

**Energy Transformation Acceleration Fund
Advanced Research Projects Agency – Energy (ARPA-E)**

Proposed Appropriation Language

For necessary expenses in carrying out the activities authorized by section 5012 of the America COMPETES Act (Pub. L. No. 110-69), [\$10,000,000] \$299,966,000, to remain available until expended.

Explanation of change

Changes are proposed to reflect the FY 2011 funding request.

**Energy Transformation Acceleration Fund
Advanced Research Projects Agency – Energy (ARPA-E)**

Overview

Appropriation Summary by Program

	FY 2009 Current Appropriation ¹	FY 2009 Current Recovery Act Appropriation	FY 2010 Current Appropriation	FY 2011 Request
Energy Transformation Acceleration Fund				
Advanced Research Projects Agency (ARPA-E)				
ARPA-E Projects	0	377,556	0	273,400
Program Direction	15,000	11,300	0	26,566
Total, Energy Transformation Acceleration Fund	15,000	388,856	0	299,966

Public Law Authorizations:
P.L. 110-69, “America COMPETES Act” (2007)

Preface

As envisioned by the National Academies 2005 report, *Rising Above the Gathering Storm*,² and authorized by the America COMPETES Act of 2007, the Advanced Research Projects Agency – Energy (ARPA-E) is responsible for funding specific high-risk and high-payoff game-changing research and development projects to meet the nation’s long-term energy challenges. ARPA-E received initial funding in FY 2009 to fund transformational energy research that industry by itself cannot and will not support. There is an inherent risk associated with these programs, but the payoff from those that are successful promises great economic and social rewards. Furthermore, it is expected that these programs will result in the flow of new ideas and continue to fuel the economy, create new jobs, provide security, and enhance the quality of life.

While announcing its formation in April 2009, President Obama said of the new program, “ARPA-E seeks to do the same kind of high-risk, high-reward research [as DARPA]... We will put in place the resources so that scientists can focus on [renewable energy]...and I am confident that we will find a wellspring of creativity just waiting to be tapped.”³ On another occasion, while addressing an MIT audience, the President challenged Americans to lead the global economy in clean energy and echoed previous statements about ARPA-E in saying that, “[America is a nation that supports] those intrepid few willing to take risks on an idea that might fail -- but might also change the world... After the Soviet launch of Sputnik, the first artificial satellite to orbit the Earth, the United States went about winning the Space Race by investing in science and technology... Now, while the challenges today are different, we have to draw on the same spirit of innovation that's always been central to our success. And that's especially true when it comes to energy. From China to India, from Japan to Germany, nations everywhere are racing to develop new ways to [produce] and use energy. The nation that wins this competition will be the nation that leads the global economy... And I want America to be that nation...”

¹ The Omnibus Appropriations Act of 2009 provided \$15,000,000 for the Advanced Research Projects Agency – Energy in the Science appropriation. The Energy and Water Development and Related Agencies Appropriations Act, 2010, transferred these funds to the Energy Transformation Acceleration Fund. For comparison purposes across Fiscal Years, the total is shown here.

² Report available at the National Academies Press web site: http://www.nap.edu/catalog.php?record_id=11463

³ http://www.whitehouse.gov/the_press_office/Remarks-by-the-President-at-the-National-Academy-of-Sciences-Annual-Meeting

[The] pioneers are all around us -- the entrepreneurs and the inventors, the researchers, the engineers -- helping to lead us into the future, just as they have in the past... This is the nation that will lead the clean energy economy of tomorrow.”¹

ARPA-E is a high priority for Secretary Chu. As Director of Lawrence Berkeley National Laboratory, the Secretary testified in support of its formation and now plans to use ARPA-E as a model for how DOE can foster innovation and support game-changing technologies that could transform the global landscape. In announcing the first round of projects funded by ARPA-E in November 2009, Secretary Chu said, “After World War II, America was the unrivaled leader in basic and applied sciences. It was this leadership that led to enormous technological advances. ARPA-E is a crucial part of the new effort by the U.S. to spur the next Industrial Revolution in clean energy technologies, creating thousands of new jobs and helping cut carbon pollution.”

Within the Energy Transformation Acceleration Fund Appropriation, ARPA-E has two programs: ARPA-E Projects and Program Direction.

The ARPA-E Projects program provides funding and commercialization support to research and development programs at the intersection of applied sciences and integrated energy systems. ARPA-E has created a matrix-based organization structure. On one hand is the Applied Science and Technology Office or the “Technology Push” Office which will invest in platform technologies that can be integrated into various energy systems. On the other hand is the Integrated Energy Systems Office or “Technology Pull” Office, which will invest in the integration of these technologies into smart, energy efficient, and cost-effective energy systems that will have direct market impact. This matrix structure will maximize ARPA-E’s resources and prevent organizational stove piping that could hinder innovation and stifle creative problem solving. This is discussed further in the ARPA-E Projects section.

ARPA-E Program Directors will lead topic programs and work directly with the award recipient project teams. Program Directors will have term-limited appointments lasting only the three to four year duration of the projects they support. Rotating program leadership in this way will provide fresh perspective and energy to each round of funding for projects. ARPA-E is also employing a novel program creation process: working closely in collaboration with other DOE basic and applied research offices to identify gaps in their research portfolios (“white space”) as well as utilizing Requests for Information and topical Workshops to uncover the specific technical barriers worthy of being addressed with ARPA-E funding. The Department of Energy has other transactional authority in procurement and statutory authority to start and stop targeted programs on the basis of performance; authorities that ARPA-E plans to make wise use of. Finally, ARPA-E will have an overarching dedication to the commercialization of the technologies we fund in our projects.

The ARPA-E Program Direction subprogram provides funding for the federal and contractor staff charged with fulfilling the ARPA-E mission. ARPA-E has special hiring authority to bring on Program Directors and other program leadership, and is a lean and agile organization able to recruit and rotate the best and brightest minds in energy research fields. Project teams receiving funding from ARPA-E get more than just federal funds; they receive full coordinated support and scrutiny from the ARPA-E team. This support includes: a Program Team to provide technical help and monitor technical progress; an Operations Team to expedite transactions within the constraints of Congressional statute; an Outreach Team to highlight progress to all stakeholders; and a Commercialization Team to accelerate the

¹ <http://www.whitehouse.gov/the-press-office/remarks-president-challenging-americans-lead-global-economy-clean-energy>
Energy Transformation Acceleration Fund/ **FY 2011 Congressional Budget**
ARPA-E

deployment of technology developed by ARPA-E funded entities. This is discussed further in the Program Direction section.

Mission

The mission of ARPA-E is to overcome the long-term and high-risk technological barriers in the development of energy technologies.

To achieve this mission, ARPA-E will pursue the following goals: First, ARPA-E aims to enhance the economic security of the United States through the development of energy technologies that result in: reduced energy imports, reduced energy-related emissions, including greenhouse gases, improved energy efficiency across all economic sectors. Second, ARPA-E aims to ensure that the United States maintains a technological lead in developing and deploying advanced energy technologies.

Benefits

Three Sputniks: Just as DARPA was created in 1958 in response to Sputnik, ARPA-E was created in response to the 3 “Sputniks” of our generation: energy dependence, greenhouse gas emissions and climate change, and maintaining U.S. technological leadership. These challenges are reflected in the ARPA-E mission and goals.

The U.S. must step up its clean energy efforts. The U.S. market share in sales of photovoltaics, a technology first developed in the U.S., has fallen from over 40 percent of world-wide sales in 1997 to less than 10 percent in 2009. The U.S. is home to only one of the 10 largest solar panel producers in the world, and two of the top 10 advanced battery manufacturers. The U.S. and global hybrid electric vehicle (HEV) battery market is dominated by Asian companies. In 2008 the U.S. accounted for less than 2 percent of worldwide sales of nickel metal hydride (NiMH) batteries for HEV. Future HEV/plug-in hybrid electric vehicle (PHEV)/electric vehicle (EV) battery demand will be met by Asian producers, currently dominated by Japan, South Korea, and China, without transformative American innovation in advanced batteries. In another facet, the U.S. energy intensity in buildings far exceeds that of similar buildings in similar climates in China and Europe. China is investing 10 times as much on clean power, as a percentage of gross domestic product, as the U.S. is; and has plans to deploy 120 gigawatts of wind power in the next 10 years, equal today’s global total, which will create an estimated 150,000 jobs. Of the top five manufacturers in wind power, only one is American.

Pace and Scale of Innovation Needed: The pace and scale of the innovations needed in energy technologies is unprecedented. We need to achieve the equivalent of all of the world altering technological innovations from the 20th Century in the span of the next few decades. ARPA-E will help us meet this challenge by identifying and supporting the best ideas and minds in the energy field.

Game Changers from 20th Century

Artificial Fertilizers
Green Revolution
Transistor
Airplanes
Electrification
Polio Vaccination
Antibiotics
Nuclear Energy
Integrated Circuits
Fiber Optic Communication
CCD cameras
Wireless Communication
Internet

**Imagine all of this happening in a span
of the next few decades...**

**That is what we need now to address the
biggest challenge of our lifetimes...**

**Identify and support today's
Haber, Bosch, Borlaug,
Bardeen, Shockley, Brattain,
Salk, Wright brothers, Kilby,
Noyce, Gates, Jobs, Page, Brin
of the energy field**

Figure: The Pace and Scale of Innovation Needed

America's Strengths: To win the the clean energy race, the U.S. has formidable strengths upon which to call including:

1. The best research and development infrastructure in the world,
2. The best innovation ecosystem in business and entrepreneurship, and
3. Highly energized youth who are ready to step up and engage to meet these challenges.

