ARPA-E: Launching Energy Innovation in the 21st Century

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October 6, 2011

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

The Creation of ARPA-E

Innovation based on science and engineering will be primary driver of our future prosperity & security

2006
Rising Above the Gathering Storm
(National Academies)

2007
America COMPETES Act

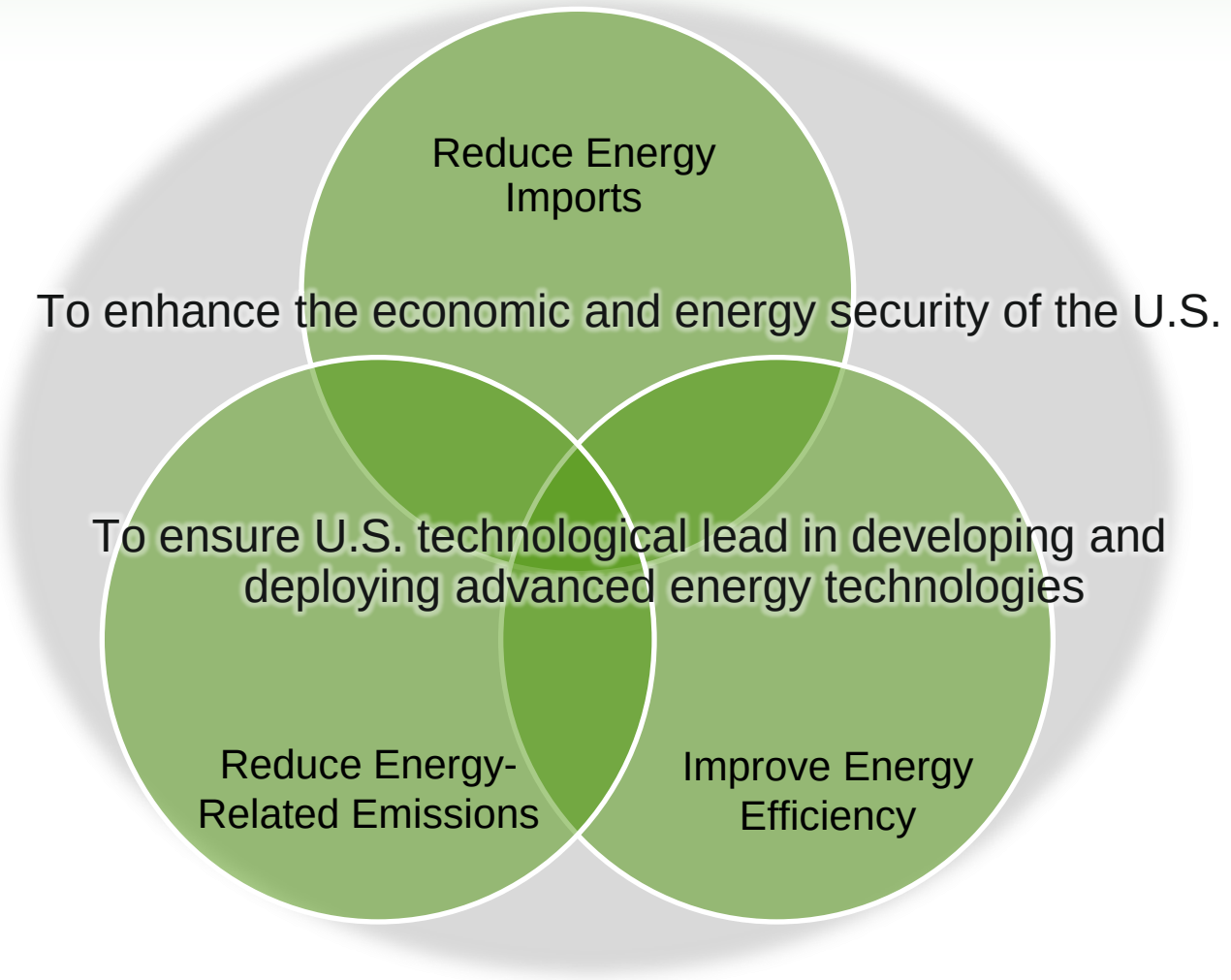
2009
American Recovery and Reinvestment Act
($400M appropriated)

2011
FY2011 Budget
($180M appropriated)

2012
FY2012 Budget
($180M House Bill
$250M Senate Bill)

President Obama launches ARPA-E at National Academies on April 27, 2009

ARPA-E's Mission and Means



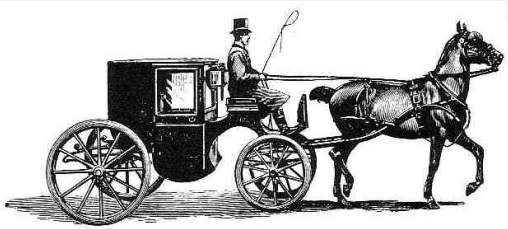
To overcome the long-term and high-risk technological barriers in the development of energy technologies.

