Advanced Research Projects Agency – Energy (ARPA-E)

Dr. Arun Majumdar
Director, ARPA-E
U.S. Department of Energy

http://arpa-e.energy.gov/
Example

Lithium-ion battery manufacturing volumes in 2009 (millions of cells/year)

- Japan, 1392.1 (46%)
- U.S., 39.6 (1%)
- Taiwan, 49.5 (1%)
- China, 759.3 (25%)
- South Korea, 817.8 (27%)

Greenhouse Gas Emissions & Global Warming

U.S. Technological Lead

Energy Security

SPUTNIK MOMENT OF OUR GENERATION

The Enrico Fermi Award

2009

John Goodenough, U. Texas at Austin
CREATION OF ARPA-E

2006
Rising Above the Gathering Storm
(National Academies)

2007
America COMPETES Act

American Recovery and Reinvestment Act of 2009
(Recovery Act)

$400M appropriated for ARPA-E
President Obama launches ARPA-E in a speech at NAS on April 27, 2009
FIRST ROUND OF FUNDING

Concept Paper Phase

- 3700 Received
- April - June 2009
- Review 312 Encouraged Full Applications
- June - July 2009

Full Application Phase

- Panel Reviews
- September – Early October 2009

Final Selection

- 37 Projects (avg. $4M) (2-3 years)
- Announced on October 26

Award Negotiations Completed in 3 months including 3 Uses of Other Transaction Authorities

“In my 30 years of doing Government contracting…..I have never seen any government project move from selection to contracts and to actual work with such speed anywhere near what we are seeing out of ARPA-E…..”  CEO, Diversified Energy Corporation, Gilbert, AZ - 01/27/10
Cellulosic Biofuels

Artificial Cellulose
Breakdown is Expensive ($$)

Breakthrough High Efficiency
Mixer/Ejector Wind Turbine (MEWT) - FloDesign Wind Turbine Corp.

- Mimic jet engines, not propellers, for wind turbine
- 40% lower cost expected vs. horizontal axis wind turbines (HAWT)

Grid-Level Electricity Storage - MIT

GreenGenes™ Technology

Putting the cow inside the plant!

Plant produces all the enzymes & chews itself from the inside!!

EXAMPLES FROM FIRST ROUND OF FUNDING
WHAT IS AN ARPA-E PROJECT?

- High Impact on ARPA-E Mission Areas
- Disruptive, Innovative Technical Approaches & New Learning Curves
- Best-in-class People & Teams; Attract the US Intellectual Horsepower to Energy
- Strong Impact of ARPA-E Funding Relative to Private Sector
BATTERIES FOR ELECTRICAL ENERGY STORAGE FOR TRANSPORTATION (BEEST)

**Program Director:** David Danielson (PhD Materials Sci, MIT; General Catalyst)

- **Cell-level energy density:** 400 W-hr/kg (2.5X higher)
- **Cost:** $250/kW-hr (4X lower)
- **New architectures & manufacturing processes**

**Ultra-High Energy**

- PolyPlus (Li-Air)
- Missouri Inst of Sci/Tech
- Sion Power (Li-S)
- ReVolt (Zn-Air Flow)
- Pellion (Mg-Ion)

**Infrastructure Compatible**

- AMAT/A123/ LBNL (Li Ion Mfg)
- Planar Energy Devices (Solid State Li-Ion)

**Mfg Innovations**

- **Time to Market**
INNOVATIVE MATERIALS AND PROCESSES FOR ADVANCED CARBON CAPTURE TECHNOLOGIES (IMPACCT)

Program Director: Mark Hartney (PhD Chem Engr, UC Berkeley, DARPA, Lincoln Labs, Bell Labs, Flex Tech)

Today: \( \text{CO}_2 + \text{Amine Chemistry} \) Bind, Isolate & Release
Cost: $70-100/tCO_2
Cost Above Price = Loss!

High-Temperature Heat

Market Price of CO_2: \( \approx $30/tCO_2 \)

ARPA-E
High-Risk/
Phase Changing Absorbents

Phase Changing Ionic Liquids

Joan Brennecke (2009 Lawrence Awardee)
(U. Notre Dame, MATRIC)
**Program Director:** Eric Toone (Robert Bass Prof of Chemistry, Duke; PhD-Toronto; Post-Doc - Harvard)

**PIs:** David Baker (U. Washington), Jay Keasling (Berkeley), Pam Silver (Harvard), …

**Electrofuels**

1. **Difficult to store**
2. **Difficult to store**
3. Greenhouse gas emissions
4. 60% imported

- **CO₂**
- **H₂**
- **Electricity**
- **Non-Photosynthetic/Modular/Mix-and-Match**
- **Gasoline**
- **Octane**
ROUND 3 PROGRAMS

Grid-Scale Rampable Intermittent Dispatchable Storage (GRIDS)

Program Director: Mark Johnson
(Prof. of Mat Sci, NCSU)

Building Energy Efficiency Through Innovative Thermo-devices (BEETIT)

Program Director: Ravi Prasher (Formerly Intel, PhD-ASU)

Power Electronics

Program Director: Rajiv Ram (Professor, EECS Dept, MIT)

Announced: March 2, 2010
Awardees Selected: July, 2010
All Awards Made: September, 2010
ARPA-E TEAM