Facing the 3 “Sputniks” of our generation and considering the pace and scale of innovation needed, ARPA-E will work to recruit and rotate the best and brightest minds in the energy field to develop topical research and development programs that build on the nation’s strengths to accelerate the pace of innovation. ARPA-E will select game changing ideas and the best research teams, in the context of an organizational structure promoting collaboration and debate and using innovative processes for program creation, proposal reviews, and transactions, along with keeping stakeholders informed and engaged. The inherent risk associated with research of this nature precludes measuring success by the percentage of projects that meet their research goals (Secretary Chu has stated that he would consider ARPA-E successful if only 10% of the projects were successful). Instead, ARPA-E will define its success in terms of accelerating science to the market and the scope of the commercialization of technologies funded by ARPA-E.

Performance

ARPA-E will develop technologies and assess capabilities that could potentially enable transformational changes in areas that address the biggest challenges of our lifetimes:

- Energy dependence,
- Greenhouse gas emissions and climate change, and
- Maintaining U.S. technological leadership

ARPA-E will achieve this by identifying and promoting revolutionary advances in fundamental sciences, translating scientific discoveries and cutting-edge inventions into technological innovations, and accelerating transformational technological advances in areas that industry by itself is not likely to undertake because of technical and financial uncertainty.

To this end, ARPA-E will help fill the gaps in the energy innovation pipeline through the targeted acceleration of:

- Novel, early-stage energy technology development that are potential game-changers for the energy industry and market;
- Development of techniques, processes, and technologies, and related testing and evaluation;
- Research and development of manufacturing processes for novel energy technologies; and
- Coordination with nongovernmental entities for demonstration of technologies and research applications to facilitate technology transfer.

**Energy Transformation Acceleration Fund
Advanced Research Projects Agency – Energy (ARPA-E)**

Funding by Site by Program

(dollars in thousands)

	FY 2009 ¹	FY 2010	FY 2011
Washington Headquarters			
ARPA-E Projects	377,556	0	273,400
Program Direction	26,300	0	26,566
Total, Washington Headquarters	403,856	0	299,966
Total, Energy Transformation Acceleration Fund	403,856	0	299,966

Major Changes or Shifts by Site

ARPA-E received funds in FY 2009 under the American Recovery and Reinvestment Act and through the Science appropriation to establish the program and to fund initial projects. In FY 2011 ARPA-E will for the first time fund projects with regular appropriations.

Site Description

Washington Headquarters

In support of the Energy Transformation Acceleration Fund (the Fund) and the ARPA-E Projects and Program Direction budget elements, the Washington Headquarters site provides management and leadership of ARPA-E, oversight of the Fund, and administers contracts/agreements with the award recipients, support services contracts, and all other financial/contract agreements associated directly with ARPA-E.

¹ARPA-E was created in FY 2009. For comparison purposes, the sum of FY 2009 appropriations (FY 2009 Omnibus and Recovery Act) is shown in the FY 2009 column for ARPA-E. This represents the total funding available to ARPA-E.

Advanced Research Projects Agency – Energy (ARPA-E)

Funding Profile by Subprogram

	FY 2009 Current Appropriation ¹	FY 2009 Current Recovery Act Appropriation	FY 2010 Current Appropriation	FY 2011 Request
ARPA-E Projects				
Decision Science/Buildings	0	4,993	0	30,000
Materials/Buildings	0	9,505	0	0
Thermal/Buildings	0	35,000	0	0
Materials/Transportation	0	62,678	0	0
Thermal/Transportation	0	5,195	0	0
Materials/CO2	0	3,895	0	0
Biological Chemical/CO2	0	42,251	0	0
Materials/Industrial Power	0	0	0	35,000
Thermal/Industrial Power	0	4,716	0	30,000
Information Science/Transmission	0	0	0	30,000
Electronics/Transmission	0	44,910	0	0
Materials/Renewables	0	54,477	0	30,000
Biological Chemical/Renewables	0	0	0	30,000
Materials/Fuels Synthesis	0	5,993	0	0
Biological Chemical/Fuels Synthesis	0	65,865	0	0
Materials/Water & Agriculture	0	2,031	0	0
Thermal/Water & Agriculture	0	0	0	30,000
Biological Chemical /Water & Agriculture	0	36,047	0	30,000
Seedlings	0	0	0	20,745
SBIR/STTR	0	0	0	7,655
Total, ARPA-E Projects	0	377,556 ²	0	273,400

Public Law Authorizations:
P.L. 110-69, “America COMPETES Act” (2007)

Mission

ARPA-E projects directly support the program’s mission to sponsor specific high-risk and high-payoff game-changing research and development projects that overcome the long-term technological barriers in the development of energy technologies.

Benefits

To accomplish its mission, ARPA-E will draw upon the nation’s strengths of having the best R&D infrastructure in the world, an unparalleled innovation ecosystem in business and entrepreneurship, and the American enthusiasm for pioneering and taking risks. ARPA-E itself performs no research, but rather funds transformational energy research and development projects that are conducted by teams of

¹ The Omnibus Appropriations Act of 2009 provided \$15,000,000 for the Advanced Research Projects Agency – Energy in the Science appropriation. The Energy and Water Development and Related Agencies Appropriations Act, 2010, transferred these funds to the Energy Transformation Acceleration Fund in FY 2010.

² Total is reduced by \$11,144; \$9,950,000 of which was transferred to the Small Business Innovation Research (SBIR) program and \$1,194,000 of which was transferred to the Small Business Technology Transfer (STTR) program.

small businesses, large businesses, universities, non-profits, national laboratories, and other federally funded research and development centers. The inherent risk associated with the types of projects ARPA-E will fund means we fully expect a large number of projects to miss the mark. Secretary Chu has stated publically he will consider the program a success if even as low as 10 percent of the projects meet their research goals. Given the transformational nature of the technologies, even a small percentage of successful projects would yield a payoff that will be not only monetary but also socially rewarding. Furthermore, it is expected that these programs will result in the flow of new ideas and continue to fuel the economy, create new jobs, provide security, and enhance the quality of life.

Government investment versus private investment: ARPA-E seeks to make seed investments in transformational technologies that involve both technological and market risks. Furthermore, ARPA-E will also make investments in enabling technologies such as improvements to the electric grid network, grid-level storage, and carbon capture and utilization. For the sake of our nation's technological lead and energy infrastructure, we need to nurture the early stage work on these topics, which could possibly be later scaled up by private investments. ARPA-E realizes that it is critical to examine the entire energy ecosystem as it will enable and spawn various other technological developments.

Among the 37 projects that ARPA-E committed to fund under FOA-1, approximately 35% were projects at academic institutions and 60% were ground-breaking ideas conceived, but not being actively pursued, at small and large businesses. The latter lacked capital, but had the people and infrastructure to bring the technology to fruition. Going forward, we expect a greater percentage of ARPA-E funded entities to be academic and research institutions that are not ready to receive private capital. We are confident that the projects that ARPA-E has continued to support (fund and guide) will be ready to scale with private capital after a few years.

We recognize that in some instances, government funding could possibly crowd-out private capital. We are aware of this and we are working cautiously to avoid the areas where this could happen. We are presently focusing ARPA-E investments in "white-spaces" in which there is minimal competition. Furthermore, identified white-spaces include areas where the United States severely lags the rest of the world. For example, in next-gen battery technology, the Japanese government finances over \$60M annually and these monies are leveraged approximately 10 times by industry funding. These areas have not received private capital in the U.S. since they are considered technologically risky. Yet, we as a nation must not only be globally competitive, but unleash the U.S. innovation ecosystem in areas that are risky, and yet could produce game changing technologies. In many instances seed investments, similar to those of ARPA-E, by the government has historically spawned new industries. For example, investment into stealth technology by DARPA, has led to development of an entire industry on next generation materials. The origins and the growth of the internet is a similar story. Similarly, we believe that ARPA-E funding will lead to new industries and ecosystems in clean-energy and other related industries.

Innovations in Business Processes

ARPA-E is envisioned by the Secretary and Director to be organized and administered in ways that are not business-as-usual for the Department of Energy. ARPA-E has integrated several innovations into its culture in order to foster this vision, including a matrix organization structure; novel processes for program creation, and procurement transactions; term-limited Program Directors; commitment to the program's statutory mandate to stop targeted programs on the basis of performance; and a fundamental dedication to accelerating science to the market including a Commercialization Team versed in venture capital and financing to assist ARPA-E funded projects in bringing their technologies and end products to market.