(A) identifying and promoting revolutionary advances in fundamental sciences; **AND**

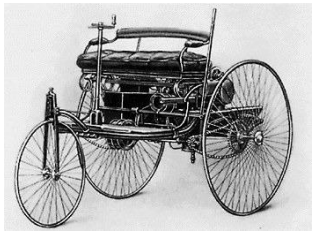
(B) translating scientific discoveries and cutting-edge inventions into technological innovations; **AND**

(C) accelerating transformational technological advances in areas that industry by itself is not likely to undertake because of technical and financial uncertainty.

ARPA-E seeks to identify and support technologies that will be both transformational and disruptive



Steam-powered Cugnot (1769)

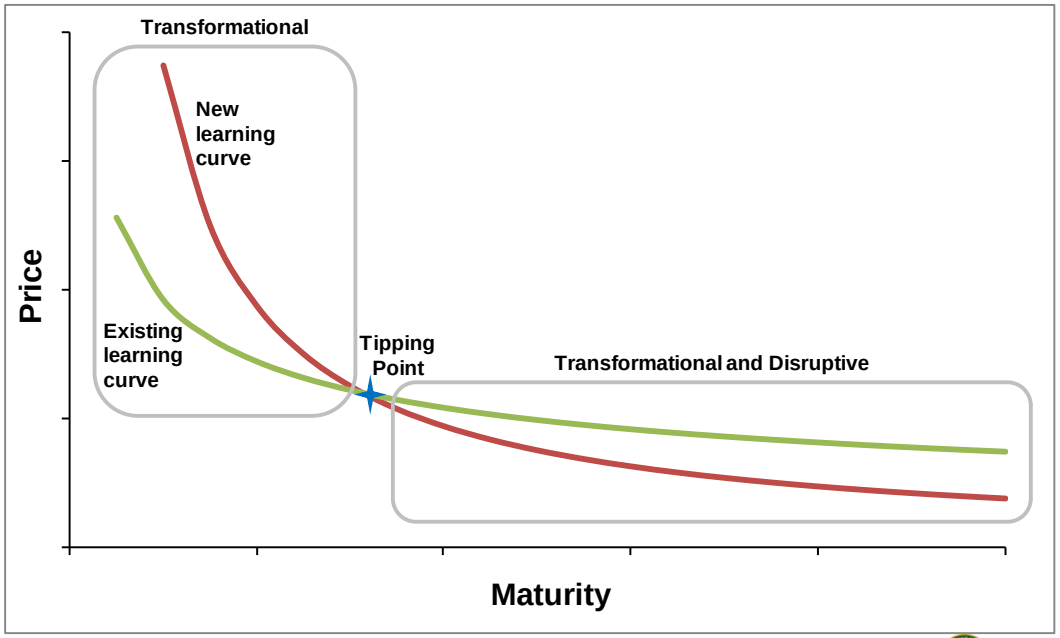


Benz Motorwagen (1885)