Program Team
- Program Directors
- ARPA-E Fellows & Senior Fellows
  - Provide Thought Leadership
  - Create New Programs
  - Hands-on Program Execution

Commercialization Team
- Help ARPA-E teams commercialize technology through company creation, entrepreneurship, ...
- Help Program Directors create programs based on global market data and trends

ARPA-E Director & Deputy Director

ARPA-E Brain Trust

Strategic Outreach
- Strategic and Coherent engagement with all Stakeholders (Technical, Private Investment, Gov’t, Congress, ...)
- Judicious use of media for strategic outreach

Operations Team
- Efficient and Fast in IP, Legal Counsel, Procurement, Contracting, Hiring, ...
MANAGING EXPECTATIONS

NOW

• Attracting the best minds to energy R&D
• Follow on investment post ARPA-E award ($)
• Increase in enterprise value of company ($)
• Companies created (#)
• Initiating new technology-business ecosystems
• Accelerated market entry - Products to market (#) / Product sales ($)
• Patents filed and licensed (#)
• Papers published in top journals (#)
• World Record-setting “best-in-class” performance (#)

3 - 5 YRS

• Home Runs
  • Domestic and global sales, US market share ($)
  • Avoided greenhouse gas emissions (tCO₂ equivalent)
  • Reduced oil imports (barrels of oil equiv.)
  • Creation of new technology/business or new industry ecosystem (#)
  • Jobs created (#)
  • Beating current projections and trajectories (Moving McKinsey GHG abatement cost curves, EIA & IPCC projections, etc.)

10+ YRS

• []
**ENERGY INNOVATION NETWORK – How to scale?**

**Historically:** (a) Change is slow; (b) Energy is a ubiquitous commodity; (c) Investments & systems can last a long time

- 2 months preparation; 1700 attendees
- Summit acting as a “catalyst” by integrating relevant communities
- Technology showcase

“Probably the best conference I have ever attended with extremely high caliber speakers and panelists. Great job!”

– Executive from large corporation

“It was great to see a fast paced, entrepreneurial mentality applied to energy.” – Technology company executive

“Great event. Came away with renewed enthusiasm for DOE’s ability to be part of the solution.” – Academic researcher

“As an investor, I found the technology showcase to be of tremendous value. Not only in terms of finding prospective investments, but also to get my finger on the pulse of up and coming technologies in the field. This was by far the best part of the conference for me.” – Investor
Direct reporting to and engagement of the Secretary, and thereby some nurturing and care from above

Clarity of mission and clearly defined role within the DOE

Budget with a positive slope is critical

Special hiring authority of personnel
- Civil service laws
- Finite tenure of program directors and exit strategy for programs/projects

Support from within the DOE on operations & programs
- Legal; Contracting/Procurement; HR; IT,...

Innovations in Process
- Aggressive timelines (ARRA-induced creativity), contracting/procurement, reviews, absorb and adapt best practices from everywhere...
- Questioning tradition, not afraid to try out new approaches

Close coordination and making it a win-win proposition for rest of DOE
- Office of Science, Applied Energy Programs
Issues Related to Starting Up

- Recruiting people
  - Scientifically strong and garner instant recognition and respect
  - Imaginative, entrepreneurial, collaborative
  - Both depth in one relevant field, and breadth in multiple fields
  - Intellectually flexible

- ARPA-E Team Identity
  - Common sense of mission, focus on excellence in every aspect of our work
  - Culture of open and friendly debate and “constructive confrontation” to get clarity on issues
  - Priority on technical programs
  - Both speed and doing things right are important
  - Team gelling is critical

- Quality of selected projects and focus on best ideas regardless of origin

- Close partnership with community and openness to stakeholders
  - Workshops, technical review panels, Summit, technology showcase, Congress...

- Strategic Plan
  - Process of creating one is important - debate/discussion....
  - ARPA-E plan part of a national plan
  - Engaging all relevant stakeholders
STEM Education

- Capitalize on Sputnik Moment
- ARPA-E Fellows Program and their Role in Energy STEM
- Proposal for ARPA-E Challenge: Energy competitions in schools/colleges using private-public partnerships
ARPA-E and Manufacturing

- Manufacturing R&D embedded in many of our calls to provide US competitiveness (mission impact)

- High-tech/high-quality manufacturing is critical for our R&D and innovation
  - Engagement of thought leaders around the nation
    - Andy Grove, Norm Augustine, Michael McQuade, Mark Pinto ...

- My Oral Statement at House S&T Committee Hearing (01/27/10):
  - If I have any concern for the future, it is the following: While ARPA-E’s focus is to invest upstream in the energy innovation pipeline, we must keep the scaling of these innovations within the US and thereby create new jobs in the energy sector. The purpose of the ARPA-E Energy Innovation Summit is to explore how to achieve this. In this regard, I may note that the government is the largest energy consumer. I urge Congress to consider using the government’s purchasing power to create a demand pull for American innovations, so that our businesses can get a foothold once they meet or exceed market-based performance and cost metrics. This will be critical in scaling up innovations and creating new jobs within the US, especially in manufacturing, and it will enable American taxpayers to reap the benefits of their upstream investments through ARPA-E.

- Potential Use of Executive Order for Reducing Federal Energy Use