Organization: ARPA-E is a flat, nimble, and agile organization with a small number of federal employees, all of whom have access to the Director, and who are supported by contractors with a high degree of technical expertise. The ARPA-E organization chart is not compartmentalized into discrete technology areas, but rather the program is designed as a matrix organization divided into two separate but equally important offices. On one hand is the Applied Science and Technology Office or the "Technology Push" Office which will invest in platform technologies that can be integrated into various energy systems. On the other hand is the Integrated Energy Systems Office or "Technology Pull" Office, which will invest in the integration of these technologies into smart, energy efficient and cost-effect energy systems that will have direct market impact. Once fully staffed, one or more Program Directors will lead efforts in each science and technology column and each energy system row. Rather than having the traditional federal program's linear organization and resulting stove piping of programmatic functions, this matrix structure is designed to foster internal debate, constructive confrontation, and collaboration to form a consensus on the most meaningful topics areas upon which to focus our resources. The matrix structure allows for a more robust project selection process, promotes innovation and creative problem solving, and ultimately results in better performance from the award recipients. The matrix organization shown here represents the initial notion of the program's organization. Specific column and row headings could change as ARPA-E hires new Program Directors and matures over time.

APPLIED SCIENCE AND TECHNOLOGY OFFICE					
A Marketing & Decision Science	B Information Science & Device Engineering	C Electronic & Structural Materials Science & Device Engineering	D Thermal Science & Device & Process Engineering	E Chemical & Biological Science & Process Engineering	
FOA-1 (1 / \$5M) FY 2011		FOA-1 (2 / \$9.5M)	FOA-3		1 Buildings & Appliances (Homes, Buildings, Data Centers)
		FOA-1 (6 / \$27.7M) FOA-2 (BEEST)	FOA-1 (2 / \$5.2M)		2 Transportation
		FOA-1 (3 / \$3.9M)		FOA-1 (2 / \$7.3M) FOA-2 (IMPACCT)	3 Carbon Dioxide Capture and Utilization
		FY 2011	FOA-1 (2 / \$4.7M) FY 2011		4 Industrial Power Generation & Use (Cement, Metals, Glass, Paper)
	FY 2011	FOA-1 (3 / \$14.9M) FOA-3			5 Transmission & Distribution
		FOA-1 (4 / \$24.5M) FOA-3 FY 2011		FY 2011	6 Renewable Power (Solar, Wind, Hydroelectric, & Geothermal)
		FOA-1 (1 / \$6M)		FOA-1 (9 / \$35.9M) FOA-2 (Electrofuels)	7 Fuels Synthesis
		FOA-1 (1 / \$2M)	FY 2011	FOA-1 (1 / \$4.6M) FOA-3 FY 2011	8 Water & Agriculture

INTEGRATED ENERGY SYSTEMS OFFICE

Shaded cells show program topic areas (specific FOA or potential future FOA) for ARPA-E funding

FOA-1 (# Projects / \$ Funding) awards announced October 2009; FOA-2 topic areas announced November 2009 and award announcement expected in April 2010; FOA-3 announcement expected in March 2010 and award announcement expected in July

Figure: ARPA-E's Matrix Organization Structure

Openness and Integrity: ARPA-E is open to the best ideas regardless of origin and is dedicated to sharing and partnership with Congress and other stakeholders, as well as enhancing public understanding of the value of technology to society. The ARPA-E Projects subprogram provides funding and commercialization support to research and development projects in program topic areas at the intersection of applied sciences and integrated energy systems. Program topic areas for specific Funding Opportunity Announcements (FOAs) are determined by exhaustive research by Program Directors and staff, including ARPA-E Fellows; close coordination with the other DOE basic and applied research offices (see figure below) to identify gaps in their research portfolios (i.e., “white space”); Requests for Information (RFIs) from the technology community to identify technology or market gaps; and topic area Workshops meant to hone in on specific technological barriers that need to be overcome to achieve a transformational advancement. In addition to targeted, focused FOAs, ARPA-E will also hold open solicitations so as to not miss out on any potential game-changing ideas that happen to be outside the targeted program topic areas. ARPA-E Program Directors, and ultimately the Director, have final say on which projects will receive ARPA-E funding. ARPA-E is taking advantage of the Department’s Other Transactions Authority (OTA) to provide for flexible and rapid contracting and procurement transactions.

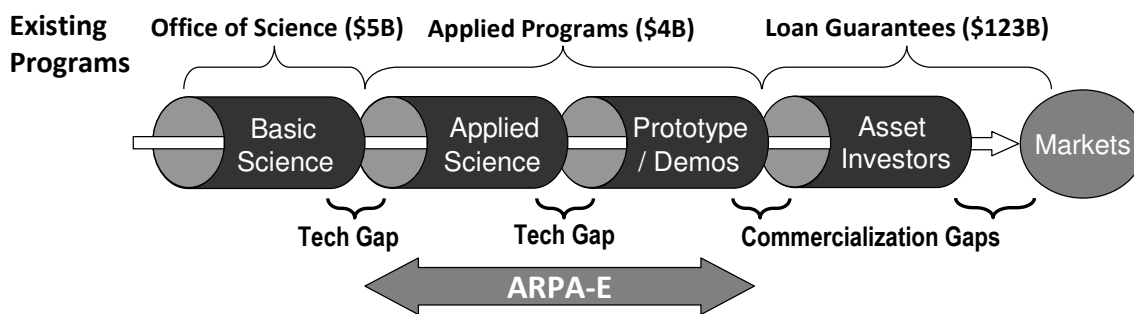


Figure: ARPA-E’s Role in Collaboration with Other DOE Programs

Excellence: ARPA-E is staffed with an all-star team of technical experts who focus on highly selective and potentially game-changing ideas and enable the creation and support of the best teams receiving ARPA-E funding. ARPA-E employs Program Directors to serve discrete time-limited terms and run projects in different program topic areas. Each program topic area’s projects last between two and four years, and once a Program Director’s projects are completed so ends his or her term of employment with ARPA-E and new Program Directors begin with fresh ideas and energy. ARPA-E seeks out and selects Program Directors who are not only leaders in their technological field, but also who have success in bringing a product from the research phase to the market. Each Program Director is responsible for managing RFIs and Workshops, creating their program topic areas, overseeing the process of reviewing proposals, presenting selections to the Director for final award decisions, negotiating awards to include technical deliverables and milestones, overseeing the performer’s research efforts including site visits, and deciding to stop targeted programs on the basis of performance.

ARPA-E also follows an aggressive award schedule for getting contracts negotiated and signed. Using FOA-1 as an example, three months after the award announcement ARPA-E completed all of the award contracts, a very rapid pace for federal contracting. In fact, ARPA-E has cut 60 percent off the average Department of Energy procurement cycle time, defining a new benchmark for program performance.

Accelerating Science to Market: One final and essential component of ARPA-E’s culture is an overarching focus on accelerating science to market. This focus is apparent in ARPA-E staffing and structure in that individuals who have demonstrated past success in this area are sought after and hired as Program Directors, and that ARPA-E has a Commercialization Team dedicated to this proposition. Additionally, all solicitations were required to include a transition plan to the next stage of development for the technology being funded in order to be considered. Finally, and perhaps most telling, ARPA-E’s self-imposed internal measures of success are centered on post-research market adoption metrics such as follow on investment post ARPA-E award, increase in enterprise value of a company, companies created, new frontiers or industries created, new jobs in existing or newly created industries, and accelerated market entry of products and product sales. The innovation here is not that ARPA-E includes the commercialization of technologies it funds as a measure of success, but rather that the acceleration of technologies to the market is the essence of the program’s existence.

Report on FOA-1

ARPA-E’s initial Funding Opportunity Announcement (FOA), announced in April 2009, was open to all technologies and energy areas in order to convey to the community the program’s openness to all ideas and to get a sense of what projects were out there. ARPA-E received 3,682 concept papers in response to FOA-1, highlighting the pent up innovation in the technology community. After an initial review ARPA-E encouraged 312 full applications, and ultimately received and processed 338 full applications with 95 percent of those encouraged applying. During the full application phase, panel reviews by topical experts and the ARPA-E Program Directors led to the final selection of 37 projects, announced on October 2009, totaling \$151 million with each averaging \$4 million and 3 years duration. Of the applications funded, the lead organization of the winning teams was most often a small business (43 percent) or an educational institution (35 percent); only half as often were large businesses the lead (19 percent), and rarely non-profits (3 percent). Less than two months after the award announcement, ARPA-E completed more than two-thirds of the award contracts, a record pace for federal contracting at the Department. In fact, the demonstrated speed in contracting from FOA-1 is being promoted as a pilot example of how contracting can be streamlined in the rest of the Department. While too early to show successes from the research, there is early traction evident in the fact that ARPA-E’s commitment of \$151 million leveraged an additional \$57 million in cost share from the award recipients. Additionally, ARPA-E’s awards catalyzed \$33 million more of new investment within only two months of the award announcements, mostly from the private sector with a small part coming (\$4 million) from the USDA as part of a collaborative effort on Biofuels.