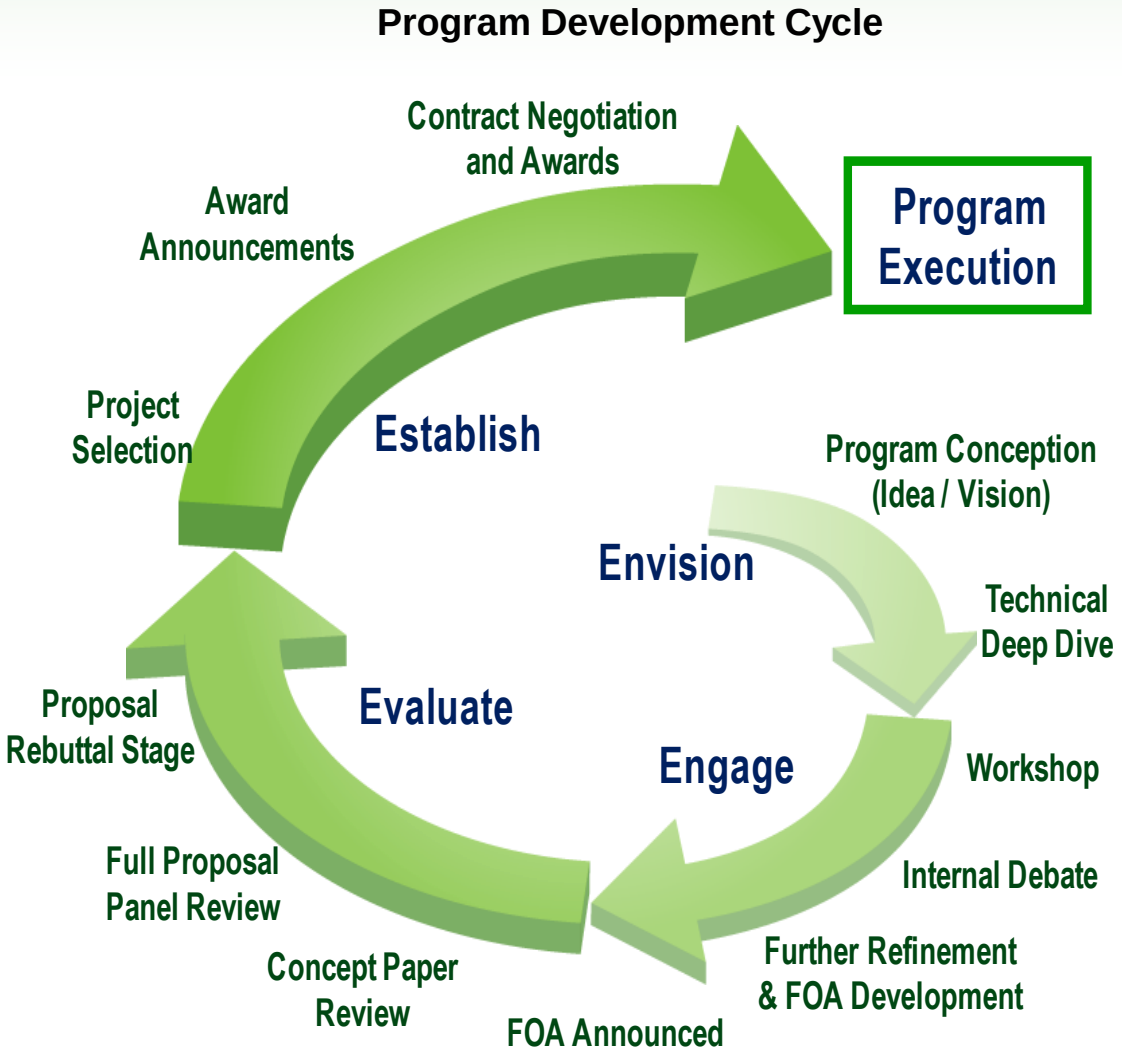
Ford Model T (1914)

New energy technologies matter only to the extent that they are:

- Both transformational and disruptive
- Adopted and deployed by private industry
- Meaningful way to consumers
- Able to hit a key price tipping point



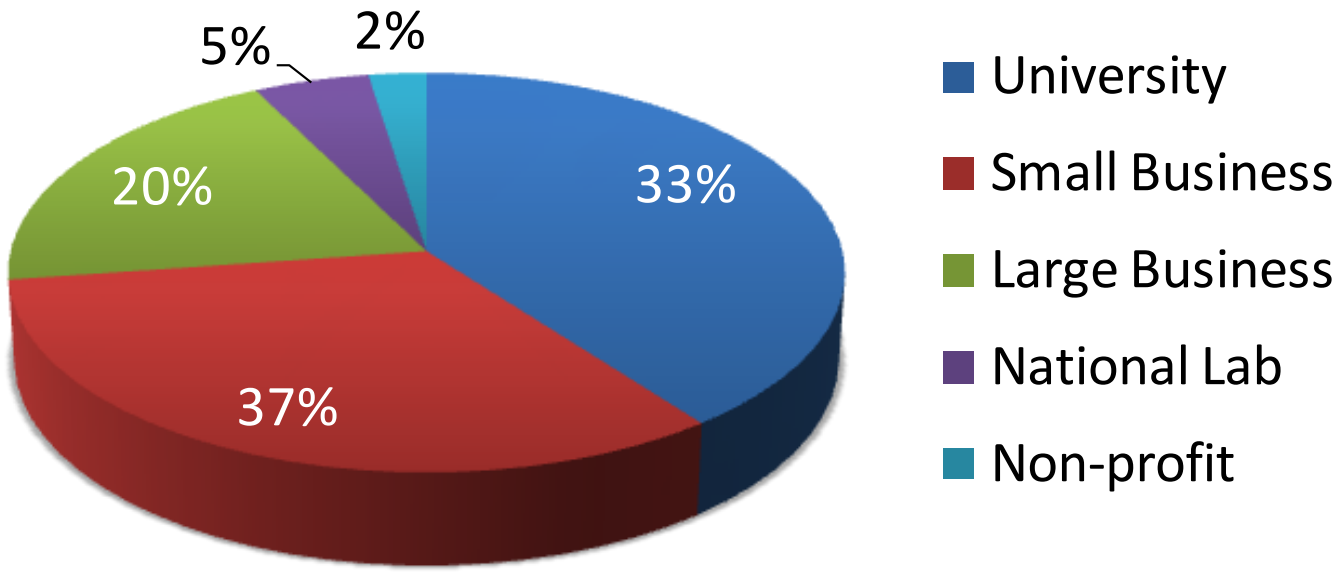
ARPA-E's program development process is extremely fast



