The ARPA-E Mission

Catalyze and support the development of transformational, high-impact energy technologies

Ensure America’s

- National Security
- Economic Security
- Energy Security
- Technological Lead

History of ARPA-E

2007 RISING ABOVE THE GATHERING STORM PUBLISHED
2007 AMERICA COMPETES ACT SIGNED
2009 AMERICAN RECOVERY & REINVESTMENT ACT $400M
2011 FY2011 BUDGET $180M
2012 FY2012 BUDGET $275M
2013 FY2013 BUDGET $250M

2009 – Present

| Programs | 2 Open + 14 |
| Projects | 285 |
| Dollars (MM) | $770 |

Creating New Learning Curves

COST / PERFORMANCE

NEW LEARNING CURVES

CURRENT LEARNING CURVE

TIME / SCALE
What Makes an ARPA-E Project?

**IMPACT**
- High impact on ARPA-E mission areas
- Credible path to market
- Large commercial application

**TRANSFORM**
- Challenges what is possible
- disrupts existing learning curves
- Leaps beyond today’s technologies

**BRIDGE**
- Translates science into breakthrough technology
- Not researched or funded elsewhere
- Catalyzes new interest and investment

**TEAM**
- Comprised of best-in-class people
- Cross-disciplinary skill sets
- Translation oriented

Technology Acceleration Model

**How does ARPA-E Enable Transformations?**

Science & Technology Knowledgebase | Unique Project Team | Disruptive New Technologies
---|---|---
ARPA-E teams come from a multiple segments of the S&T base to attack problems in entirely new ways

Measuring ARPA-E’s Success

**MOVING TECHNOLOGY TOWARD MARKET**
- Partnerships with Other Government Agencies
- New Company Formation
- Established Company Partnerships
- New Communities

**BREAKTHROUGH ACHIEVEMENTS**
- Technology breakthroughs
- Patents
- Publications

**OPERATIONAL EXCELLENCE**
- Expedited program development and project selection
- Aggressive performance metrics
**OPEN 2012: 66 Projects, 24 States, 11 Areas**

- **2 Advanced Vehicles**
- **2 Water**
- **13 Advanced Fuels**
- **3 Building Efficiency**
- **2 Stationary Generation**
- **9 Grid Modernization**

**66 Projects**

**Focused Programs**

**BEEST**
**ELECTRIC VEHICLE BATTERIES**

**Mission**
Develop a variety of electric vehicle battery technologies that can compete in both cost and performance with traditional gasoline-powered cars.

**Goals**
- Cost-competitive with traditional cars
- 30% of today's cost at 2-5x energy storage
- 300-500% longer battery life + range

**Highlights**
- PolyPlus
  - $9 million Vehicle Technologies grant
  - Contracted with Hitachi for fabrication line (Navy as first market)
- Sion
  - CERDEC grant from Army for lithium sulfur battery for UAV's/air Force
  - Funding from Simon Foundation and $20M from BASF

**Program Director**
Dr. Dane Boysen

**Year**
2010

**Projects**
6

**Total Investment**
$35.5 Million

**Mission**
Develop technologies that can store renewable energy for use at any location on the grid at an aggressive investment cost less than $100 per kilowatt hour, creating a stronger and more robust electric grid.

**Program Director**
Dr. Mark Johnson

**Year**
2010

**Projects**
12

**Total Investment**
$33.2 Million

**GRIDS**
**GRID-SCALE RENEWABLE ENERGY STORAGE**

**Mission**
Develop technologies that can store renewable energy for use at any location on the grid at an aggressive investment cost less than $100 per kilowatt hour, creating a stronger and more robust electric grid.

**Goals**
- Balance intermittent renewable sources connected to the grid
- Efficiently store and send electricity anywhere in the U.S. at a lowest possible cost
- Strong, efficient, stable and robust electric grid

**Highlights**
- General Compression:
  - $54.5M follow-on funding from private investors for CAES technology deployment
- ABB/SuperPower/Brookhaven NL
  - $4.2M follow-on funding from US Army Research Laboratory for SMES development and testing in DOD microgrids
- Bosch/Lawrence Berkeley NL
  - Attained highest power density ever in hydrogen-bromine flow battery system
# HEATS
## THERMAL ENERGY STORAGE

**Mission**
Develop revolutionary, cost-effective ways to store thermal energy by innovating electricity delivery, creating synthetic fuel from sunlight, and improving the range of electric vehicles (EVs).

**Goals**
- Enable non-intermittent solar power plants and peak-power nuclear power plants
- Create transportable fuels from sunlight
- Modular thermal energy storage for EVs

**Highlights**
- **UT Austin**
  - Developing sugar derivatives-graphene foam composites with heat of fusion 2-3 x of state of the art and thermal conductivity > 10 – 20 x of state of the art
- **Halotechnics**
  - Developing low cost molten glass as heat transfer and thermal storage for CSP
- **MIT**
  - Developing energy storage device which captures energy from the sun, is transportable like fuels, rechargeable like a battery and emissions-free

**Program Director** Dr. James Klausner

**Year** 2011

**Projects** 15

**Total Investment** $37.6 Million

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# Electrofuels
## VERSATILE TRANSPORTATION FUEL SOLUTIONS

**Mission**
Develop microorganisms to create liquid transportation fuels in a new and different way that could be up to 10 times more energy efficient than current biofuel production methods.