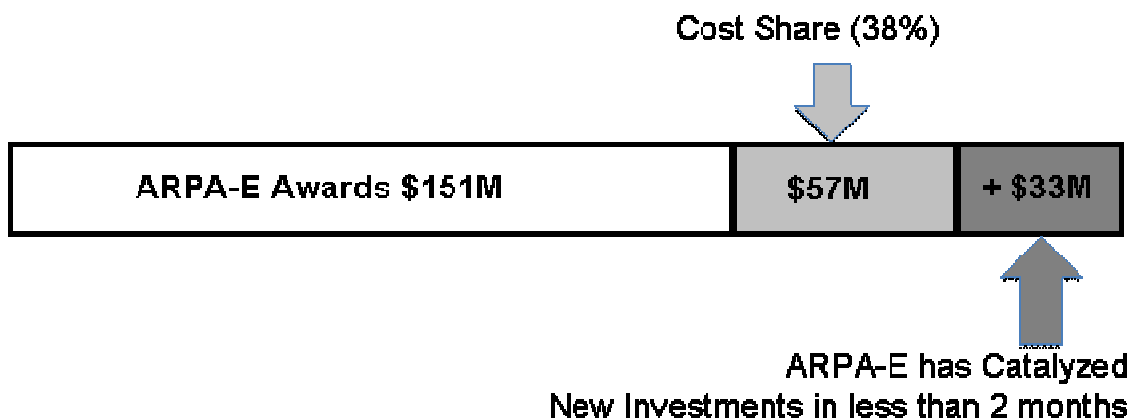


Figure: ARPA-E Awards Catalyze Follow-On Investment

Report on FOA-2

Announced in December 2009, this FOA makes available \$100 million in three focused project areas. These focused areas were determined in part by what was learned from FOA-1, and also through formal Requests for Information (RFIs) and ARPA-E Workshops. The concept papers were due in January 2010. The award announcements for FOA-2 are expected to be made in April 2010 and the awards completed in June 2010. Program topic areas for FOA-2 include:

1. Electronic and structural materials science/engineering for transportation
2. (Bio)Chemical reactions catalysis, and thermodynamics/kinetics for new carbon dioxide reaction for carbon dioxide capture and utilization
3. (Bio)Chemical reactions catalysis, and thermodynamics/kinetics for fuels synthesis

Report on FOA-3

At the time of printing, efforts for this FOA are well underway. These program topics areas are being selected, as with FOA-2, based on what was learned from the FOA-1 applications, the RFIs, and the Workshops. This Funding Opportunity Announcement is expected to be released in March 2010, and award announcements are expected to be made in July 2010. Program topic areas for FOA-3 may include:

1. Thermal management devices, process engineering, and technologies for buildings
2. Electronic and structural materials science/engineering for electricity transmission and distribution
3. Electronic and structural materials science/engineering for renewable power source
4. (Bio)Chemical reactions catalysis, and thermodynamics/kinetics for water purification and management

Report on FY 2011 FOAs

Program topic areas for FY 2011 FOAs have not been finalized at this time; however, based on the concept papers and proposals received from the initial FOA, the input received from the Requests for Information (RFIs), and the six Workshops that we have held already, in addition to outreach and coordination with DOE applied and basic science offices the following are program topic areas of interest for ARPA-E for funding projects in FY 2011:

1. Electronic and structural materials science/engineering for industrial power generation and use
2. Thermal management devices and technologies for industrial power generation and use
3. Information science and device engineering for electricity transmission and distribution
4. Electronic and structural materials science/engineering for renewable power sources
5. (Bio)Chemical reactions, catalysis, and thermodynamics/kinetics for renewable power sources
6. Thermal processes for heating/cooling or water and water purification/management
7. Marketing and decision science for energy consumption in buildings
8. (Bio)Chemical reactions catalysis, and thermodynamics/kinetics for water purification and management, genetic engineering of plants for rapid/efficient carbon capture and storage

The specific nature of the projects to be funded in each of the program topic areas of interest will be determined by the Program Directors, whom ARPA-E is currently negotiating the hiring of; upcoming RFIs and Workshops; as well as continued outreach and coordination with the relevant DOE program offices and stakeholders in the technical, policy, and financial communities.

Annual Performance Results and Targets

The research and development projects funded by ARPA-E will contribute to several of the Secretary's Strategic Priorities. First and foremost, the primary contribution will be to the following priorities:

- Clean, Secure Energy: Change the landscape of energy demand and supply
- Lower GHG Emissions: Position U.S. to lead on climate change policy, technology, and science

In addition, the technological advances stemming from ARPA-E projects will contribute to the following priorities:

- Science and Discovery: Invest in science to achieve transformational discoveries
 - ARPA-E: Translating science to business opportunities that have large market impact
- Economic Prosperity: Create millions of green jobs and increase competitiveness

ARPA-E has annual performance metrics that give guidance to the direction the agency is heading in order to develop technologies and assess capabilities. These results and targets will show the overall performance of the programs and projects. These metrics are created to gain exact measurement of performance. They are part of the over arching ARPA-E performance and will lead into the long-term metrics.

- Percentage of Funding Committed or “best-in-class” performance (#) – This metric is defined as the performance of ARPA-E as a research and development funding agency as compared to other similar agencies in terms of its ability to successfully and quickly fund projects and meet its mandates.

Annual Performance Targets and Results

Secretarial Goal: Science and Discovery: Invest in science to achieve transformational discoveries

GPRA Unit Program Goal: ARPA-E: Translating science to business opportunities that have large market impact

FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Performance Measure: Cumulative percentage of award funding committed 45 days after funding opportunity announcement (FOA) award announcements									
T: n/a A: n/a	T: n/a A: n/a	T: n/a A: n/a	T: n/a A: n/a	T: n/a A: n/a	T: 70% A:	T: 70% A:	T: 75% A:	T: 75% A:	T: 75% A:

Means and Strategies

The ARPA-E program will pursue the following means and strategies to achieve its program goals:

- Identifying and promoting revolutionary advances in fundamental sciences;
- Translating scientific discoveries and cutting-edge inventions into technological innovations; and
- Accelerating transformational technological advances in areas that industry by itself is not likely to undertake because of technical and financial uncertainty.

Validation and Verification

The validation and verification of the program's activities are subject to continuing review by Congress, the Government Accountability Office, and the DOE Inspector General. The Program will conduct an annual internal controls review under the Federal Managers' Financial Integrity Act. The Program's performance measures and associated quarterly milestones will be reviewed and approved by the ARPA-E Director. Performance measures on quality improvements are being established and monitored.

Detailed Justification

(dollars in thousands)

FY 2009	FY 2010	FY 2011
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ARPA-E Projects **377,556** **0** **265,000**

▪ **Decision Science/Buildings** **4,993** **0** **30,000**

The focus of this program topic area is marketing and decision science for energy consumption in buildings. This program topic area could potentially cover communication, psychology, and cognition related to better understanding personal and group behavior on energy consumption in buildings including homes, offices, retail/commercial, and data centers.

This program topic area supports DOE's goal of developing the technical foundations necessary to enable massive reductions in energy consumption in buildings. ARPA-E is specifically focused on technologies which can help buildings achieve net zero energy status through improvements such as the development of "smart" sensors and equipment which can detect what is going on in the building and alter the energy consuming equipment, such as lights and the heating, ventilation and air conditioning (HVAC) system, to conserve the most energy while meeting the needs of the occupants.

There is currently one project supported in this program topic area, which is being fully funded by ARRA funds.

In FY 2011, a FOA announcement for this program topic area is planned for early or mid fiscal year which will likely support seven to ten additional projects, pending availability of funding.

- | | | | |
|----------------------------|--------------|----------|----------|
| Materials/Buildings | 9,505 | 0 | 0 |
|----------------------------|--------------|----------|----------|
- The focus of this program topic area is electronic and structural materials science/engineering for energy consumption in buildings. This program topic area could potentially cover rapid discovery, manufacturing, and devices, including high-temperature strength/toughness in materials related to electrochromics, phase change, construction (cement, steel, etc.), and insulation to address energy consumption in buildings including homes, offices, retail/commercial, and data centers.
- This program topic area supports DOE's goal of developing the technical foundations necessary to enable massive reductions in energy consumption in buildings. ARPA-E is specifically focused on improvements such as the development of "smart" sensors and equipment which can detect what is going on in the building and alter the energy consuming equipment, such as lights and the heating, ventilation and air conditioning (HVAC) system, to conserve the most energy while meeting the needs of the occupants.
- There are currently two projects supported in this program topic area, both of which are being fully funded by ARRA funds.
- | | | | |
|--------------------------|---------------|----------|----------|
| Thermal/Buildings | 35,000 | 0 | 0 |
|--------------------------|---------------|----------|----------|
- The focus of this program topic area is thermal science and device and process engineering for energy consumption in buildings. This program topic area could potentially cover heating, cooling, and thermal management devices and technologies related to storage, transport, and efficient heating and cooling in buildings including homes, offices, retail/commercial, and data centers.
- This program topic area supports DOE's goal of developing the technical foundations necessary to enable massive reductions in energy consumption in buildings. ARPA-E is specifically focused on possible improvements such as separation of temperature control and dehumidification, decentralization of centralized cooling systems, and development of alternate refrigeration devices and refrigerants, to reduce the cost and electrical demand of building HVAC systems while meeting the needs of the occupants.
- A round of funding in this program topic area is planned to be announced with FOA-3 in March 2010 which will likely support seven to ten additional projects.
- | | | | |
|---------------------------------|---------------|----------|----------|
| Materials/Transportation | 62,678 | 0 | 0 |
|---------------------------------|---------------|----------|----------|
- The focus of this program topic area is electronic and structural materials science/engineering for transportation. This program topic area could potentially cover rapid discovery, manufacturing, and devices, including high-temperature, high strength/toughness, and light weight materials for batteries.