From Program Conception to Execution in 6-8 Months

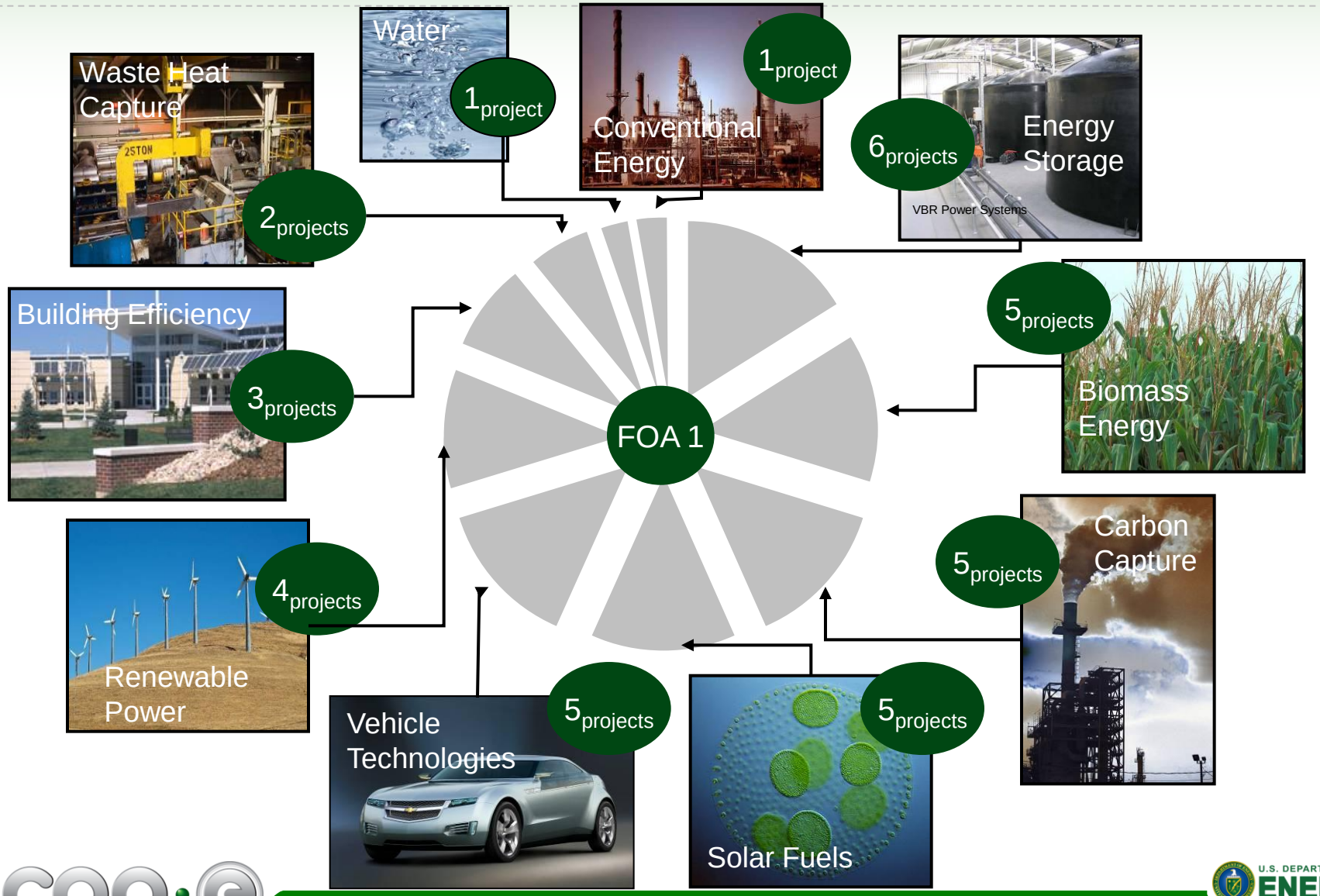
To date ARPA-E has made 121 awards from the first seven FOAs to a wide variety of organizations

