



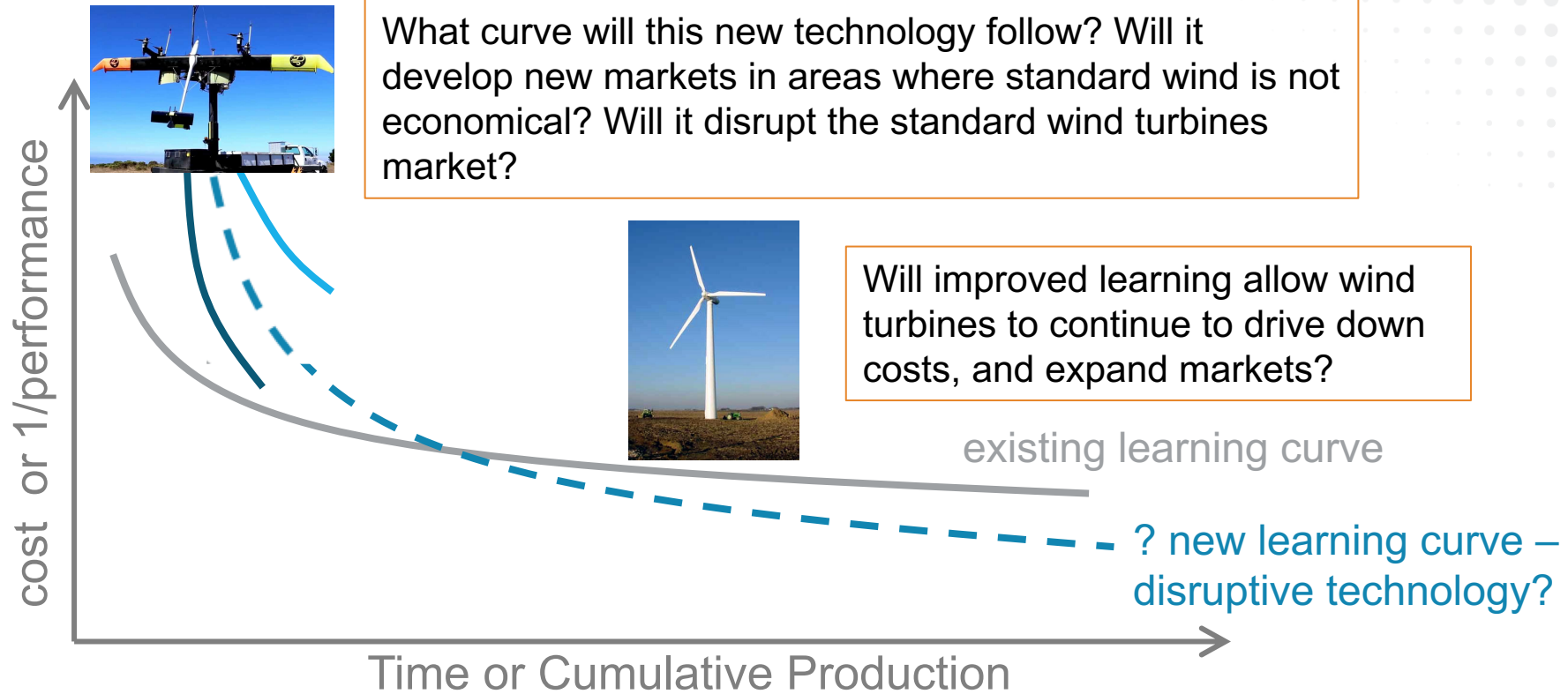
Moving Innovation from Invention to Investment

February 27, 2018

Dr. Ellen D. Williams

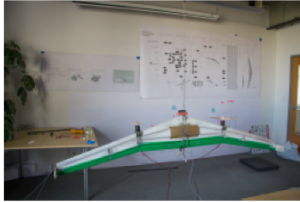
Distinguished University Professor

Incremental and Disruptive Technology Advances



Innovation, Investment, Demonstration - Makani

2008

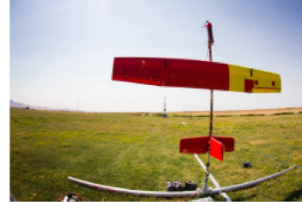


Wing 1
Wingspan: 3.7m
First rigid kite

2009



Wing 2
Wingspan: 5.5m
First rigid kite made out of carbon fiber



Wing 3
Wingspan: 3.7m
First autonomous crosswind flight

2010

ARPA-E project term begins
(Sep '10 - Oct '13)