Currently, approximately 2/3 of U.S. oil consumption is devoted to transportation. There is no other method of storing portable energy that is cheaper or more energy-dense than liquid fuels. High energy/high power batteries for electric vehicles are a promising alternative to the gasoline vehicle paradigm, but current technology must increase battery performance and cost by 8-10x to make domestically generated electricity compete with foreign oil. ARPA-E is working to significantly improve the energy efficiency of vehicles by funding projects which have the potential to revolutionize vehicle energy consumption by either drastically improving the efficiency of technologies currently in vehicles or by replacing current vehicle components with novel, more efficient systems. ARPA-E is aggressively pursuing this goal for a more secure energy future.

There are currently six projects supported in this program topic area, all of which are being fully funded by ARRA funds. Our first transformational effort in this area targets production of high performance supercapacitors that could replace the batteries in electric vehicles, but could be recharged in seconds, not hours. A second project aims to dramatically increase the performance and lower the cost of lithium ion batteries - the dominant technology for vehicle electric batteries, using a proprietary nanotechnology approach. Third, we are funding a public-private partnership to develop high energy density, low cost next generation Li-ion batteries which could triple the energy density of existing electric vehicle batteries. Fourth, a university-small business team will produce metal-air batteries that could finally overcome the recharging difficulties that have plagued this genre of battery in the past. Fifth, a consortium of six American research institutions, will seek to develop world record performance, next-generation, domestically available permanent magnet materials, with a 2x target increase over the state-of-the art magnetic energy density. This project is of high importance to electric motor construction for vehicles and many other applications, and could eliminate the current dependency of this industry on foreign-obtained rare-earth metals. A sixth project integrates advances in the fabrication of semiconductor materials with device packaging that allows for enhanced cooling, and thus improved power devices for vehicles.

A second round of funding in this program topic area was announced in December under the title Batteries for Electrical Energy Storage in Transportation (BEEST); which will likely support seven to ten additional projects. These projects will also be fully funded by ARRA funds. With BEEST, ARPA-E seeks to develop a new generation of ultra-high energy density, low-cost battery technologies for long electric range plug in hybrid electric vehicles and electric vehicles (EVs). The development of high energy, low cost batteries represents the critical barrier to widespread deployment of EVs, which if achieved would have a profound impact on U.S. oil security, greenhouse gas emissions, and economic growth. The ambitious goals for this program are largely based upon the aggressive long term EV battery goals set forth by the United States Automotive Battery Consortium, public-private collaboration between the U.S. Department of Energy and leading U.S. automotive companies. If successful, new battery technologies developed under this program will give electrified light-duty vehicles range, performance, lifetime, and cost required to shift transportation energy from oil to the domestically powered U.S. electric grid. ARPA-E's objective is to fund high-risk, high reward research efforts that will promote leadership in this emerging EV battery market.

▪ Thermal/Transportation	5,195	0	0
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The focus of this program topic area is thermal science and device and process engineering for transportation. This program topic area could potentially cover heating, cooling, and thermal management devices and technologies related engine performance and efficiency, and waste heat recovery.

Approximately 60% of the energy generated in the U.S. is lost in the form of waste heat. Sources of loss include power plants, industrial processes, and vehicles. While technologies such as Rankine cycles and thermoelectric materials can convert waste heat into electricity, high capital costs and low conversion efficiencies hind their widespread adoption. The objective of the ARPA-E projects in this topic area is to revolutionize the conversion efficiency of thermoelectric devices through advanced materials and novel silicon nanotubes in order to effectively harness waste heat.

There are currently two projects supported in this program topic area, both of which are being fully funded by ARRA funds.

▪ **Materials/CO2** **3,895** **0** **0**

The focus of this program topic area is electronic and structural materials science/engineering for carbon dioxide capture and utilization. This program topic area could potentially cover rapid discovery, manufacturing, and devices related to carbon dioxide binding and reacting materials.

Carbon capture and sequestration (CCS) technologies offer the potential to continue harnessing energy from coal while minimizing release of Carbon Dioxide (CO₂) into the atmosphere. However, CCS is an energy-intensive process, and the largest contribution to the energy and cost penalties stems from capture of CO₂ from flue gas. The objective of the ARPA-E projects in this topic area is to drastically reduce the energy and cost penalties currently required for carbon capture through integration of recent scientific breakthroughs, such as carbon nanotubes, and advanced electrochemical techniques, with traditional carbon capture processes.

There are currently three projects supported in this program topic area, all of which are being fully funded by ARRA funds. The first effort attempts to improve both the speed and selectivity of CO₂ membranes through the integration of carbon nanotubes into the membrane. The second project attempts to control CO₂ capture and release through an electrochemical technique, which could drastically reduce the energy losses associated with changes in temperature that are currently needed. The third effort will harness the effect of electric fields to decrease the energy that is required for CO₂ to be removed from the material used for capture.

▪ **Biological Chemical/CO2** **42,251** **0** **0**

The focus of this program topic area is chemical and biological science and process engineering for carbon dioxide capture and utilization. This program topic area could potentially cover new catalysts, robust materials, alternative CO₂ chemistries, and advanced CO₂ capture processes from new and existing coal-fired power plants.

As described above, carbon capture and sequestration (CCS) is an energy-intensive process, and the largest contribution to the energy and cost penalties stems from capture of CO₂ from flue gas. The objective of the ARPA-E projects in this topic area is to drastically advance catalysts and robust materials, which are necessary enabling elements for CCS technologies that would impose lower cost and energy penalties than what is required for CCs today.

There are currently two projects supported in this program topic area, both of which are being fully funded by ARRA funds. The first effort will develop a synthetic version of an enzyme that is highly effective at catalyzing CO₂ reactions, but is currently too fragile to survive inside a coal plant. The second project will build a 250 kW pilot scale capture system to assess the feasibility of a technique that uses novel materials chemistry in an alternative and potentially lower-cost CO₂ capture process.

A second round of funding in this program topic area was announced in December under the title Innovative Materials and Processes for Advanced Carbon Capture Technologies (IMPACCT). Coal-fired power plants currently generate approximately 50% of the electricity in the United States. While coal is a cheap and abundant resource, the continued reliance upon coal as an energy source could potentially have serious consequences in terms of global warming. The objective of this topic is to fund high risk, high reward research efforts that will revolutionize technologies that capture carbon dioxide from coal-fired power plants, thereby preventing release into the atmosphere. ARPA-E seeks to complement existing DOE efforts in the field of carbon capture, led by the Office of Fossil Energy and National Energy Technology Laboratory, by accelerating promising ideas from the basic research stage towards large-scale demonstrations and ultimately, commercialization. Areas of interest defined in IMPACCT include: low-cost catalysts to enable systems with superior thermodynamics that are not currently practical due to slow kinetics; robust materials that resist degradation from caustic contaminants in flue gas; and advanced capture processes that dramatically reduce the parasitic energy penalties and corresponding increase in the cost of electricity required for carbon capture.

▪ **Materials/Industrial Power** 0 0 35,000

The focus of this program topic area is electronic and structural materials science/engineering for industrial power generation and use. This program topic area could potentially cover rapid discovery, manufacturing, and devices, including high-temperature strength/toughness in materials for power generation, and alternative materials, as they relate to industrial power generation and use in energy intensive activities such as the production of cement, metals, glass and paper.

Industry is the largest and most diverse energy-consuming sector in the United States. The nation's top eight energy intensive industries are aluminum, chemicals, forest products, glass, metal casting mining, petroleum refining, and steel. ARPA-E is specifically focused on technologies which can help to significantly reduce the industrial sector's energy requirements through development of new energy efficient and potentially paradigm-changing methods and technologies which have the potential to drastically reduce the energy and cost penalties currently associated with the industrial sector.

In FY 2011, a FOA for this program topic area is planned for early or mid fiscal year which will likely support seven to ten additional projects, pending availability of funding.

▪ **Thermal/Industrial Power** 4,716 0 30,000

The focus of this program topic area is thermal science and device and process engineering for industrial power generation and use. This program topic area could potentially cover heating, cooling, and thermal management devices and technologies, including waste heat recovery and devices for thermal integration for industrial power generation and use in energy intensive activities such as the production of cement, metals, glass and paper.

Approximately 60% of the energy generated in the U.S. is lost in the form of waste heat, from sources such as power plants, industrial processes, and vehicles. The objective of the ARPA-E projects in this topic area is to revolutionize the conversion efficiency of thermoelectric devices through advanced materials and novel silicon nanotubes in order to effectively harness waste heat.

There are currently two projects supported in this program topic area, both of which are being fully funded by ARRA funds. The first effort will develop advanced materials and new device architectures to create high efficiency thermoelectric modules that convert waste heat into electricity. The second project focuses on the use of silicon nanotubes to drastically increase the efficiency of thermoelectric modules, accelerating adoption of this technology on a widespread scale.

In FY 2011, a FOA announcement for this program topic area is planned for early or mid fiscal year which will likely support seven to ten additional projects, pending availability of funding.

▪ **Information Science/Transmission** **0** **0** **30,000**

The focus of this program topic area is information science and device engineering for electricity transmission and distribution. This program topic area could potentially cover computations, controls, communications, sensors, and actuators, including those for measurements, control, stability, optimization and demand response in electricity transmission and distribution.