Project Breakdown by Lead Organization Type (% based on award value)*



*Total Value of Awards = $366 million

Projects from ARPA-E's first broad solicitation fall into ten energy technology areas:



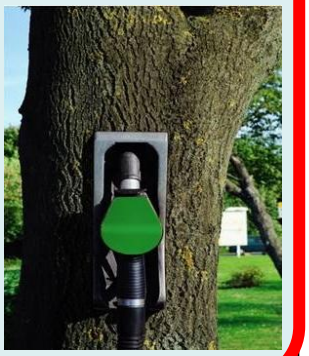
ARPA-E has 11 focused programs, five of which are currently in the contracting phase

Transportation

Electrofuels

BEEST

PETRO



End-Use Efficiency

HEATS

BEETIT

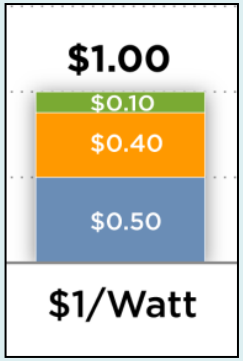
Stationary Power

IMPACCT

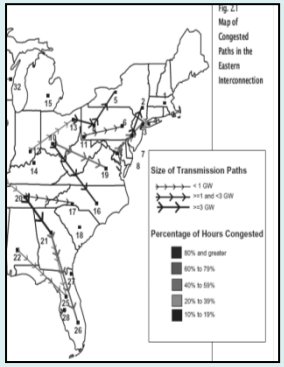
ADEPT

GRIDS

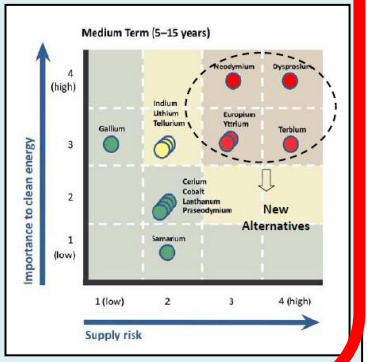
Solar ADEPT



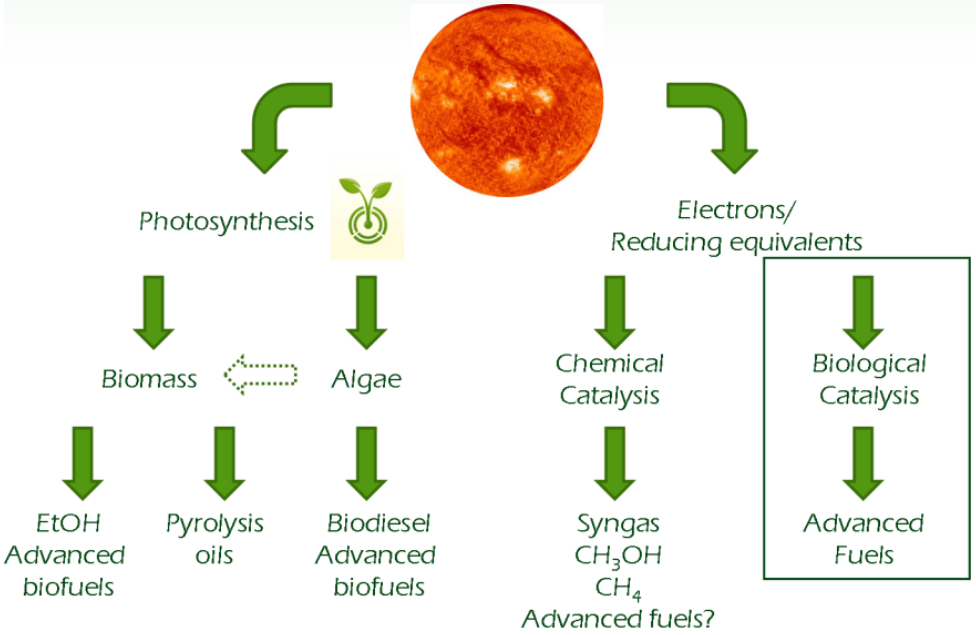
GENI



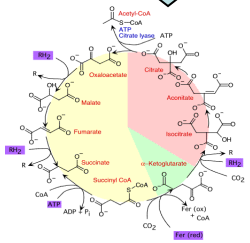
REACT



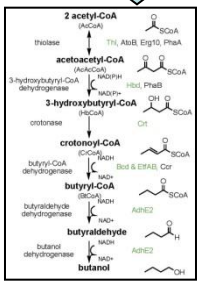
“Electrofuels,” a program area for mid-to-long term solutions to many current biofuel production inefficiencies



Assimilate Reducing Equivalents: *other than reduced carbon or products from Photosystems I & II (ex. direct current, H_2, H_2S, etc.)*

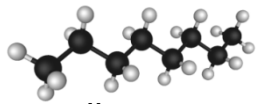


Pathways for Carbon Fixation: *reverse TCA, Calvin- Benson, Wood-Ljungdahl, Hydroxpropionate-hydroxybutyrate, or newly designed biochemical pathways*



