Brown University – Auto-adaptive Tidal Power Conversion

1. Active control of two-degrees of freedom of the hydrofoil.
2. Real-time measurement & optimization of extracted power.
3. Continuously learn and adapt to current environment.

Basic mechanism: Orient hydrofoil so that lift always points in the direction of motion.
Portable, Resilient Power

- Install multiple 50 kW units to achieve desired capacity
- Floating design facilitates deployment and accessibility
- Swing arm allows for easy service of wet components
- Electronics and critical components are located above water
- Modular hydrofoil design allows for quick swapping of hydrofoils
ARPA-E Mission

Mission: To overcome long-term and high-risk technological barriers in the development of energy technologies

Means:
- Identify and promote revolutionary advances in fundamental and applied sciences
- Translate scientific discoveries and cutting-edge inventions into technological innovations
- Accelerate transformational technological advances in areas that industry by itself is not likely to undertake because of technical and financial uncertainty
Energy Technology “Mountains of Opportunity”

- Research
- Prototype
- Demonstration
- Other Investors
- Concept
- Time
- $100M
- $10M
- $1M

ARPA-E
Developing Our Focused Programs

PROGRAM DEVELOPMENT CYCLE

ESTABLISH
- Project Selection
- Contract Negotiations & Awards

EXECUTE
- Ongoing Technical Review
- Proposal
- Project Handoff
- Transition Toward Market Adoption

EVALUATE
- Rebuttal
- Merit Review of Proposals

ENVISION
- Program Conception (Idea/Vision)
- Workshop

ENGAGE
- Program Approval
- FOA Development & Issuance
## Program Portfolio

### ELECTRICITY GENERATION
- MOSAIC
- GENSETS
- ALPHA
- REBELS
- FOCUS
- SOLAR ADEPT
- IMPACCT

### EFFICIENCY & EMISSIONS
- CIRCUITS
- PNDIODES
- ENLITENED
- SHIELD
- ROOTS
- MONITOR
- ARID
- DELTA
- SWITCHES
- METALS
- REACT
- BEETIT
- ADEPT

### TRANSPORTATION & STORAGE
- NEXTCAR
- REFUEL
- TRANSNET
- TERRA
- RANGE
- REMOTE
- MOVE
- PETRO
- ELECTROFUELS
- AMPED
- BEEST

### GRID & GRID STORAGE
- IONICS
- GRID DATA
- CHARGES
- NODES
- HEATS
- GENI
- GRIDS

### OPEN 2009, 2012, & 2015 Solicitations
Complement Focused Programs
OPEN Solicitations Supplement Portfolio

OPEN

2018

We are looking for the best ideas and teams to transform our energy future

*Pending FY 2018 appropriations and review
If it works... will it matter?
Impact Indicators

Since 2009 ARPA-E has provided $1.5 billion in R&D funding to more than 580 projects.

56 projects have formed new companies.

1,328 peer-reviewed journal articles from ARPA-E projects.

68 projects have partnered with other government agencies to further development.

74 Projects have attracted more than $1.8 billion in private-sector follow-on funding.

208 patents issued by U.S. Patent and Trademark Office.

As of February 2017
Impact Requires Work Both In and Out of the Lab

Work in the lab is critical
- Core of innovation
- Discovery
- Ideas are tested and proven to work

Beyond the lab work is required for solving big problems
- Provides direction for lab experimentation
- Validates the impact and viability of lab work
- Generates resources needed in the lab
Tech-to-Market: Preparing Teams for Success

**Scope**
Support creation of highly innovative, commercially-relevant programs

**Manage**
Manage project teams’ T2M efforts through T2M plans and jointly developed milestones

**Advise**
Support project teams with skills & knowledge to align technology with market needs

**Partnerships**
Engage third-party investors and partners to support technology development towards the market
An Evidence-based Approach

TEA
(How much does it cost to make and why?)

Customer Discovery
(Who would buy it, why, and for how much?)

Product Hypothesis
(What will you make? What does it do?)

IP Plan
(Can you legally make it? Can others legally make it?)

T2M

Follow on Funding
(Who will finance it?)

Value Chain Analysis
(Who’s involved in it?)

Scaling
(How would you make many?)