To meet future energy demands, the US must transform its outdated US electricity grid into a modern system that is less polluting, more reliable, and highly efficient. Since 2000, fewer than 700 miles of interstate transmission lines have been added to the country’s grid, and line losses due to heavy utilization and congestion have nearly doubled during the past three decades. As we move toward a “smart” electricity grid, new technologies will be required that enable major changes in how our electricity is delivered. The goal of ARPA-E is to develop these enabling technologies, which include high-efficiency AC-DC converters, advanced power flow controllers, and new information technologies (such as novel control algorithms and system protocols). These innovations will allow integration of new energy storage technologies with the grid, improve power transfer levels on existing infrastructure, and increase overall system efficiency.

In FY 2011, a FOA announcement for this program topic area is planned for early or mid fiscal year which will likely support seven to ten additional projects, pending availability of funding.

▪ **Electronics/Transmission** **44,910** **0** **0**

The focus of this program topic area is electronic and structural materials science/engineering for electricity transmission and distribution. This program topic area could potentially cover rapid discovery, manufacturing, and devices including high-power electronics and component materials for the storage, transmission, and distribution of electricity.

As the electrical grid migrates to lower carbon generation modes, energy storage will greatly aid in the battle to reduce greenhouse gases. High capacity storage methods will reduce the need for polluting "spinning reserve" electrical plants, which generate power only in times of peak demand, but which run constantly to assure power quality. Electrical energy storage will also help smooth the power from renewable sources such as wind and solar, making these very intermittent alternative energy sources sufficiently reliable to be connected to the U.S. grid en masse. In turn, a "greener" grid will reduce overall emissions from the electrified transportation sector.

There are currently three projects supported in this program topic area, all of which are being fully funded by ARRA funds. First, ARPA-E is funding a fundamentally new all-liquid battery concept that would provide highly scalable energy storage for the grid. This battery would also use only domestically available materials, unlike lithium ion batteries designed for this application today. In a second project, a public-private alliance of scientists is moving to rapidly develop very high energy sodium batteries that perform better than similar large storage batteries produced today, but at much lower cost. Finally, our last grid storage project is a university-small business alliance to produce metal-air batteries that could finally overcome the recharging difficulties that have plagued this genre of battery in the past.

A round of funding in this program topic area is planned to be announced with FOA-3 in March 2010 which will likely support seven to ten additional projects.

▪ **Materials/Renewables**

54,477

0

30,000

The focus of this program topic area is electronic and structural materials science/engineering for renewable power sources. This program topic area could potentially cover rapid discovery, manufacturing, and devices, including photovoltaics, power electronics, high-strength materials for wind turbines, new device designs, and high temperature materials for solar thermal storage and conversion for renewable power sources including solar, wind, hydroelectric, and geothermal.

Renewable sources of electrical power are key components to increasing U.S. energy security, and reducing carbon emissions simultaneously. Improved drilling technologies for geothermal power, high efficiency (above 15% efficient) solar PV collectors, and more efficient wind turbine generation systems are all examples of ways that ARPA-E will help reach national and state-wide goals to increase our renewable energy generation profile to as high as 33% by 2020 (in the case of California). These technologies will also approach the amortized cost of alternative power generation to complete with fossil fuels on a pure-cost basis.

There are currently four projects supported in this program topic area, all of which are being fully funded by ARRA funds. A second round of funding in this program topic area is planned to be announced with FOA-3 in March 2010 which will likely support seven to ten additional projects. These projects will focus on electrical energy conversion devices, including AC/DC and DC/DC converters, and underlying technologies that can reduce the size, cost, and complexity of these devices. Promising areas for technology breakthroughs include novel circuit topologies that enable smaller device form-factors, wide-bandgap semiconductors and other high-efficiency switch technologies, and new soft-magnetic materials including novel alloys, thin films, and nanoparticles. Low-cost, reduced-form-factor power electronics can be applied in numerous applications; one key area is PV arrays, where these devices can increase overall system efficiency, reduce system cost, enhance reliability, and simplify system expansion and maintenance.

In FY 2011, a FOA announcement for this program topic area is planned for early or mid fiscal year which will likely support seven to ten additional projects, pending availability of funding.

- **Biological Chemical /Renewables** **0** **0** **30,000**
The focus of this program topic area is chemical and biological science and process engineering for renewable power sources. This program topic area could potentially cover (bio)chemical reactions, catalysis, and thermodynamics/kinetics related to photon capturing (bio)chemical reactions for storage and conversion of energy from renewable power sources including solar, wind, hydroelectric, and geothermal.

This topic will build on two of the FOAs released in 2009 on electrofuels and advanced batteries and will enhance the research done under those FOAs while broadening the scope beyond biofuels and batteries. The research covered under this topic has the potential to further the understanding of the underlying science which can enable new technologies in many different areas of renewable energy. ARPA-E hopes to find researchers who may have a strong scientific background but little energy experience and help them determine how their research can be applied to renewable energy systems.

In FY 2011, a FOA announcement for this program topic area is planned for early or mid fiscal year which will likely support seven to ten additional projects, pending availability of funding.

- **Materials/Fuels Synthesis** **5,993** **0** **0**
The focus of this program topic area is electronic and structural materials science/engineering for fuels synthesis. This program topic area could potentially include rapid discovery and manufacturing of devices related to electrochemical materials used in fuels synthesis.

Direct-solar fuels refers to the direct use of carbon dioxide and sunlight to produce fuels, a process generally called photocatalysis. These fuels could be combustion fuels or redox active fuels such as hydrogen which can generate electricity in a fuel cell. If fully realized, direct-solar fuel technologies could revolutionize fuel production and energy storage by providing local, on-site fuel production. Artificial light harvesting and energy transduction has been feasibly demonstrated; however, photocatalytic carbon-carbon bond formation remains a significant challenge. Further, mechanisms for energy transduction need to be improved to increase the overall energy efficiency of such technologies. New materials are also required for the selective reduction of carbon dioxide to fuels. To address these challenges, ARPA-E is funding both biochemical and inorganic approaches. These projects target important key challenges including carbon dioxide assimilation, off-grid hydrogen production from water, and innovative catalysts to produce methane from carbon dioxide and water.

Biomass energy refers to the use of photosynthetically-derived, non-food organic material as the starting material, or feedstock, for the production of fuels and power. However, current strategies for biomass energy are not economically competitive with traditional fuels. While significant investments have been made in this area, each step along the biomass energy supply chain - from biomass production through conversion to a final fuel - still face many challenges. ARPA-E selected five projects in this area that target key challenges along the entire biomass supply chain. Specifically, projects in this area seek to dramatically improve the availability and properties of biomass feedstock through advanced genetic engineering technologies and a technology to improve the conversion of biomass to pyrolysis oil, or bio-crude. Other novel projects include development of economical methods for algae harvesting and the development of macroalgae as a promise source of feedstock material. Each of these projects target critically important problems in their respective areas. This topic area currently funds five projects, all of which are being fully funded by ARRA funds.

There is currently one project supported in this program topic area, which is being fully funded by ARRA funds.

- **Biological Chemical /Fuels Synthesis** **65,865** **0** **0**
The focus of this program topic area is chemical and biological science and process engineering for fuels synthesis. This program topic area could potentially cover (bio)chemical reactions, catalysis, and thermodynamics/kinetics related to fuels synthesis.

Direct-solar fuels refers to the direct use of carbon dioxide and sunlight to produce fuels, a process generally called photocatalysis. These fuels could be combustion fuels or redox active fuels such as hydrogen which can generate electricity in a fuel cell. If fully realized, direct-solar fuel technologies could revolutionize fuel production and energy storage by providing local, on-site fuel production. Artificial light harvesting and energy transduction has been feasibly demonstrated; however, photocatalytic carbon-carbon bond formation remains a significant challenge. Further, mechanisms for energy transduction need to be improved to increase the overall energy efficiency of such technologies. New materials are also required for the selective reduction of carbon dioxide to fuels. To address these challenges, ARPA-E is funding both biochemical and inorganic approaches. These projects target important key challenges including carbon dioxide assimilation, off-grid hydrogen production from water, and innovative catalysts to produce methane from carbon dioxide and water.

Biomass energy refers to the use of photosynthetically-derived, non-food organic material as the starting material, or feedstock, for the production of fuels and power. However, current strategies for biomass energy are not economically competitive with traditional fuels. While significant investments have been made in this area, each step along the biomass energy supply chain - from biomass production through conversion to a final fuel - still face many challenges. ARPA-E selected five projects in this area that target key challenges along the entire biomass supply chain. Specifically, projects in this area seek to dramatically improve the availability and properties of biomass feedstock through advanced genetic engineering technologies and a technology to improve the conversion of biomass to pyrolysis oil, or bio-crude. Other novel projects include development of economical methods for algae harvesting and the development of macroalgae as a promise source of feedstock material. Each of these projects target critically important problems in their respective areas. This topic area currently funds five projects, all of which are being fully funded by ARRA funds.

There are currently nine projects supported in this program topic area, all of which are being fully funded by ARRA funds.

