, and reliability. Under RANGE, ARPA-E anticipates \$20-\$30 million in awards.

#### **Milestone**

Make decisions on program goals, activities, and funding based on annual review, contingent upon appropriations.

#### **Date**

April 2013

#### **Program Planning and Management**

ARPA-E programs are created through a technology acceleration model that begins with a thorough vetting of a particular technology concept. Figure 2 shows the full life cycle of an ARPA-E program (Envision, Engage, Evaluate, Establish, and Execute) from program conception through transition toward market adoption (See Figure).

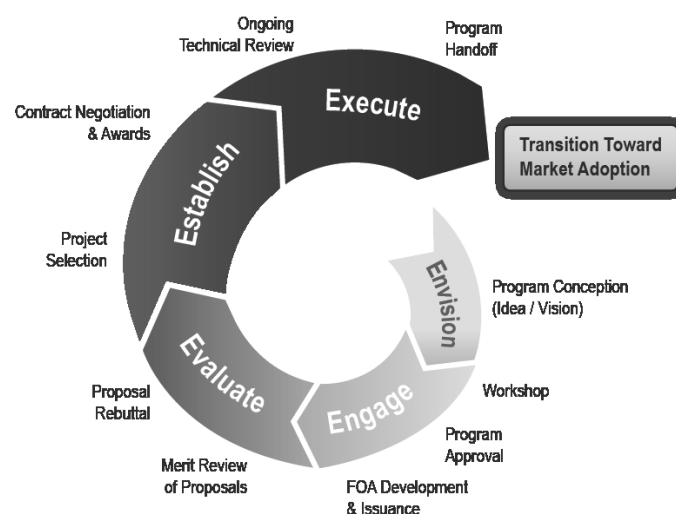


Figure: ARPA-E Technology Acceleration Model

ARPA-E selects potential investment areas by considering the science and technology landscape, the market

landscape, and the regulatory landscape. ARPA-E will invest in technology development only in instances where circumstances in each of these areas are aligned to enable transformative, breakthrough discoveries that have the potential to then be brought to market scale. Technical flexibility and empowerment of Program Directors are key aspects of ARPA-E. Before starting a program ARPA-E Program Directors and staff will do in-depth research, including market studies and consultations with experts from the technical community, and hold a technical workshop to determine if ARPA-E should start a program in an area of interest. Not every workshop necessarily leads to a program/FOA, but every program/FOA follows from a workshop. This deliberative approach gives ARPA-E confidence that the space is ripe for an ARPA-E investment.

By bringing together experts from across disciplines in science, technology, and business, ARPA-E breaks down silos between disciplines. This cross-disciplinary inquiry bridges the gap between basic and applied research and development. ARPA-E workshops bring together the leading experts to identify technical challenges and opportunities that connect science to technology and markets—linking knowledge of what science is capable of to what technology can achieve and what the market needs.

Before issuing a FOA in any particular technology area, ARPA-E engages members of other DOE offices to participate in ARPA-E workshops, help define the FOAs, and review proposals.

ARPA-E appoints Program Directors (PD) for three year terms, and PDs play a significant role in program identification and development. Often a new program's relevant discoveries will be recent, allowing ARPA-E to move quickly and strategically to capitalize on recent advances in science. As a result, ARPA-E's FY 2014 activities will be highly dependent upon scientific and technical breakthroughs and PD recruitment in FY 2013.

Much of ARPA-E's funding is awarded to projects in specific energy-related technology areas, but ARPA-E also provides open funding opportunities for high-potential projects that address the full range of energy-related technologies and concepts. ARPA-E's "OPEN" funding opportunities are announced periodically and evaluated based on their compatibility with ARPA-E's mission, the novelty of their approach to energy innovation, and the extent to which they meet technical needs currently underserved by other parts of Department of Energy (DOE) or the private sector. In FY 2012 ARPA-E issued its



second open funding opportunity designed to catalyze transformational breakthroughs across the entire spectrum of energy technologies. At this time ARPA-E does not plan on issuing an Open FOA in FY 2014.

### **Strategic Management**

To overcome challenges associated with the Transportation Systems thrust, ARPA-E will:

1. ARPA-E will pursue the most promising pathways to increased adoption of alternative liquid fuels production, vehicle electrification, and other technologies with market-oriented performance metrics designed to spur further follow-on funding.
2. ARPA-E's research programs will partner with the private sector, national laboratories, other Federal agencies, and universities to develop advanced energy technologies.