Fuel synthesis: *metabolic engineering to direct carbon flux to fuel products*

Butanol



Alkanes

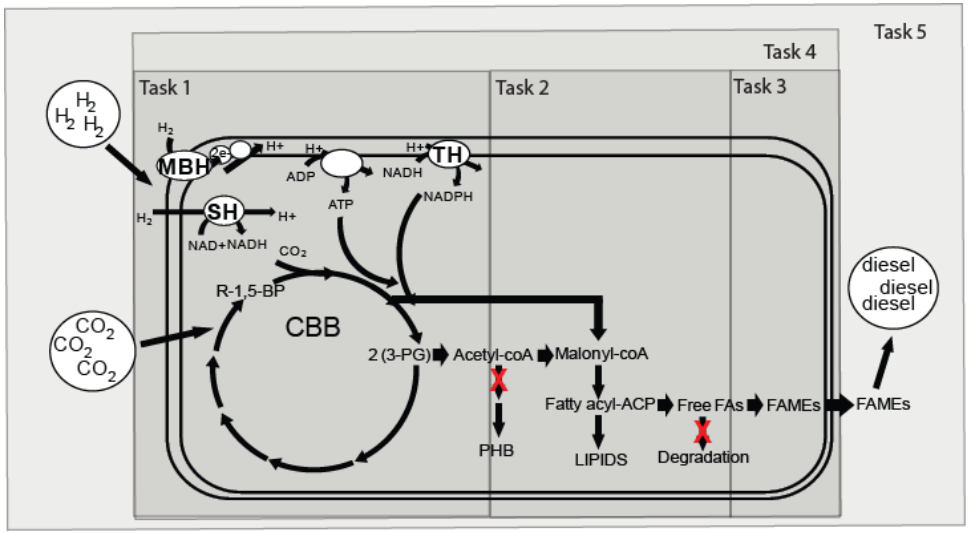
Etc.

“Electrofuels” targets the first application of non-photosynthetic, autotrophic microorganisms for the production of infrastructure compatible biofuels.

13 projects, $45M ARPA-E, $56M Total

OPX Biotechnologies is developing a *Ralstonia*-based system for the conversion of H_2 and CO_2 to hydrocarbons

Title	Novel biological conversion of hydrogen and carbon dioxide directly into biodiesel				
Team Lead	OPX Biotechnologies, Boulder, CO	**Project Budget**	$8.6 Million	**POP**	7/12/2010 - 7/11/2013 (36)



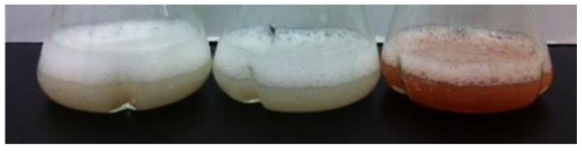
Task 1	Optimize hydrogenase and rubisco activity
Task 2	Optimize free fatty acid biosynthesis
Task 3	Optimize FAME biosynthesis
Task 4	Bioprocess optimization
Task 5	Catalytic conversion of FAME to diesel
Task 6	Commercial technology evaluation

OPX has succeeded in engineering key biological steps, including conversion of acetyl-CoA to malonyl-CoA.

opxbio good chemistry.

Malonyl-coA flux screening in C. necator

opxbio good chemistry.