A second round of funding in this program topic area was announced in December under the title Electrofuels, which will likely support seven to ten additional projects. ARPA-E is seeking new ways to make liquid transportation fuels - without using petroleum or biomass - by using microorganisms to harness chemical or electrical energy to convert carbon dioxide into liquid fuels. Many methods of producing advanced and cellulosic biofuels are under development to lessen our dependence on petroleum and lower carbon emissions. Most of the methods currently under development involve converting biomass or waste, while there are also approaches to directly produce liquid transportation fuels from sunlight and carbon dioxide. Although photosynthetic routes show promise, overall efficiencies remain low. The objective of this program topic area is to develop an entirely new paradigm for the production of liquid fuels that could overcome the challenges associated with current technologies. ARPA-E requests innovative proposals which can overcome these challenges through the utilization of metabolic engineering and synthetic biological approaches for the efficient conversion of carbon dioxide to liquid transportation fuels. ARPA-E specifically seeks the development of organisms capable of extracting energy from hydrogen, from reduced earth-abundant metal ions, from robust, inexpensive, readily available organic redox active species, or directly from electric current.

Theoretically such an approach could be 10 times more efficient than current photosynthetic-biomass approaches to liquid fuel production.

- **Materials/Water & Agriculture** **2,031** **0** **0**
The focus of this program topic area is electronic and structural materials science/engineering for water and agriculture. This program topic area could potentially include rapid discovery and manufacturing of materials and devices related to water purification, desalination, and management.

Water is the world's most essential natural resource and is required for all life on the biosphere. Current state-of-the-art desalination technologies are quickly approaching theoretical operating efficiencies, yet innovative technologies are required to reduce the energy intensity and cost of desalination to face the challenges posed by population growth and continual depletion of fresh water resources. ARPA-E is funding an interesting approach to develop carbon nanotubes to make industrially scalable high efficiency reverse osmosis membranes with 10 times the flux of existing membranes. If successful, the technology will enable cost-effective harvesting of fresh water from the 97% of global water found in the oceans and provide a critical source of fresh water for U.S. energy and food crops, power plants, industrial plants, and water-stressed communities.

There is currently one project supported in this program topic area, which is being fully funded by ARRA funds.

- **Thermal/Water & Agriculture** **0** **0** **30,000**
The focus of this program topic area is thermal science and device and process engineering for water and agriculture. This program topic area could potentially cover heating, cooling, and thermal management devices and technologies, thermal processes for use of water (heating/cooling) and water purification/management.

Water is the world's most essential natural resource and is required for all life on the biosphere. A large growth in demand for water is expected over the next 25 years, with many localities experiencing significant and sustained increases. Conservation alone will be insufficient to meet this demand. Technologies that can increase effective supplies by many factors with low energy intensity will be critical. A viable strategy is to produce clean water from contaminated water, including wastewater and saltwater. Current thermal methods for treatment of contaminated water, especially desalination, are very energy intensive. ARPA-E will be focused on developing novel thermal methods, technologies, and thermal management systems to efficiently produce clean water from contaminated water. Additionally, many large infrastructure systems, including manufacturing plants, nuclear power plants, and many others, require cooled water to sustain their operation. Similar to the heating of water, cooling large amounts of water is energy intensive. ARPA-E will also focus on technologies and methods to efficiently produce large amounts of coolant water.

In FY 2011, a FOA announcement for this program topic area is planned for early or mid fiscal year which will likely support seven to ten additional projects, pending availability of funding.

- **Biological Chemical /Water & Agriculture** **36,047** **0** **30,000**

The focus of this program topic area is chemical and biological science and process engineering for water and agriculture. This program topic area could potentially cover (bio)chemical reactions, catalysis, and thermodynamics/kinetics related to reactions for water purification and management, and genetic engineering of plants for rapid/efficient carbon capture and storage. In the future, contaminated water, including wastewater and saltwater may be the best available resource to address growing water needs. Generating clean water from wastewater is non-trivial due to the presence of solids and volatiles, pathogens, and small toxins, as well as the high variability of wastewater (water content, temperature, pH, protein, fats, salts, & carbohydrates). A viable strategy to combat these challenges, in an energy-efficient way, is through biological or chemical methods and technologies. ARPA-E will focus on biochemical technologies and methods, such as algae use, new materials and biological microbes, catalysts and photocatalysts, and others, to efficiently generate clean water from contaminated water. Many of these technologies may have the added benefit of co-generation and CO₂ capture, processing to liquid fuels, and the separation and harvesting of rare earth minerals.

A round of funding in this program topic area is planned to be announced with FOA-3 in March 2010 which will likely support seven to ten additional projects.

In FY 2011, a FOA announcement for this program topic area is planned for early or mid fiscal year which will likely support seven to ten additional projects, pending availability of funding.

- **Seedlings** 0 0 20,745

The focus of the Seedlings line is to provide funding for innovative projects that happen to fall outside the boundaries of the specific focus topic area FOAs. ARPA-E feels this is important in order to not miss out on any truly innovative projects that may be out there, and to foster a sense in the community that ARPA-E is open to funding projects that are outside of the specific focus topic areas FOAs.

In FY 2011, a FOA announcement for this program topic area is planned for early or mid fiscal year, pending availability of funding.

- **SBIR/STTR** 0 0 7,655

The FY 2011 amount shown for the SBIR and STTR programs is the estimated requirements for continuation of these congressionally mandated programs.

Total, ARPA-E Projects	377,556	0	273,400
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Explanation of Funding Changes

	FY 2011 vs. FY 2010 (\$000)
ARPA-E Projects	
<ul style="list-style-type: none"> ▪ Decision Science/Buildings The increase is due to the fact that ARPA-E received zero funding in FY 2010. 	+30,000
<ul style="list-style-type: none"> ▪ Materials/Industrial Power The increase is due to the fact that ARPA-E received zero funding in FY 2010. 	+35,000
<ul style="list-style-type: none"> ▪ Thermal/Industrial Power The increase is due to the fact that ARPA-E received zero funding in FY 2010. 	+30,000
<ul style="list-style-type: none"> ▪ Information Science/Transmission The increase is due to the fact that ARPA-E received zero funding in FY 2010. 	+30,000
<ul style="list-style-type: none"> ▪ Materials/Renewables The increase is due to the fact that ARPA-E received zero funding in FY 2010. 	+30,000
<ul style="list-style-type: none"> ▪ Biological Chemical/Renewables The increase is due to the fact that ARPA-E received zero funding in FY 2010. 	+30,000
<ul style="list-style-type: none"> ▪ Thermal/Water & Agriculture The increase is due to the fact that ARPA-E received zero funding in FY 2010. 	+30,000
<ul style="list-style-type: none"> ▪ Biological Chemical/Water & Agriculture The increase is due to the fact that ARPA-E received zero funding in FY 2010. 	+30,000
<ul style="list-style-type: none"> ▪ Seedlings The increase is due to the fact that ARPA-E received zero funding in FY 2010. 	+20,745
<ul style="list-style-type: none"> ▪ SBIR/STTR The support for SBIR/STTR is funded at the mandated level. 	+7,655
Total Funding Change, ARPA-E Projects	+273,400

Advanced Research Projects Agency – Energy (ARPA-E)

Program Direction

Funding Profile by Category

(dollars in thousands)

	FY 2009 ¹	FY 2010	FY 2011
Headquarters			
Salaries and Benefits	7,900	0	7,916
Travel	500	0	1,000
Support Services	14,900	0	15,650
Other Related Expenses	3,000	0	2,000
Total, Headquarters	26,300	0	26,566
Full Time Equivalents	8	15	35
Total Program Direction			
Salaries and Benefits	7,900	0	7,916
Travel	500	0	1,000
Support Services	14,900	0	15,650
Other Related Expenses	3,000	0	2,000
Total, Program Direction	26,300	0	26,566
Total, Full Time Equivalents	8	15	35

Benefits

Program Direction provides the Federal staffing resources and associated costs required to provide overall direction and execution of the Advanced Research Projects Agency – Energy (ARPA-E) mission. This budget provides for salaries and benefits of federal staff, including awards, federal staff and contractor travel, and the support services contracts required for technical advisory and assistance services. This budget further provides funding for other related expenses, including leased office space and for the DOE Working Capital Fund.

Innovations in Business Processes

As described in the ARPA-E Projects section, the Secretary and Director envision ARPA-E to not be business-as-usual for the Department of Energy. ARPA-E has integrated several innovations into its culture for the administration of projects including: term-limited Program Directors; an ARPA-E team providing programmatic, operations, outreach, and commercialization support; the wise use of all available hiring and procurement authorities; and the ARPA-E Fellows program.

¹ ARPA-E was created in FY 2009. For comparison purposes, the sum of FY 2009 appropriations (FY 2009 Omnibus and Recovery Act) is shown in the FY 2009 column for ARPA-E. This represents the total funding available to ARPA-E. Amounts shown represent budget levels covering both FY 2009 and FY 2010.

Program Directors: The Director will designate employees to serve as Program Directors for each of the program topic areas established pursuant to the responsibilities outlined in the preface. By statute, ARPA-E has very broad authority in hiring Program Directors that is largely unrestricted by civil services laws. ARPA-E employs Program Directors to serve discrete time-limited terms and run projects in different topic areas. Each FOA topic area's projects last between two and four years, and once a Program Director's projects are completed so ends his or her term of employment with ARPA-E. New Program Directors are then hired to research, create, and oversee new programs. Rotating Program Directors in this way ensures that ARPA-E will always have new ideas and a fresh perspective on this rapidly evolving field.

Team ARPA-E: Project teams receiving funding from ARPA-E get more than just federal funds; they receive fully coordinated support and scrutiny from the ARPA-E team. This support includes: a Program Team to provide technical help and monitor technical progress; an Operations Team to expedite transactions within the constraints of Congressional statute; an Outreach Team to highlight progress to media, Congress, and other stakeholders, in addition to the ARPA-E Innovations Summit; and a Commercialization Team to provide feedback from and links to potential technology adopters as well as venture capitalists and other financiers.