Three external factors present the greatest obstacles to advancement within the Transportation Systems thrust:

1. Transportation fleets are relatively long-lived assets (with a current average passenger car expected to be on the road for 11 years) and slow adoption rates for new technologies both mean that the energy and efficiency savings can take a long time to accrue.
2. Drop-in replacement technologies can offer more immediate impact but research must be mindful of the cost and time required for testing and certification.
3. Current transportation patterns and associated land-use patterns are historically slow to change.

To overcome challenges associated with the Stationary Power Systems thrust, ARPA-E will:

1. ARPA-E will engage the power generation community to help identify and promote the development of transformational, cost-competitive technologies
2. ARPA-E's research programs will partner with other DOE Offices and programs, the private sector, national laboratories, other Federal agencies and universities to develop advanced energy technologies

Three external factors present the greatest obstacles to advancement within the Stationary Power Systems thrust:

1. Components of the stationary power system must operate with extremely high and proven reliability, which can slow the adoption of new technologies.
2. The stationary power system is highly complex, regulated, and inter-connected with many

stakeholder requirements to be satisfied prior to technology adoption.

3. Adoption of improved efficiency technologies is dependent on economic and environmental factors beyond the scope of DOE R&D programs.

### **Program Goals and Funding**

ARPA-E's goal is to fulfill its statutory mission to develop transformational energy research. As described in PL 110-69 and PL 111-358, the goal of ARPA-E is:

- (A) to enhance the economic and energy security of the United States through the development of energy technologies that result in—
  - (i) reductions of imports of energy from foreign sources;
  - (ii) reductions of energy-related emissions, including greenhouse gases; and
  - (iii) improvement in the energy efficiency of all economic sectors; and
- (B) to ensure that the United States maintains a technological lead in developing and deploying advanced energy technologies.



**Goal Areas by Subprogram**

		Goal Area: Fulfill Statutory Mission
ARPA-E Projects		
Transportation Systems		100%
Stationary Power Systems		100%
Subtotal, ARPA-E Projects		100%

**Explanation of Funding AND/OR Program Changes**

(dollars in thousands)

FY 2012 Current	FY 2014 Request	FY 2014 Request vs FY 2012 Current
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ARPA-E Projects. The FY 2014 request for ARPA-E projects is a 36 percent increase over the FY 2012 Current level. The increase in funding will enable ARPA-E to fund more projects that could lead to transformative energy technologies.

ARPA-E will continue to incorporate a project management model hierarchy of thrust-portfolio-program-project. ARPA-E will have two primary thrusts: Transportation Systems and Stationary Power Systems.  
Total, ARPA-E Projects

253,000	344,890	+91,890
253,000	344,890	+91,890







**Transportation Systems  
Funding Profile by Activity**

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Transportation Systems	138,250	---	196,587
Total, Transportation Systems	138,250	---	196,587

\*FY 2013 amounts shown reflect the P.L. 112-175 continuing resolution level annualized to a full year. These amounts are shown only at the “congressional control” level and above; below that level a dash (—) is shown.

**Overview**

The ARPA-E Transportation Systems thrust seeks to create a diverse portfolio of technological options that would reduce our dependence on oil while also focusing on reducing fuel consumption and energy-related emissions.

Some broad goals and benefits of the Transportation Systems thrust include development of batteries and energy storage systems, development of competitively-priced transportation fuels, novel uses of information technology to improve energy efficiency, and natural gas vehicle technologies consistent with overall Administration priorities.

**Explanation of Funding Changes (Comparable)**

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs FY 2012 Current
Transportation Systems. Though exact allocations between thrusts will depend on the applications received, ARPA-E anticipates the funding level for the Transportation Systems thrust to be as shown.	138,250	196,587	+58,337
Total, Transportation Systems	138,250	196,587	+58,337



## Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	<p>In FY 2012, ARPA-E invested in the following innovative Transportation Systems technologies:</p> <ul style="list-style-type: none"> <li>• Advanced Management and Protection of Energy Storage Devices (AMPED): Advanced sensing, control and power management technologies that redefine how we think about battery management and could dramatically improve safety, performance, and lifetime for grid-scale and vehicle batteries.</li> <li>• Methane Opportunities for Vehicular Energy (MOVE): Novel and low-cost natural gas compression and storage technologies with the potential to enable widespread adoption of natural gas fueled vehicles.</li> <li>• OPEN 2012: A Broad Funding Opportunity Announcement open to all energy ideas and focused on transformational, breakthrough technologies that show fundamental technical promise but are too early for private-sector investment. Of the 66 projects selected, 27 projects focus on transportation systems including advanced fuels, advanced vehicle design and materials, and novel battery chemistries and configurations.</li> <li>• Under the SBIR and STTR programs, ARPA-E funded research of transformational transportation technologies in new battery chemistries and designs such as low-cost nano-composite materials.</li> </ul>	138,250
FY 2013	<p>In FY 2013, ARPA-E planned to invest in innovations in:</p> <ul style="list-style-type: none"> <li>• Technologies that overcome limitations in traditional biological systems to dramatically increase biofuel production for transportation.</li> <li>• Batteries and systems for electric vehicles that aim to have a range of 300-500 miles while costing less than cars based on internal combustion engines.</li> <li>• Early-stage technology alternatives that reduce or eliminate the dependence on rare earth materials by developing substitutes for electric vehicle motors.</li> <li>• Novel cost-effective power generation or propulsion systems that have significantly higher efficiency than today's internal combustion engines. This will maximize the use of transportation fuels.</li> <li>• Development of sustainable and market-competitive transportation fuels using domestic resources such as natural gas or a combination of carbon dioxide and hydrogen that have 5-10 times less land and water use than that of biomass or algae-based biofuels.</li> </ul>	---
FY 2014	<p>In FY 2014 ARPA-E will continue to work on all aspects of transportation, including synthetic approaches, tools and ancillary devices related to alternative and bio-derived fuels, batteries and components for the electrification of transportation, and advanced vehicle designs and materials. ARPA-E believes there are critical technological opportunities uniquely suited to the ARPA-E mission within the field of Transportation Systems. These opportunities focus on transformational, breakthrough technologies that show fundamental technical promise but are too early for private-sector investment.</p> <p>ARPA-E's technology acceleration model seeks to find new and timely opportunities. While the goals of specific Funding Opportunity Announcements (FOA) will be informed via a collaborative approach between ARPA-E and the technical community, ARPA-E is currently considering investing in the following areas related to Transportation Systems:</p> <ul style="list-style-type: none"> <li>• ARPA-E may consider transformational approaches to light weight materials and structures that can be produced with dramatically reduced energy consumption</li> </ul>	196,587



Fiscal Year	Activity	Funding (dollars in thousands)
	<p>and cost while enabling economically feasible automotive light-weighting.</p> <ul style="list-style-type: none"> <li>• Although battery technology to eliminate so-called ‘range anxiety’ in electric vehicles is proceeding apace, the slow development of novel technologies that facilitate rapid charging of EVs remains as an obstacle to EV deployment. This area of potential interest may include improvements to both battery and charging technologies that will facilitate wide-spread capabilities for full charge of electric vehicles in time frames not dissimilar from those required for liquid fuel refilling.</li> <li>• Currently the only renewable carbon available at a reasonable cost is that fixed by photosynthesis. ARPA-E may explore pathways to the sustainable production of liquid fuels through either entirely new sources of renewable carbon or higher energy yields of photosynthetic biofuels.</li> <li>• ARPA-E may consider the interaction of surfaces with several types of media across multiple scales and applications. Such a tribology-inspired program could utilize enabling technologies that include computational modeling, materials design and system engineering that significantly impact high friction surfaces and processes.</li> <li>• ARPA-E may consider additional efforts in the conversion and management of thermal energy for transportation applications, including novel approaches to high-efficiency thermoelectric technology and improved utilization of thermal energy to minimize waste heat.</li> </ul>	







**Stationary Power Systems  
Funding Profile by Subprogram and Activity**

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Stationary Power Systems	114,750	---	148,303
Total, Stationary Power Systems	114,750	---	148,303

\*FY 2013 amounts shown reflect the P.L. 112-175 continuing resolution level annualized to a full year. These amounts are shown only at the “congressional control” level and above; below that level a dash (—) is shown.

**Overview**

The ARPA-E Stationary Power Systems thrust supports high-impact technologies that are not related to transportation. Some of these areas include: power electronics, solar, wind, smart grid technologies, natural gas, geothermal, and waste heat capture. To accomplish its mission and address the scientific challenges outlined below, ARPA-E’s Stationary Power Systems is organized into four portfolios: Stationary Power, Electrical Infrastructure, End Use Efficiency, and Embedded Efficiency.

ARPA-E will continue its mission in this sector to move beyond incremental changes to existing energy technology and to identify those transformational technologies which will make current technologies obsolete. ARPA-E is investing in transformational research in a number of power generation technologies, and coordinating that investment with DOE’s Office of Science and the applied research offices engaged in complementary activities to maximize impact and avoid inappropriate duplication.