Wing 4
Wingspan: 5.5m
First autonomous crosswind flight + generation

2011



Wing 5
Wingspan: 2.5m
Developed tail configuration



Wing 6
Wingspan: 3m
First autonomous transitions between hover and crosswind



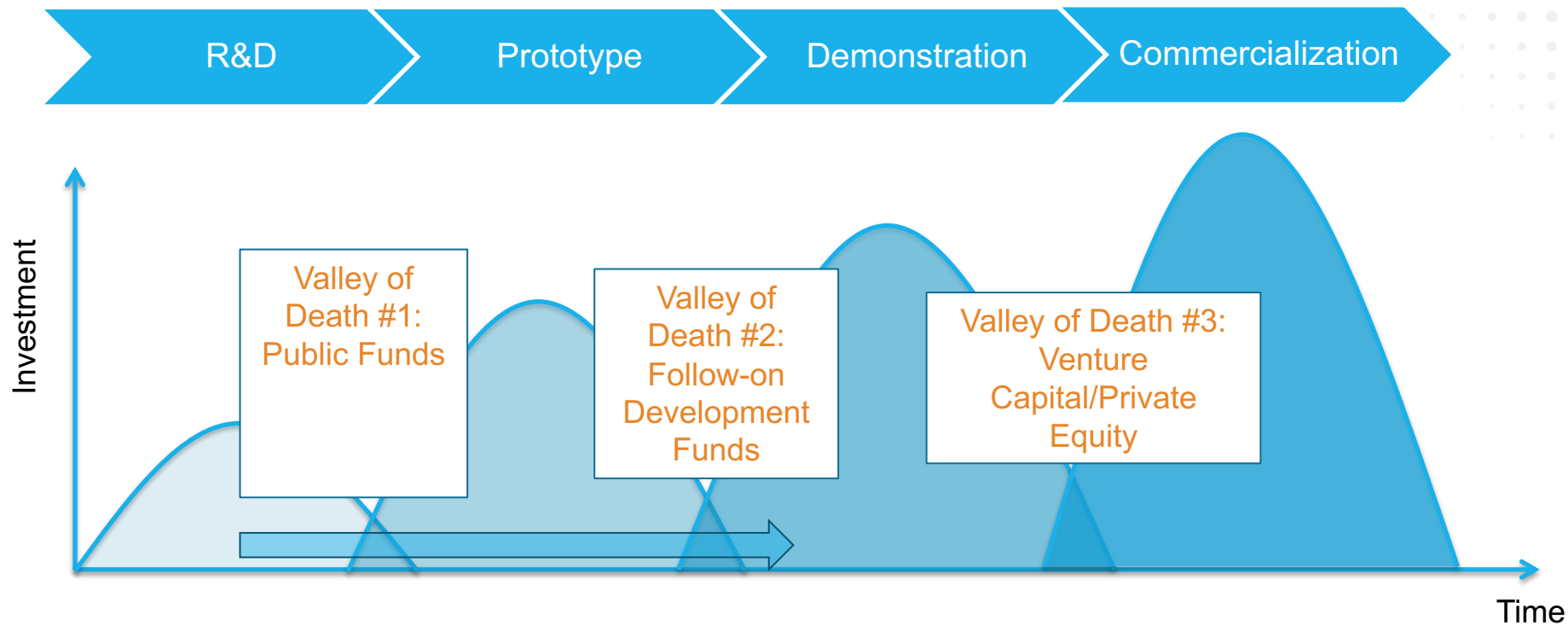
Wing 7
Wingspan: 8m
First fully autonomous system; funded by ARPA-E