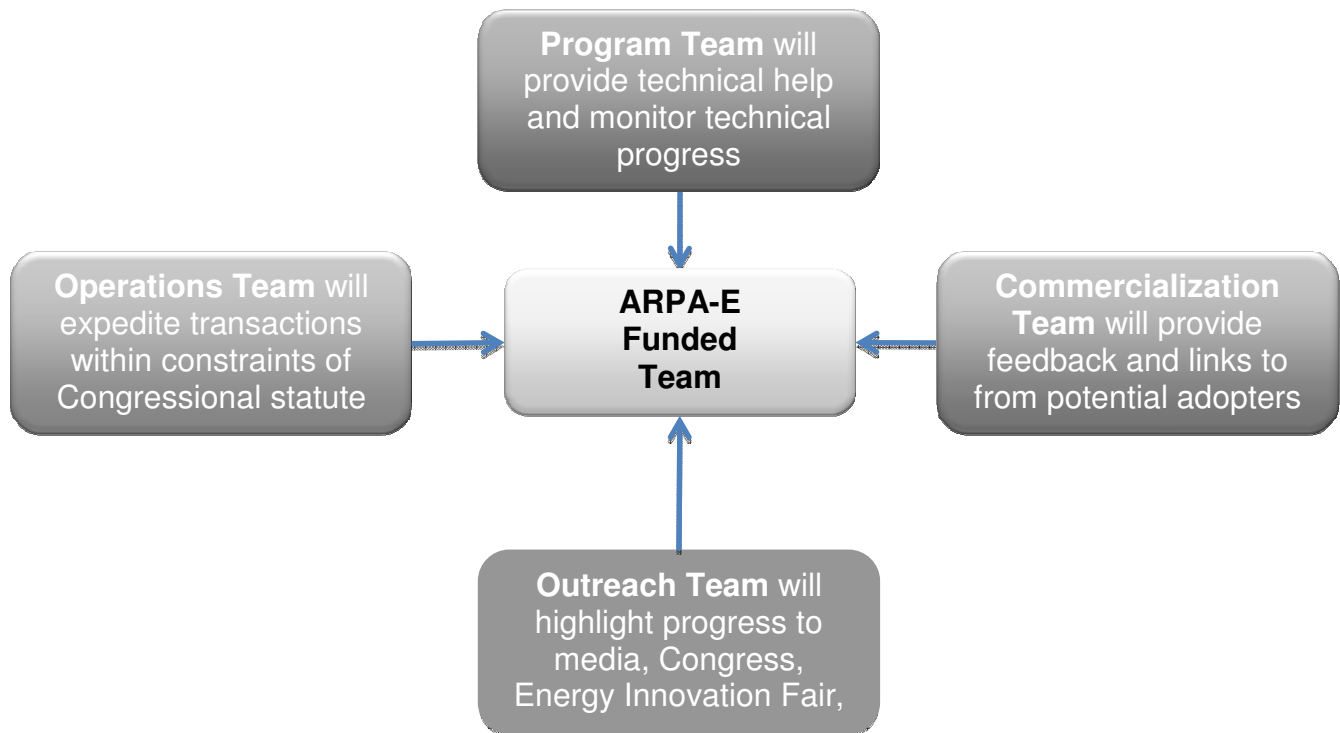


Figure: Value of ARPA-E Investment, More Than Just Funding

Hiring and Procurement Authorities: The Director will make wise use of existing DOE authorities that are provided to the Secretary to hire administrative, financial, and clerical staff as necessary, and will use the Department's Other Transactions Authority (OTA) for contracting and procurement to enable ARPA-E to maintain a fast-moving and flexible.

ARPA-E Fellows Program: The program will also call upon the nation's highly energized youth, who are ready to step up and engage on important energy issues, through the ARPA-E Fellows Program. This program will bring the best and brightest recent PhDs to ARPA-E to form an internal think tank to identify technological barriers and opportunities for ARPA-E funding. This two-year fellowship program will consist of highly technical recent post-doctoral scientists and researchers, as well as similarly degreed individuals from the financial and policy communities. Fellows will not conduct research, but rather will actively help create the strategic direction and vision of ARPA-E. Fellows will support Program Directors in program creation; undertake independent explorations of promising future research areas for ARPA-E; engage with world-class researchers and innovators to develop theses for high-impact ARPA-E research program areas; prepare energy technology and economic analyses; and make recommendations to ARPA-E senior management. With this program, ARPA-E hopes to tap into a young generation of motivated, energetic "rising stars" who will bring fresh perspectives on transformational technology development areas ripe for ARPA-E program development, and that Fellows will learn about the whole lifecycle of energy technology development and commercialization. Armed with this learning, it is expected that Fellows will go on to be global leaders in the energy technology research, development, policy, and commercialization field. ARPA-E Fellows will be full-time federal employees paid a competitive salary based on experience and skill level.

ARPA-E Innovations Summit and Venture Capital Day: Finally, ARPA-E will have a strong component of community building and outreach. Plans are underway for an ARPA-E Innovations Summit to be held on March 1-3, 2010; which is planned to be an annual event that showcases ARPA-E technology innovations, provides a platform to connect with potential investors, and builds the community. Another annual event we are looking to hold is an ARPA-E Venture Capital Day at which we hope to bring together people from the research and financing communities to identify strategies for leveraging funding and to accelerate scaling of ARPA-E technologies for market impact.

Detailed Justification

(dollars in thousands)

FY 2009	FY 2010	FY 2011
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Salaries and Benefits

7,900 0 7,916

ARPA-E federal staff will provide leadership and management for ARPA-E in both administrative and program management functions. Administrative functions include the Director's office, contract management, general counsel, financial management, and human capital management. Program Directors will establish research and development goals, solicit applications for specific areas of particular promise, build research collaborations, and select projects to be supported under the program. Staff will monitor, support, and evaluate over 100 grants and contracts initiated under the Recovery Act, as well as all additional grants and contracts funded in FY 2011.

Travel

500 0 1,000

The request funds travel by ARPA-E staff to carry out the activities supported under the program. Includes all costs of transportation of persons, subsistence of travelers, and incidental travel expenses in accordance with federal travel regulations which are directly chargeable to ARPA-E.

Support Services

14,900 0 15,650

The ARPA-E Support Services budget element provides funds for non-federal contractor and consultant support functions, defined as advisory and assistance services acquired by contract from non-governmental services, necessary to carry out the activities supported under the program. Support services include, but are not limited to, Technical Science Engineering and Technical Assistance (SETAs) providing scientific, engineering support to ARPA-E and Program Science Engineering and Technical Assistance (SETAs) program planning, financial and administrative support to ARPA-E for existing and planned tasks.

Other Related Expenses

3,000 0 2,000

The Other Related Expenses budget element includes costs for building leases and other related expenses (communications, utilities, compute and video support, training, printing and graphics, photocopying, postage, supplies, and common administrative services).

Total, Program Direction

26,300 0 26,566

Explanation of Funding Changes

FY 2011 vs. FY 2010 (\$000)

Salaries and Benefits

+7,916

The increase is due to the fact that ARPA-E received zero funding in FY 2010.

Additionally, ARPA-E is seeking to increase from three Program Directors and 15 total federal FTEs in FY 2010 up to ten Program Directors and 35 total federal FTEs in FY 2011.

Travel

+1,000

The increase is due to the fact that ARPA-E received zero funding in FY 2010.

Additionally, the FY 2011 estimate reflects more Program Director and staff travel to an increased number of award recipient locations to conduct first-hand monitoring and evaluation of progress towards technical deliverables and milestones. This travel is essential to assessing the performer's research efforts and informing any decision to stop targeted programs on the basis of performance.

Support Services

+15,650

The increase is due to the fact that ARPA-E received zero funding in FY 2010.

Additionally, ARPA-E is seeking to increase from 24 support service contractors in FY 2010 to a total of 40 support service contractors in FY 2011.

Other Related Expenses

+2,000

The increase is due to the fact that ARPA-E received zero funding in FY 2010.

Costs are relatively flat versus FY 2009 funding levels with a slight increase reflective of the increase in leased space costs.

Total Funding Change, Program Direction

+26,566

Support Services by Category

(dollars in thousands)

	FY 2009 ¹	FY 2010	FY 2011
Technical Support			
Management and Technical Services	7,600	0	7,850
Total, Technical Support	7,600	0	7,850
Management Support			
Administrative Services	7,300	0	7,800
Total, Management Support	7,300	0	7,800
Total, Support Services	14,900	0	15,650

Other Related Expenses by Category

(dollars in thousands)

	FY 2009 ¹	FY 2010	FY 2011
Other Related Expenses			
Rent to Others	1,900	0	1,100
Communications, Utilities, Misc.	415	0	350
Printing and Reproduction	150	0	125
Other Services	115	0	75
Purchases from Gov. Accounts	-	0	-
Supplies and Materials	60	0	50
Working Capital Fund	360	0	300
Total, Other Related Expenses	3,000	0	2,000

¹ ARPA-E was created in FY 2009. Amounts shown represent budget levels covering both FY 2009 and FY 2010.