In its Stationary Power Systems thrust ARPA-E is focusing on creating a diverse array of technological options that

would reduce energy demand and greenhouse gas emissions, create low-cost power generation from renewable sources, provide greater reliability and security in the delivery of electricity and provide a secure energy foundation for the future.

Some broad goals and benefits of the Stationary Power Systems thrust include electricity generation from solar, wind, natural gas, nuclear, and other sources to meet base load and peak power at levelized cost of electricity of 5-6 cents/kWh; lower emission power systems; integrated energy supply systems; low-cost electrical storage; advanced, low-cost and smart components for high-efficiency power transmission, conversion and management at ultrahigh voltages for transmission and medium-to-low voltages for distribution networks; technologies for system-level stability, security, high capacity and reliability; and energy efficiency.

ARPA-E’s efforts in the Stationary Power Systems thrust seek to develop advanced and efficient power generation through new sources and new production and delivery hardware consistent with overall Administration priorities; and increase energy efficiency, including in manufacturing processes.

**Explanation of Funding Changes (Comparable)**

(dollars in thousands)

FY 2012 Current	FY 2014 Request	FY 2014 Request vs FY 2012 Current
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Stationary Power Systems. Though exact allocations between thrusts will depend on the applications received, ARPA-E anticipates the funding level for the Stationary Power Systems thrust to be as shown.

114,750      148,303      +33,553



(dollars in thousands)

FY 2012 Current	FY 2014 Request	FY 2014 Request vs FY 2012 Current
114,750	148,303	+33,553

Total, Stationary Power Systems

**Funding and Activity Schedule**

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	<p>In FY 2012, ARPA-E invested in the following innovative Stationary Power Systems technologies:</p> <ul style="list-style-type: none"> <li>Advanced Management and Protection of Energy Storage Devices (AMPED): Advanced sensing, control and power management technologies that redefine how we think about battery management and could dramatically improve safety, performance, and lifetime for grid-scale and vehicle batteries.</li> <li>OPEN 2012: A Broad Funding Opportunity Announcement open to all energy ideas and focused on transformational, breakthrough technologies that show fundamental technical promise but are too early for private-sector investment. Of the 66 projects selected, 39 projects focus on stationary power systems including building efficiency, grid modernization, and stationary energy generation and storage.</li> <li>Under the SBIR and STTR programs, ARPA-E funded research of transformational stationary energy storage technologies in low-cost, grid-scale storage especially advanced cell design, components, and innovative chemistries.</li> </ul>	114,750
FY 2013	<p>In FY 2013, ARPA-E planned to invest in innovative technologies to address the following challenges:</p> <ul style="list-style-type: none"> <li>Develop clean and efficient power generation technologies that are cost-competitive with today's resources</li> <li>Develop robust and efficient hardware/software for the future of power transmission, distribution, and end-use</li> <li>Increase end-use energy efficiency in residential and commercial sectors</li> <li>Create higher-performing and less energy intensive manufactured goods and services</li> <li>Engage the energy community to develop the next generation of energy technology leadership</li> </ul>	---
FY 2014	<p>In FY 2014 ARPA-E will continue to work on all aspects of stationary power systems, including building efficiency, stationary energy storage systems, grid modernization, and stationary energy generation. ARPA-E believes there are critical technological opportunities uniquely suited to the ARPA-E mission within the field of Stationary Power Systems. These opportunities focus on transformational, breakthrough technologies that show fundamental technical promise but are too early for private-sector investment.</p> <p>ARPA-E's technology acceleration model seeks to find new and timely opportunities. While the goals of specific Funding Opportunity Announcements (FOA) will be informed via a collaborative approach between ARPA-E and the technical community, ARPA-E is currently considering investing in the following areas related to Stationary Power Systems:</p>	148,303