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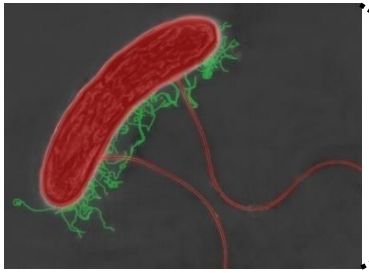
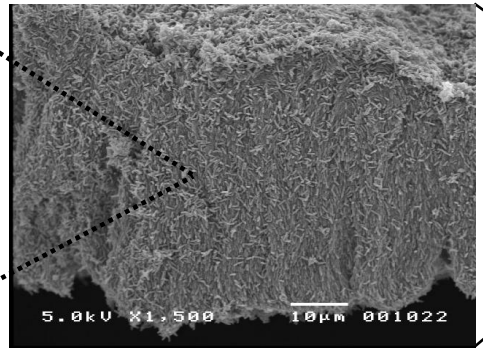
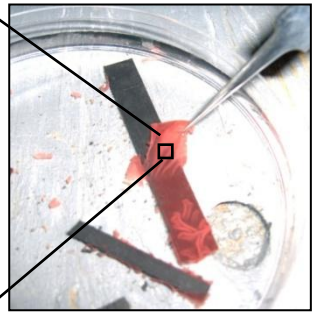
Direct electron transfer: UMass will leverage the ability of some microbes to make electrical contacts with electrodes

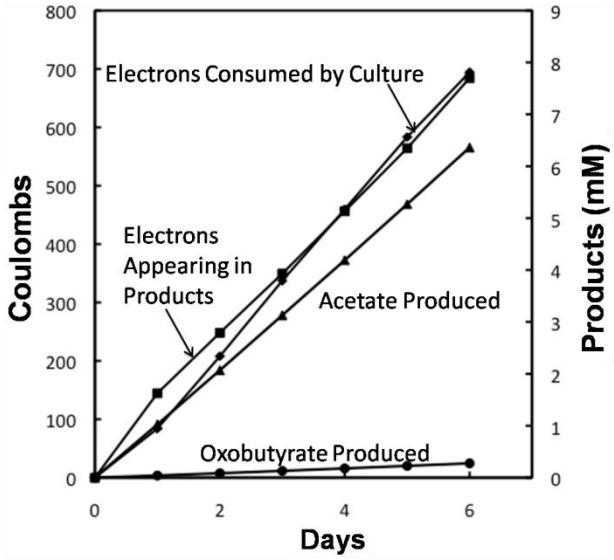
Title	Electrofuels via Direct Electron Transfer from Electrodes to Microbes				
Team Lead	U. of Massachusetts; Amherst, MA	**Project Budget**	$4.1 Million	**POP**	7/01/2010 - 7/01/2013 (36)

Geobacter metallireducens can form conductive biofilms on the surface of electrodes



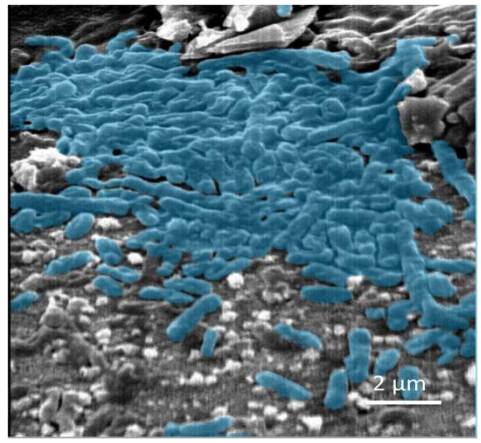






Acetogenes such as *Sporomusa ovata* have demonstrated the ability to produce acetate directly from electrons with high coulombic efficiency

Clostridium ljungdahlii will be engineered to produce butanol from electrcity



Columbia University's approach is to engineer ammonia metabolizing microorganisms to produce butanol

Title	Biofuels from CO_2 using Ammonia-Oxidizing Bacteria in a Reverse Microbial Fuel Cell				
Team Lead	Columbia University; New York, NY	**Project Budget**	$0.6 Million	**POP**	7/01/2010 - 6/30/2012 (24)

COLUMBIA UNIVERSITY

•*Nitrosomonas europaea* are chemolithoautotrophic ammonia-oxidizing-bacteria that are found in wastewater treatment operations

- *N. europaea* cells are tolerant of high ammonia and high nitrite concentrations
- Cells are not impacted by electrochemical reduction of media
- Genetic modification of *N. europaea* cells for isobutanol production currently is underway