2015



600kW Energy Kite
Wingspan: 26m
First commercial scale system

Transitions Toward Market Adoption



Support for Innovators



- ▶ US University -based
 - ▶ NSF I-Corps https://www.nsf.gov/news/special_reports/i-corps/
 - ▶ Seven-week I-Corps curriculum designed for learns to learn what it will take to achieve a commercial impact with their innovation.
 - ▶ Three person teams – Principal investigator, entrepreneurial lead, industry mentor
 - ▶ Teams conduct 100+ interviews of customers and stakeholders
 - ▶ Incubators
 - ▶ First stage: space, facilities, advice
 - ▶ Second stage: Space for early scale up, mentoring

Financial Support for early stage innovators

- ▶ Government grants -
 - ▶ DOE applied energy programs
 - ▶ Small Business Innovation Research
 - ▶ ARPA-E
- ▶ Private Sector
 - ▶ Prizes
 - ▶ Angel Investors
 - ▶ Mission-oriented investors
 - ▶ Round A venture investment

Issues of Intellectual Property
And
Ownership of Equity

ARPA-E Authorizing Legislation - 2007

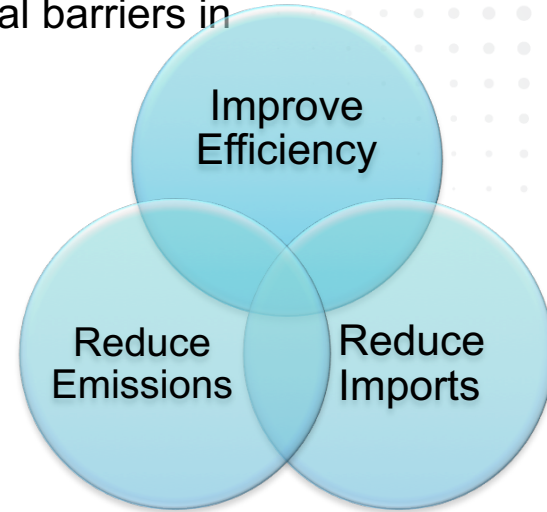
Mission: To overcome long-term and high-risk technological barriers in the development of energy technologies

Goals: Ensure

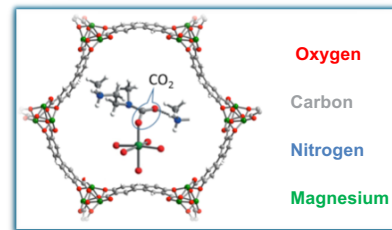
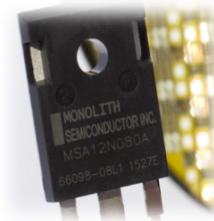
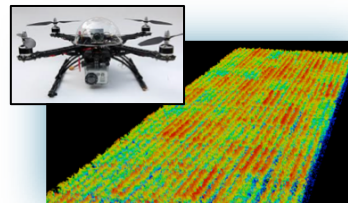
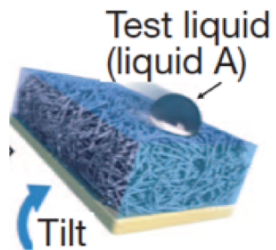
- ▶ Economic Security
- ▶ Energy Security
- ▶ Technological Lead in Advanced Energy Technologies

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



Innovation Portfolio



IMPACT

Energy and Economic Security, Technological Lead

If it works...

will it matter?