Market Analysis
(Who’s currently buying and consuming it?)
Our Tech-to-Market Team

Constant feedback between engagement and management efforts brings value to ARPA-E awardees
Tech-to-Market Plan

- Product Hypothesis
- Intellectual Property Strategy
- Manufacturing and Scalability
- Value Chain Analysis
Tech Focus: Solar Energy

ARPA-E has funded innovative solar energy technologies in specific, targeted areas, including power electronics for solar applications, hybrid conversion systems, and microscale CPV.

Since 2009, ARPA-E has provided over $142 million in R&D funding to 59 active projects in solar energy.
Tech Focus: Grid Management

ARPA-E has funded a broad range of technologies including software and hardware solutions designed to build the grid of tomorrow.

Since 2009, ARPA-E has provided over $135 million in R&D funding to 50 projects under several focused programs in grid management.
Tech Focus: Natural Gas

ARPA-E has funded a broad range of technologies including conformable compressed natural gas tanks, methane-to-liquid processes, combustion engines and fuel cells to generate on-site electricity, and technologies to monitor costly methane leaks.

Since 2009, ARPA-E has provided over $222 million in R&D funding to 82 projects related to natural gas use under several focused programs.
Tech Focus: Energy Storage

ARPA-E has funded a broad range of battery technologies, including flow batteries, metal-air chemistries, and advanced lithium-ion, for both grid-scale storage and transportation.

Since 2009, ARPA-E has provided over $257 million in R&D funding to 102 projects in energy storage.
Project Spotlight: NC State

**Program:** PETRO

**Program Director:** Dr. Joe Cornelius

**Technology:** Optimized Biofuel Crops

**Location:** Raleigh, NC

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### Summary

- NC State produced economic models demonstrating that increasing oil yield in Camelina seeds by 70%—the level observed in the greenhouse with experimental plants—could more than triple farmers’ profits.

### Highlights

- The team engineered the gene to increase sugar available for biomass production and seed yield, which led to Camelina with higher vegetative biomass (greater than 20%), higher rates of photosynthesis and increased seed yield (40-80%).
- ARPA-E encouraged NC State to work with PETRO team UMass. The two then worked with commercial partner, Metabolix, in field trials.

(A) Comparison of vegetative growth between WT and and CWII plants, and (B) per plant seed yield of CWII transgenic camelina lines (L95, L85, L96).
Project Spotlight: RTI International

Summary

- The RTI International team has demonstrated significant potential to lower the cost of carbon capture in coal-fired power plants compared with the incumbent amine treatment process.

Highlights

- RTI developed a non-aqueous solvent (NAS) that could potentially reduce the energy required for carbon capture by 20-30%.
- RTI received additional federal funding from NETL to scale the RTI NAS process up to a 60 kW facility in collaboration with SINTEF, a Norwegian research company.
- The SINTEF facility is being outfitted with a multiburner that allows, for the first time, testing of NAS in coal-derived flue gas.

Program | IMPACCT
--- | ---
Program Director | Dr. Ping Liu
Technology | CO₂ Capture
Location | Research Triangle Park, NC
Project Spotlight: Duke University

Summary
- Duke University is developing a coded aperture miniature mass spectrometer environmental sensor (CAMMS-ES) for use in a methane monitoring system.

Highlights
- Miniaturizing a mass spectrometer utilizing microfabrication and aperture coding
- High selectivity measurements at short detection times for methane as well as VOCs (such as benzene, C2-C7)
- Capable of thermogenic vs. biogenic differentiation
- Developing advanced search/location algorithms for optimum sampling

<table>
<thead>
<tr>
<th>Program</th>
<th>MONITOR</th>
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<tbody>
<tr>
<td>Program Director</td>
<td>Dr. Joe King</td>
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<tr>
<td>Technology</td>
<td>Coded Aperture Miniature Mass Spectrometer for Methane</td>
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<tr>
<td>Location</td>
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Why Work at ARPA-E?

CONTRIBUTE TO A BETTER ENERGY FUTURE
Work towards creating a more efficient, more secure energy future

WORK IN DIVERSE TECH AREAS
At ARPA-E you’ll have the opportunity to work with a diversity of energy issues and explore new fields

JOIN OUR INNOVATIVE STARTUP-LIKE CULTURE
ARPA-E is a fast-paced, action-oriented Agency

COLLABORATE WITH OTHER EXPERTS
Work with other experts from many different disciplines who are devoted to creating a better energy future

If you are interested in applying or learning more, please email arpa-e-jobs@hq.doe.gov.
Contact: Dr. Ryan Umstattd
Ryan.Umstattd@Hq.Doe.Gov

https://arpa-e.energy.gov