**Goals**
- Develop and integrate organisms for autotrophic/non-photosynthetic biological systems
- Increase liquid fuel energy density beyond ethanol

**Highlights**
- **OPX Biotechnologies (Boulder, CO)**
  - Demonstration of fatty acid production from engineered microbes fed H2 and CO2
  - Raised $64M with venture investors
  - Named to 2012 Global Cleantech 100 list
- **University of California Los Angeles**
  - Demonstration and publication in Science magazine of an integrated system for In situ formate production and microbial conversion to alcohols

**Program Director** Dr. Ramon Gonzalez

**Year** 2010

**Projects** 13

**Total Investment** $48.3 Million

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# PETRO
## HIGHER PRODUCTIVITY CROPS FOR BIOFUELS

**Mission**
Develop non-food crops that directly produce transportation fuels to be cost-competitive with petroleum and not impactful on U.S. food supply.

**Goals**
- To reduce biofuel production costs
- To increase energy yields per acre of land
- To recycle atmospheric CO2

**Highlights**
- Develop pine trees that will accumulate 20% of their biomass as high energy terpene molecules
- Develop tobacco that produces oil directly, together with high planting density agriculture
- Introduce multiple metabolic pathways into oilseed crops to significantly improve photosynthesis

**Program Director** Dr. Jonathan Burbaum

**Year** 2011

**Projects** 10

**Total Investment** $37.3 Million

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# IMPACCT
## CARBON CAPTURE TECHNOLOGY

**Mission**
Develop new materials and processes to lower the cost of removing carbon dioxide (CO2) from existing coal-fired power plants, thus enabling continued use of coal with reduced emissions.

**Goals**
- Capture 90% of CO2 from coal-fired power plants at no more than a 35% increase in the cost of electricity
- Focus on technologies that could be retrofitted to existing power plants
- Accelerate implementation of carbon capture technology

**Highlights**
- **Texas A&M University**
  - Designed new class of materials, Single Molecule Traps, tailor-made to capture CO2
  - Created spinout named framergyTM to commercialize the technology
- **University of Colorado – Boulder**
  - Developing new type of membrane based on gels and composite polymer designs
  - Engaged with Total and 3M as industrial partners to commercialize the membranes

**Program Director** Dr. Karma Sawyer

**Year** 2010

**Projects** 15

**Total Investment** $39.9 Million
REACT
ALTERNATIVES TO CRITICAL MATERIALS IN MAGNETS

Mission
Identify low-cost, abundant replacement materials for rare earths while encouraging existing technologies to use them more efficiently.

Goal
• Eliminate most or all rare earth magnets in electric vehicle motors & wind generators

Highlights
• Several new chemistries, not containing critical materials, show promise on a laboratory scale as a replacement for permanent magnets containing critical materials
• Cost-competitive large-scale off-shore wind generators will be enabled by using high current carrying superconductor wiring

Program Director
Dr. Mark Johnson

Year
2011

Projects
14

Total Investment
$27.7 Million

New Funding Opportunities

RANGE
Robust Affordable Next Generation EV-storage
Release Date: 2/19/2013

METALS
Modern Electro/Thermochemical Advances in Light-metal Systems
Release Date: 3/20/2013

REMOTE
Reducing Emissions Using Methanotrophic Organisms for Transportation Energy
Release Date: 3/15/2013

RANGE
NEXT-GENERATION ENERGY STORAGE SYSTEMS FOR ELECTRIC VEHICLES

Mission
Improve EV range and reduce vehicle costs by re-envisioning the total EV battery system, rather than working to increase the energy density of individual battery cells.

Goals
• Develop robust battery chemistries and architectures that would improve vehicle driving range and overall battery robustness
• Focus on multifunctional energy storage designs that use these robust storage systems to simultaneously serve other functions on a vehicle, thus further reducing an energy storage system’s effective weight and overall electric vehicle weight

Highlights
• Coming soon

Program Director
Dr. Ping Liu

Year
2013

Projects
TBD

Available Funding
$20 Million

METALS
ADVANCED PROCESSING AND RECYCLING OF LIGHTWEIGHT METALS

Mission
Develop innovative technologies for cost-effective processing and recycling of Aluminum, Magnesium and Titanium for lightweight vehicle materials.

Goals
• Advance technologies to develop metals have high strength-to-weight ratios, making them ideal for creating lighter vehicles that save fuel and reduce carbon emissions
• Utilize domestically available ores
• Reduce energy inputs and emissions from processing to make light metals cost competitive with current materials, such as steel
• Develop technologies for rapid and efficient light metal sorting to enable domestic recycling

Program Director
Dr. James Klausner

Year
2013

Projects
TBD

Available Funding
$20 Million
**REMOTE**
BIOLOGICAL CONVERSION OF GAS TO LIQUIDS

<table>
<thead>
<tr>
<th>Mission</th>
<th>Develop transformational biological technologies to convert gas to liquids for transportation fuels.</th>
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| Goals   | • Develop innovative catalysts and lab scale reactors to efficiently and cost-effectively convert natural gas  
         | • Lower the cost of gas to liquids conversion  
         | • Enable the use of low-cost, domestically sourced natural gas for transportation, which could reduce vehicle emissions compared to conventional gasoline engines  |
| Highlights | • Coming soon |

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