Assessment criteria

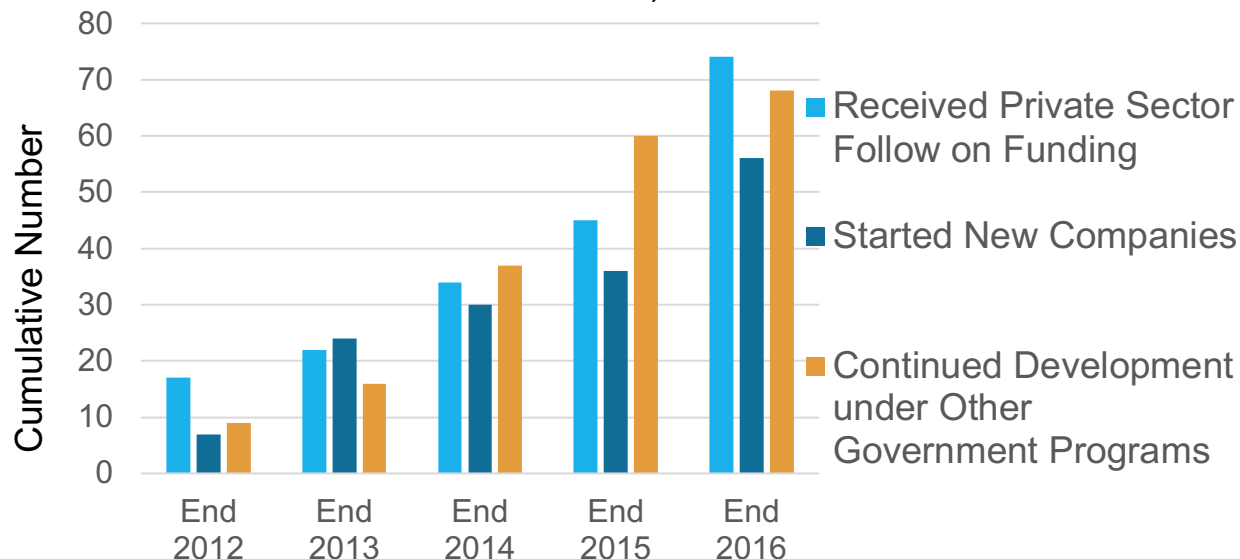
- ▶ Potential impact on Energy Mission and Goals
- ▶ Technical Challenge
- ▶ Technical Opportunity
- ▶ Innovation Demonstration
- ▶ Pathway to Economic Impact
- ▶ Potential for Large Scale Deployment



Measuring the Transitions Toward Market

Since 2009 ARPA-E has invested approximately \$1.5 billion across more than 580 projects, of which 262 have completed their ARPA-E support as of Feb 2017.

74 ARPA-E projects have attracted more than \$1.8 billion in private-sector follow-on funding (as of Feb 2017).



Innovation Opportunities in a Changing World . . .

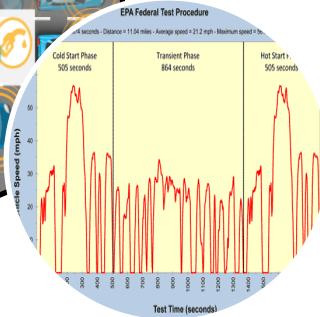
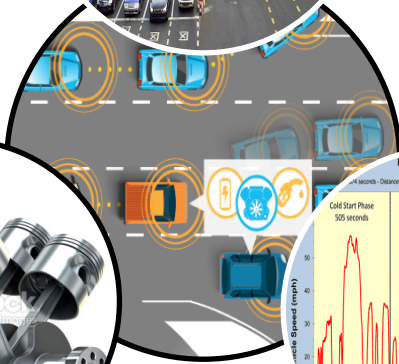
Vehicle dynamics,
optimization and
real-world driving



Powertrain
control and
optimization



Regulatory
fuel economy
and
emissions



ARPA-E NEXTCAR Goals

- ▶ **Energy consumption:** 20% reduction over a 2016/2017 baseline vehicle
- ▶ **Incremental System Cost:** <\$1,000 for Light Duty vehicle,