•Ammonia is u
microbes do r

CO_2

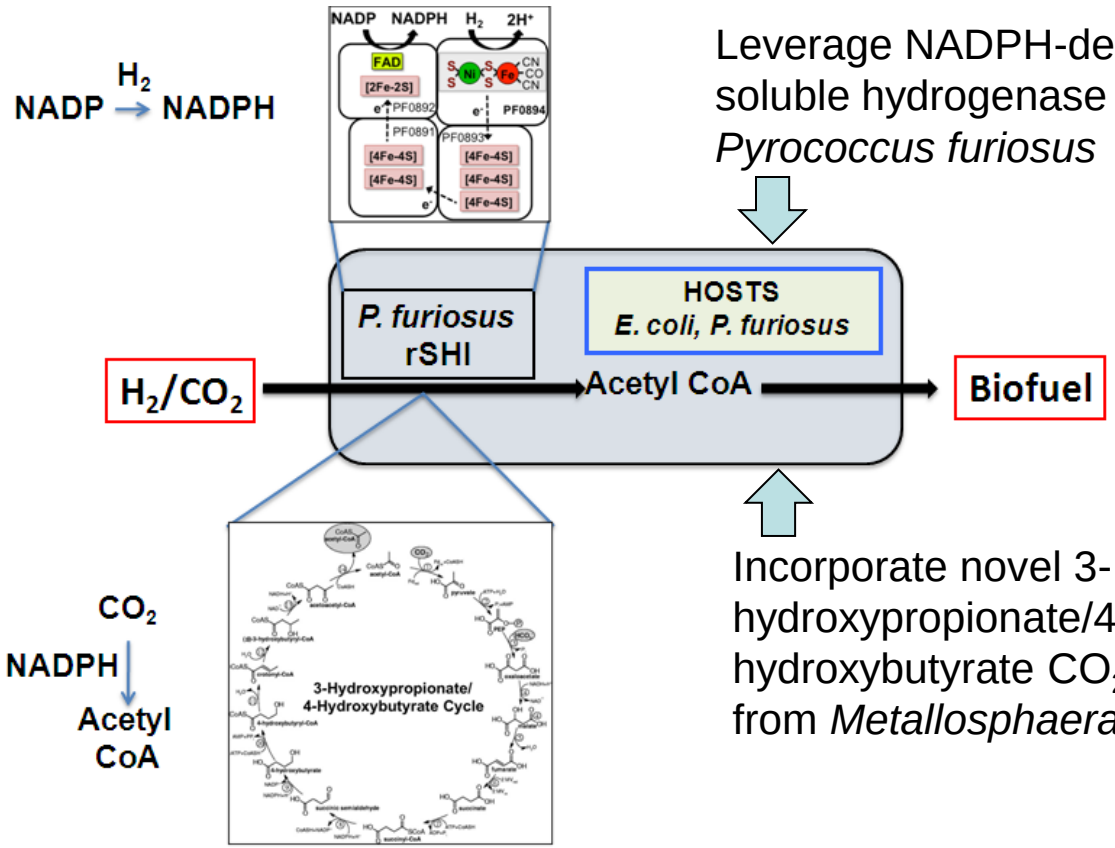
•Nitrite can be
reduced back

•*N. europaea* can
electricity and air

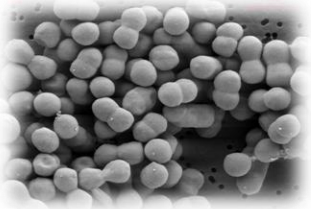
Biomass

NCSU & UGA seek to transfer novel CO_2 fixation enzymes to convert heterotrophs into autotrophs

Title	H_2-Dependent Conversion of CO_2 to Liquid Electrofuels by Thermophilic Archaea				
Team Lead	North Carolina State U.; Raleigh, NC	**Project Budget**	$3.3 Million	**POP**	7/01/2010 - 6/23/2013 (36)



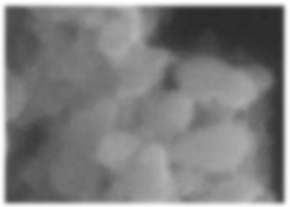
Leverage NADPH-dependent soluble hydrogenase activity from *Pyrococcus furiosus*



The University of Georgia

NC STATE UNIVERSITY

Incorporate novel 3-hydroxypropionate/4-hydroxybutyrate CO_2 fixation cycle from *Metallosphaera sedula*



Thank you

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