ARPA-E Overview

Electric Energy Systems Curriculum for Sustainability Workshop

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Deputy Director for Technology
ARPA-E
ARPA-E Mission

Catalyze the development of transformational, high-impact energy technologies

Promoting revolutionary advances in fundamental sciences

Reduce Energy-Related Emissions

Reduce Energy Imports

Improve Energy Efficiency

Translating scientific discoveries into technological innovations

Ensure the U.S. maintains a lead in the development and deployment of advanced technologies

Accelerating transformational technological advances in areas that industry by itself is not likely to undertake
Evolution of ARPA-E

- **2007**: RISING ABOVE THE GATHERING STORM PUBLISHED
- **2007**: AMERICA COMPETES ACT SIGNED
- **2009**: AMERICAN RECOVERY & REINVESTMENT ACT $400M Appropriated
- **2011**: FY2011 BUDGET $180M Appropriated
- **2012**: FY2012 BUDGET $275M Appropriated

<table>
<thead>
<tr>
<th>2009 – Present</th>
<th>Programs</th>
<th>Projects</th>
<th>Dollars (MM)</th>
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<tbody>
<tr>
<td></td>
<td>2 Open + 14</td>
<td>285</td>
<td>$770</td>
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Technology Acceleration Model

PROGRAM DEVELOPMENT CYCLE

ENVISION
- Program Conception (Idea/Vision)
  - Workshop
- Program Approval

ENGAGE
- FOA Development & Issuance

EVALUATE
- Merit Review of Proposals
- Proposal Rebuttal

ESTABLISH
- Project Selection
- Contract Negotiations & Awards

EXECUTE
- Ongoing Technical Review
- Project Handoff

Transition Toward Market Adoption
Focused Programs

TRANSPORTATION ENERGY TECHNOLOGIES

- BEEST
- Electrofuels
- PETRO
- MOVE

HEATS

REACT

AMPED

SBIR/STTR

STATIONARY ENERGY TECHNOLOGIES

- BEET-IT
- IMPACCT
- GRIDS
- Solar ADEPT
- GENI
- ADEPT
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
- 10 Renewable Power
- 8 Stationary Energy Storage
- 4 Carbon Capture
- 5 Thermal Energy Storage
- 7 Transportation Storage
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
10 Renewable Power
8 Stationary Energy Storage
4 Carbon Capture
5 Thermal Energy Storage
7 Transportation Storage
Mission
Modernize the way electricity is transmitted in the U.S. through advances in hardware and software that provide greater control over power flows.

Goals
- Enable 40% intermittent non-dispatchable generation penetration
- Facilitate implementation of “real-time” electricity markets
- >10x reduction in power flow control hardware (target < $0.04/W)
- >4x reduction in HVDC terminal/line cost relative to state-of-the-art

Highlights
- AutoGrid
  - Utilizing cloud computing and advances in forecasting and optimization to enable fast highly dispatchable and distributed demand response
- Varentec
  - Developing compact, low-cost transmission power flow controllers with fractional power rating (substantial cost reductions over state of the art).
  - Enabling greater use of grid assets.

Program Director | Projects | Total Investment
---|---|---
Tim Heidel | 15 | $39.4 Million

*Image of power lines with blue background.*
ADEPT
EFFICIENT POWER CONVERSION

Mission
Paving the way for more energy efficient power conversion and advancing the basic building blocks of power conversion: circuits, transistors, inductors, transformers, and capacitors.

Goals
- Improve the energy efficiency of electronic devices and power systems
- Contribute to the development of a smart grid

Program Director: Tim Heidel
Projects: 14
Total Investment: $34.5 million

Highlights
- Virginia Polytechnic Institute (VPI)
  - Exceeded 1,000 W/in3 for GaN power conversion modules utilizing new inductors.
  - Partnering with Enpirion to develop a manufacturable converter
- Cree
  - Partnering with ABB, Powerex, & NCSU to develop high-voltage SiC insulated transistors that can replace current distribution transformers (8000lb) with a 100lbs and 98% efficient transformer
  - Demonstrated 15kV blocking voltage for SiC IGBT device.
**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**

- 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
- Raytheon partnering with Primus Power
  - Development of energy storage system for a microgrid at Marine Corps Air Station Miramar

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**Program Director**

Mark Johnson

**Projects**

12

**Total Investment**

$27.7 Million
Thoughts on Curricular Reform

- Power systems education should create engineers who can facilitate integration of renewables and various smart grid technologies
- Distributed energy resources – generation, storage, demand response – and distributed operations and control will challenge the traditional views of power systems
- Innovations in power electronics, communications, networking, control, computation as applied to the electric grid will be critical – a Cyber-Physical System
- Power systems education will need to be integrated with education in related fields
- And all this will need to be done with limits on credit hours, teaching resources, and financial resources