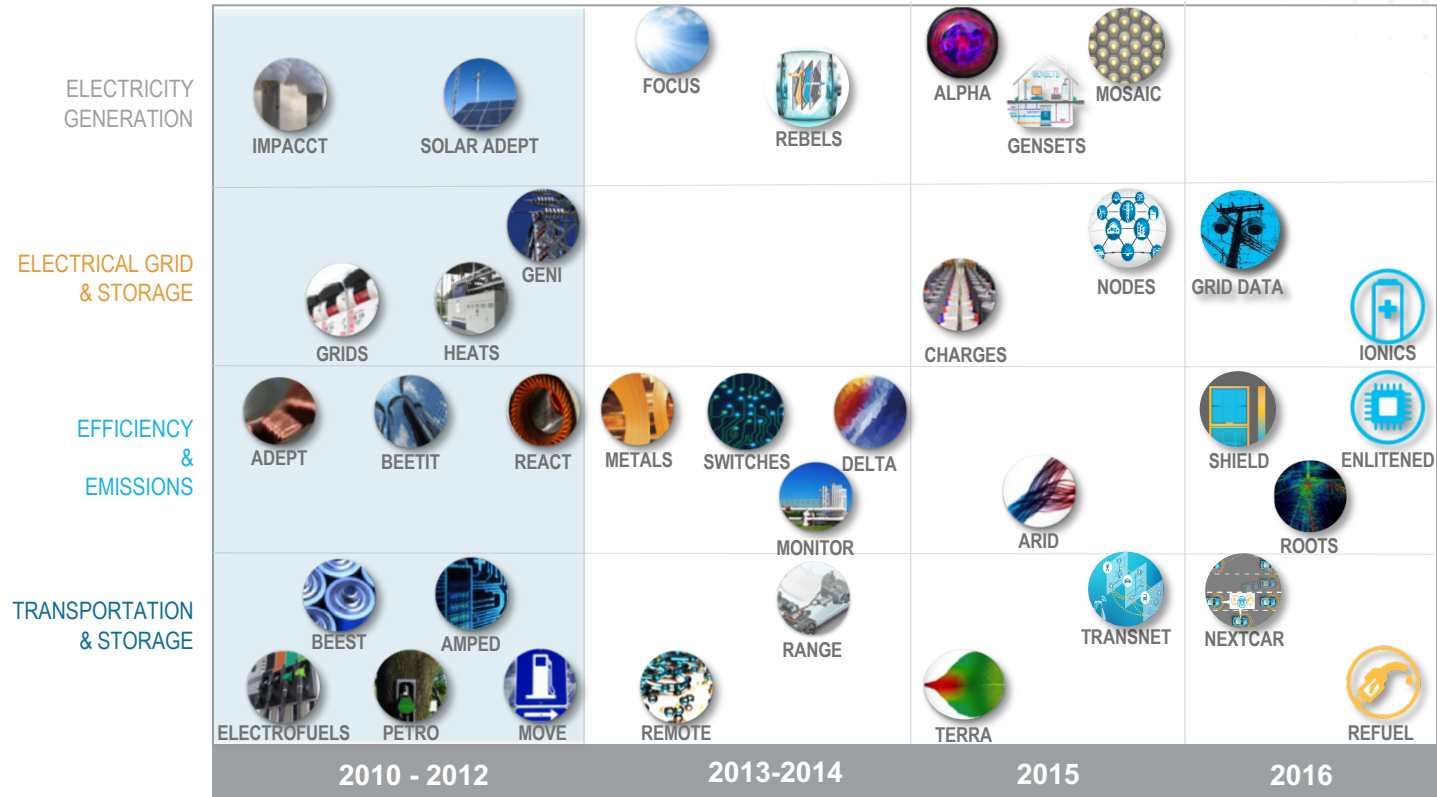
Potential Impact - US

- ▶ **Energy Consumption Reduction:** 4.4 quads/year
- ▶ **CO₂ emissions reduction:** 0.3 GT/year