Fiscal Year	Activity	Funding (dollars in thousands)
	<ul style="list-style-type: none"> <li>• The scale of digital information associated with energy systems will grow exponentially as all energy technologies become "smarter." This area of potential interest may include novel technologies for collecting, mining, standardizing, and protecting information for a diverse set of energy systems. Such information management may be coupled with additional technology development of new control software and hardware to reliably exert control over energy systems, such as the grid network.</li> <li>• ARPA-E may investigate opportunities in novel materials and manufacturing for energy applications including further advances in low-cost semiconductor materials, magnetics and motors, and low-cost/light-weight materials and manufacturing technology to improve energy efficiency.</li> <li>• ARPA-E may consider investments in technologies designed to improve efficiency and decision making across the entire energy spectrum. Examples of such technologies could include autonomous sensing devices that facilitate energy use reduction in buildings, remote sensing to target emission leaks and increase energy utilization, and devices for the inspection and repair of transmission infrastructure.</li> <li>• Consistent with Administration priorities, ARPA-E may explore programs aimed at improving the energy efficiency of conventional fossil fuel processes aimed at significant reductions in emissions, including GHG.</li> <li>• ARPA-E may consider the development of transformational technologies to harness energy from other renewable sources, including but not limited to wave energy, energy of mixing at river/ocean interfaces, and low-grade heat.</li> <li>• Although current wind towers represent efficient means for the capture and conversion of wind energy, deployment, in many instances, has become cost-prohibitive and logistically unmanageable, as towers and blades continue to increase in size. ARPA-E will explore technology solutions to these problems. Other areas of potential interest may include alternative high efficiency/low cost means of wind energy capture and conversion, software sensors, and sensing control optimization.</li> </ul>	







**Advanced Research Projects Agency – Energy (ARPA-E)**  
**Program Direction**  
**Funding Profile by Category**

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Headquarters			
Salaries & Benefits	6,650	---	8,213
Travel	900	---	2,046
Support Services	12,650	---	20,542
Other Related Expenses	1,800	---	3,309
Total, Headquarters	22,000	20,122	34,110
Full Time Equivalents	25	---	44

\*FY 2013 amounts shown reflect the P.L. 112-175 continuing resolution level annualized to a full year. These amounts are shown only at the “congressional control” level and above; below that level a dash (—) is shown.

**Public Law Authorizations**

Public Law 95-91, “Department of Energy Organization Act” (1977)

Public Law 109-58, “Energy Policy Act of 2005”

Public Law 110-69, “America COMPETES Act of 2007”

Public Law 111-358, “America COMPETES Reauthorization Act of 2010”

**Overview**

Program Direction provides the Federal staffing resources and associated costs required for overall direction and execution of the ARPA-E mission. This budget provides for salaries and benefits of federal staff; travel, support services contracts providing technical advisory and assistance services; and other related expenses, including the DOE Working Capital Fund. Starting in FY 2014, ARPA-E’s Program Direction will also support an embedded procurement staff.

**Explanation of Funding AND/OR Program Changes**

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs FY 2012 Current
Salaries and Benefits	6,650	8,213	+1,563
Increase associated with the growth of federal staff is commensurate to growth in overall relative funding. Increased federal staff includes additional Program Directors and other technical and professional staff, including the addition of procurement staff. Prior to FY 2014, procurement services were provided by the DOE Office of Headquarters Procurement and Acquisition Management.			
Travel	900	2,046	+1,146
ARPA-E performs in-depth oversight of its performers with multiple site visits per year by Program Directors. The increase reflects more travel to an increased number of award recipients. This travel is essential to assessing the performer’s research efforts and informing any decision to stop targeted programs on the basis of performance.			



(dollars in thousands)

FY 2012 Current	FY 2014 Request	FY 2014 Request vs FY 2012 Current
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Travel also includes performer community meetings which bring together performers from similar or complimentary technology areas for collaboration.

Support Services	12,650	20,542	+7,892
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Increase associated with the growth of support service contractors is commensurate with growth in overall funding. In FY 2014, ARPA-E plans to initiate approximately 150 new projects, for the management of which service contracts will provide analytical support.

Other Related Expenses	1,800	3,309	+1,509
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The increase is primarily due to additional costs commensurate with more federal staff. DOE is working to achieve economies of scale through an enhanced Working Capital Fund (WCF). The WCF increase covers certain shared, enterprise activities including enhanced cyber security architecture, employee health and testing services, and consolidated training and recruitment initiatives.

Total Funding Change, Program Direction	22,000	34,110	+12,110
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#### **Support Services by Category**

(dollars in thousands)

FY 2012 Current	FY 2014 Request	FY 2014 Request vs FY 2012 Current
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Support Services

R&D Support Services

Total, Support Services	12,650	20,542	+7,892
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	12,650	20,542	+7,892
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#### **Other Related Expenses by Category**

(dollars in thousands)

FY 2012 Current	FY 2014 Request	FY 2014 Request vs FY 2012 Current
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Other Related Expenses

Other Services

DOE/COE

Working Capital Fund

Total, Other Related Expenses	1,800	3,309	+1,509
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	1,800	3,309	+1,509
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