SEAS
Scalable Energy from Aquatic Sources

Marc von Keitz
Program Director, ARPA-E
marc.vonkeitz@hq.doe.gov

Presentation to Alaska Mariculture Task Force
Juneau, Alaska
November 9, 2016
ARPA-E Mission

Catalyze the development of transformational, high-impact energy technologies

- Reduce Energy-Related Emissions
- Reduce Energy Imports
- Improve Energy Efficiency

Ensure the U.S. maintains a lead in the development and deployment of advanced energy technologies
ARPA-E’s History

In 2007, The National Academies recommended Congress establish an Advanced Research Projects Agency within the U.S. Department of Energy*

…”The new agency proposed herein [ARPA-E] is patterned after that model [of DARPA] and would sponsor creative, out-of-the-box, transformational, generic energy research in those areas where industry by itself cannot or will not undertake such sponsorship, where risks and potential payoffs are high, and where success could provide dramatic benefits for the nation.”…

Programs To Date

Awards Announced

2007
Rising Above the Gathering Storm
Published
America COMPETES Act Signed

2009
American Recovery & Reinvestment Act
Signed

2010
America COMPETES Reauthorization
Signed

2011

2012

2013

2014

2015

2016
Anticipated

2007

2009

2010

2011

2012

2013

2014

2015

2016

$400 Million
(Recovery Act)

$180 Million
(FY2011)

$275 Million
(FY2012)

$251 Million
(FY2013)

$280 Million
(FY2014)

$280 Million
(FY2015)

$291 Million
(FY2016)
### ARPA-E Programs and OPENs

<table>
<thead>
<tr>
<th>Field</th>
<th>Projects</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ELECTRICITY GENERATION</strong></td>
<td>IMPACCT, SOLAR ADEPT, FOCUS, REBELS, ALPHA, GENSETS, MOSAIC</td>
<td>2010-2012</td>
</tr>
<tr>
<td><strong>ELECTRICAL GRID &amp; STORAGE</strong></td>
<td>GENI, GRIDS, HEATS, CHARGES, NODES, GRID DATA, IONICS</td>
<td>2013-2014</td>
</tr>
<tr>
<td><strong>EFFICIENCY &amp; EMISSIONS</strong></td>
<td>ADEPT, BEETIT, REACT, METALS, SWITCHES, DELTA, CHARGES, NODES, GRID DATA, IONICS</td>
<td>2015</td>
</tr>
<tr>
<td><strong>TRANSPORTATION &amp; STORAGE</strong></td>
<td>BEEST, AMPED, ELECTROFUELS, PETRO, MOVE, REMOTE, RANGE, TERRA, TRANSNET, NEXTCAR, REFUEL</td>
<td>2016</td>
</tr>
</tbody>
</table>

**OPEN 2009:** 36 projects

**OPEN 2012:** 66 projects

**OPEN 2015:** 41 projects
If it works…

will it matter?
Measuring ARPA-E’s Success

Since 2009 ARPA-E has invested approximately $1.3 billion across over 500 projects, through 32 focused programs and 3 open funding solicitations.

For all alumni and current projects:

- Follow-on Funding
  - 45 projects have attracted more than $1.25 billion from the private sector
- Partnerships with other government agencies
  - 60 government projects
- New company formation
  - 36 new companies formed
Oceans are the largest untapped growth opportunity for biomass

70% of world’s surface

Water

Nutrients
Biomass critical for reducing GHG emissions

Source: ETP 2016, IEA

Share of fossil fuels in primary energy is in the 2DS with 45% almost halved by 2050 compared to today (81%), biomass becomes the largest energy source in 2050 in the 2DS.
Scalable Energy from Aquatic Sources

Mariculture Biomass:
- No Land
- No Freshwater
- No Fertilizer

SEAS creates new biomass production opportunities for the vast ocean resources of the United States
Macroalgae (aka seaweed) – the quintessential ocean crop

- Amenable to cultivation & harvest
- Mostly carbohydrate & protein
- Many different species
- Fast growth rate

**Global Algae Production, 2013**

- Macro- (meter scale) 98%
- Micro- (μm scale) 2%
An existing & growing industry

http://earthobservatory.nasa.gov/IOTD/view.php?id=85747
Key Questions for ARPA-E:

Can macroalgae ever be energy-relevant?

Photo: MBARI
How much is enough?

1 Quad (10^{15} BTU) Ethanol (~13 billion gal)

210 million MT of dry seaweed (~2.1 billion MT wet)

100x current world production

18 million acres (~28,000 square miles)

½ Size of Iowa

Photo: MBARI
Where should we focus our effort?
Focus on scalable, cost-competitive, and sustainable biomass production

- Production system should be scalable to millions of tons of dry biomass
- Target to be cost competitive with terrestrially produced biomass (at “ocean” farm gate)
- Energy input requirement should not be higher than for cellulosic biomass crops
Key requirements for macroalgae energy farms

- Accessing “free” nutrients predictably and reliably
- Expanding beyond the inter-tidal zone into deeper, off-shore waters
- Energy-efficient harvesting
- High productivity of individual plant and the whole system

Photo: Erik K Veland
Program Structure Overview

Core Program Area

Cultivation & Harvesting System – Design & Demonstration

Tools Program Areas

Modeling
- Current & Hydrodynamics
- Spatial Planning
- Nutrient distribution
- Macroalgae growth

Monitoring
- Biomass growth/health
- Biomass composition
- In situ nutrients

Breeding
- Hybridization Technologies
- Sequencing
- Genetic marker identification
Thank you!

Questions?
Teaming List – Building the Community

- [Link](https://arpa-e-foa.energy.gov) (RFI-0000027)

- Opportunity to connect with interested parties in the field

- Tell people what your capabilities and relevant resources are

- Spell out areas of expertise you are looking for, if you are trying to form a team

- Link to enter your profile: [Link](https://arpa-e-foa.energy.gov/Applicantprofile.aspx)
ARPA-E Macroalgae Workshop

ARPA-E Macroalgae Workshop Agenda
February 11-12, 2016
Capital Hilton, 1001 16th St NW, Washington, DC 20036

Webpage
http://arpa-e.energy.gov/?q=workshop/macroalgae-workshop
The path to fuels will likely go through the animal feed market
Proposal Review Process (High-level view)

Receipt of Concept Papers

Concept Paper Review Process (Encourage/Discourage Full Application)

Receipt of Full Application (FA)

FA Review Process

Notification of selection for award negotiations
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