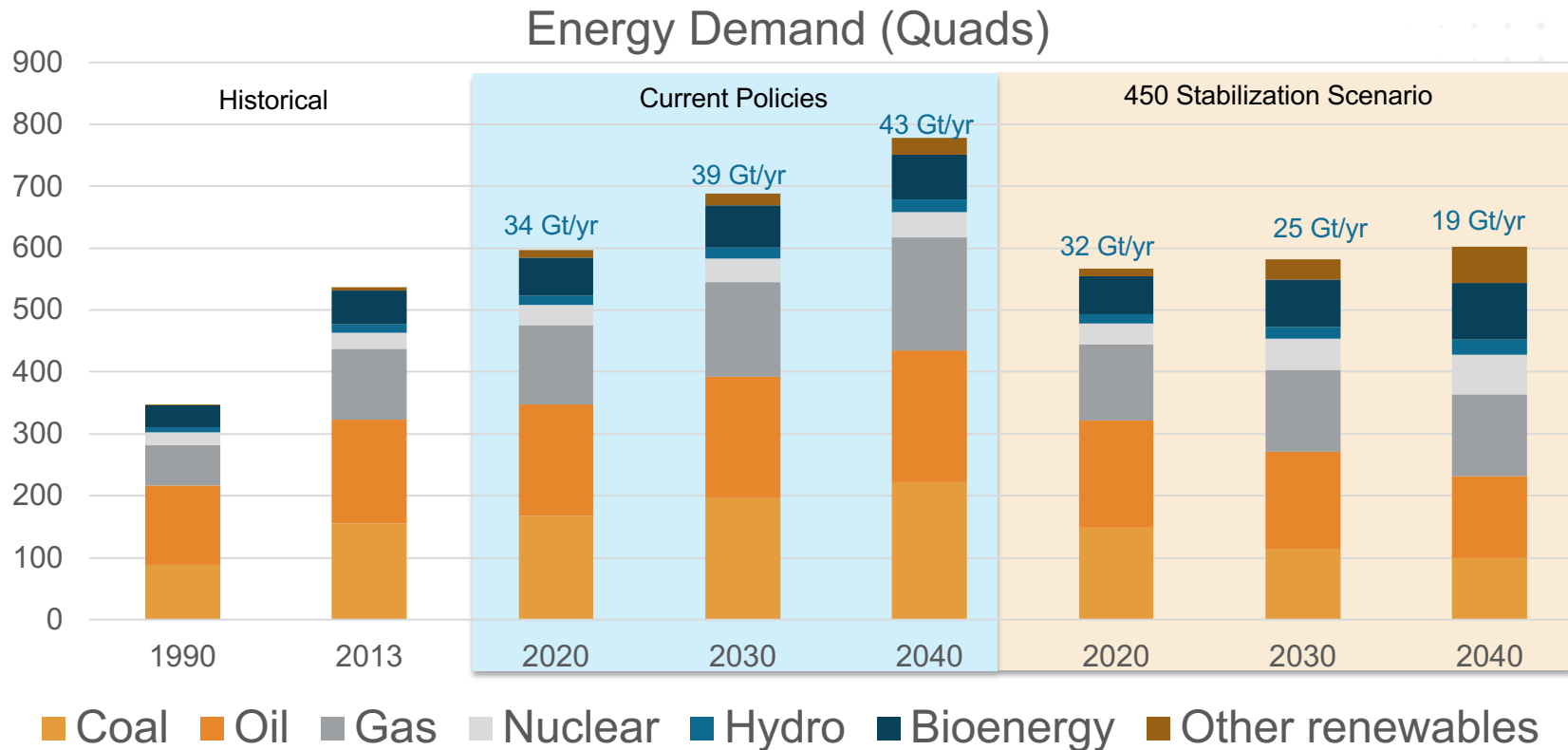


Background slides

ARPA-E: Portfolio Approach



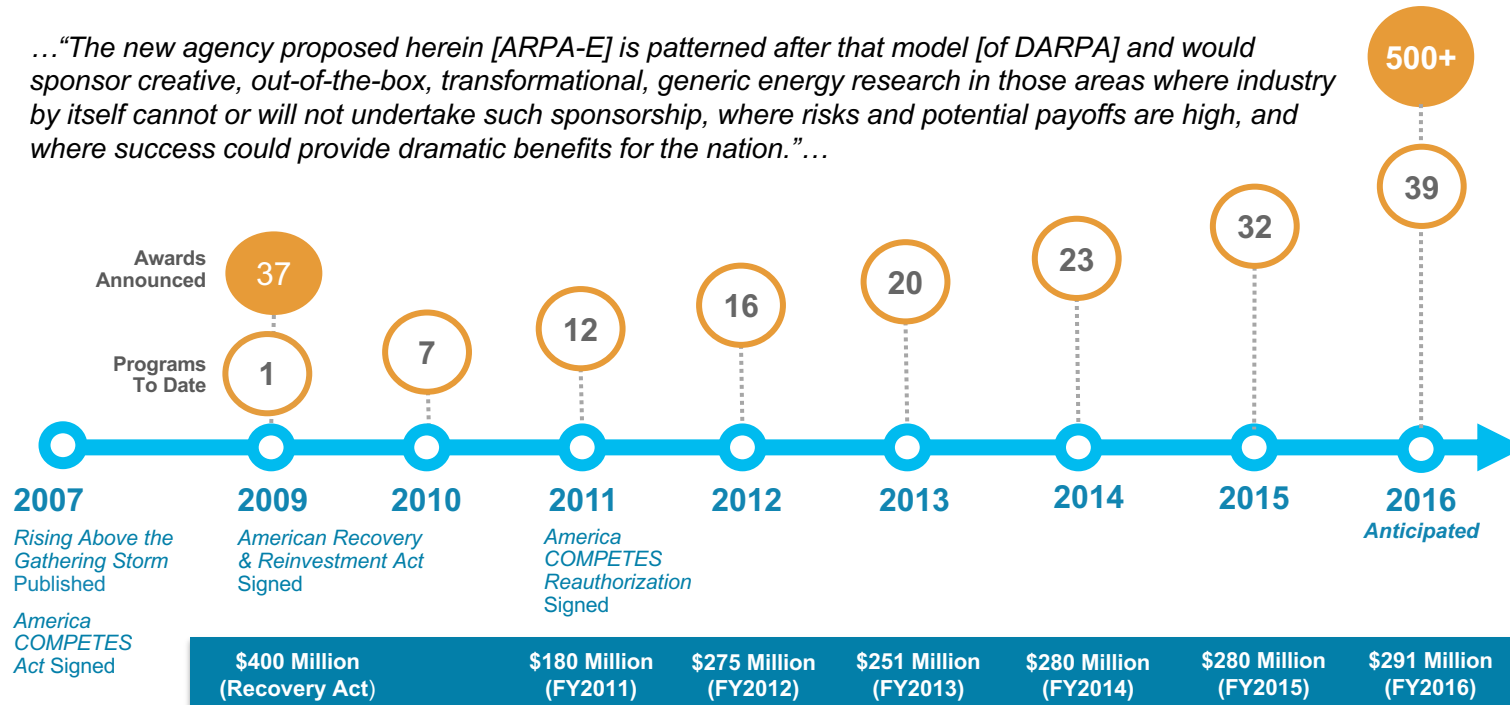
World Energy Use – Current Policies Versus 450 ppm



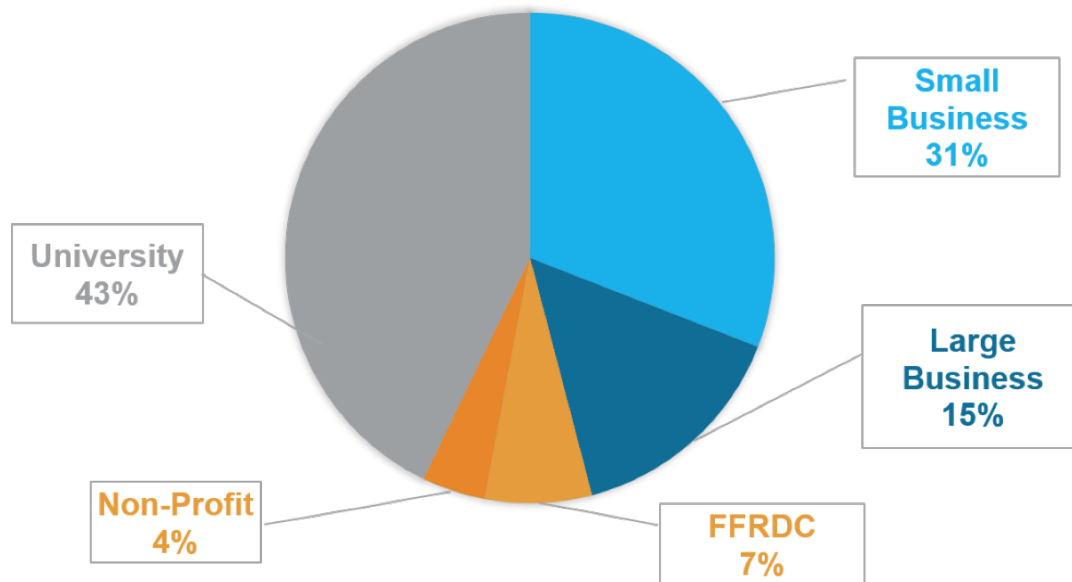
ARPA-E's History

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.”...



ARPA-E Project Portfolio by Lead Organization



ARPA-E supports multi-institutional teams with substantial involvement from the private sector:
72% of projects involve more than one institution
84% of projects include the private sector, as leads or partners