



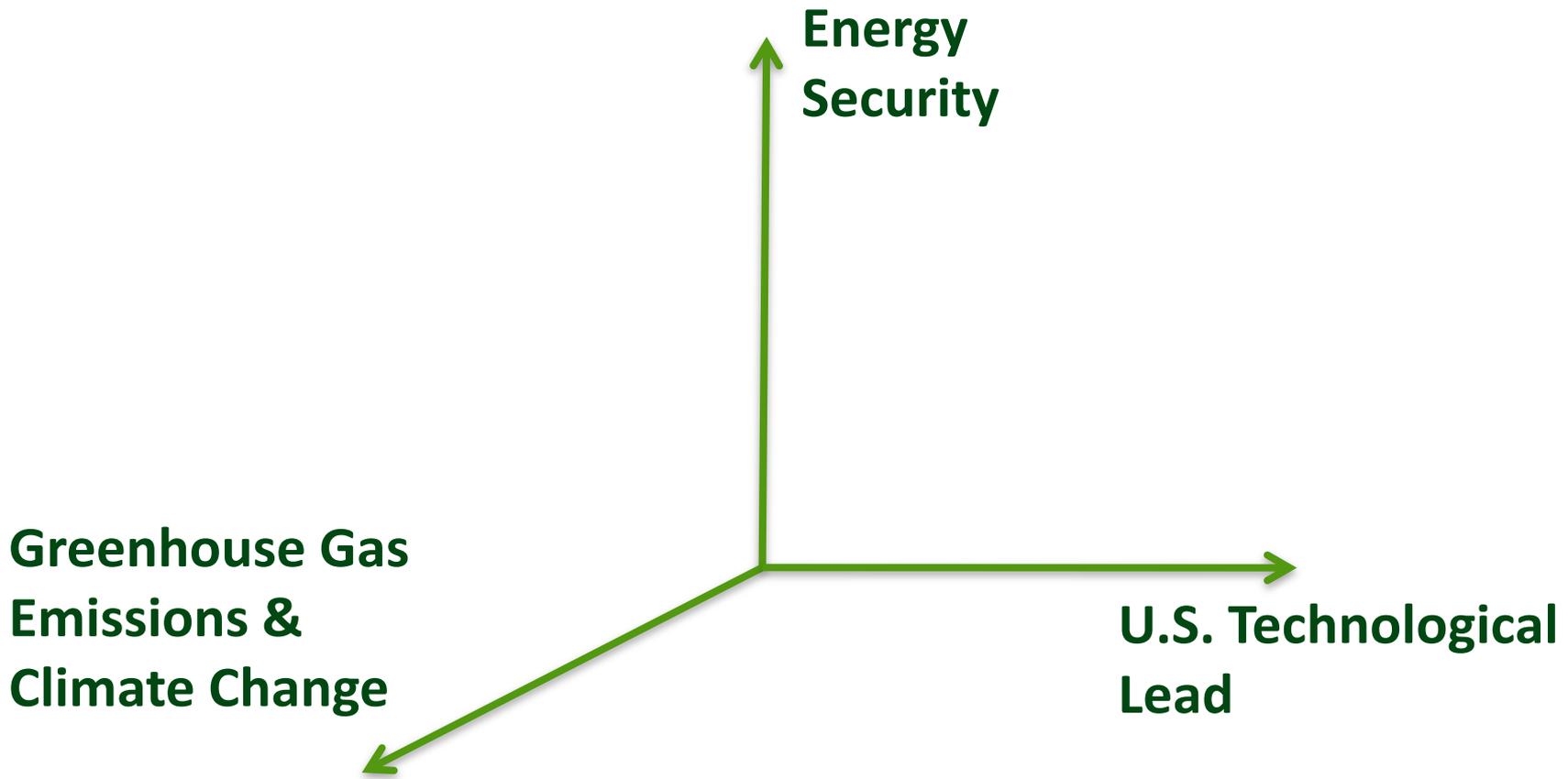
ADVANCED RESEARCH PROJECTS AGENCY (ARPA-E)

**ARUN MAJUMDAR
DIRECTOR, ARPA-E
U.S. DEPARTMENT OF ENERGY**

**ARPA-E Energy Innovation Summit
Monday, March 1 2010**

www.arpa-e.energy.gov

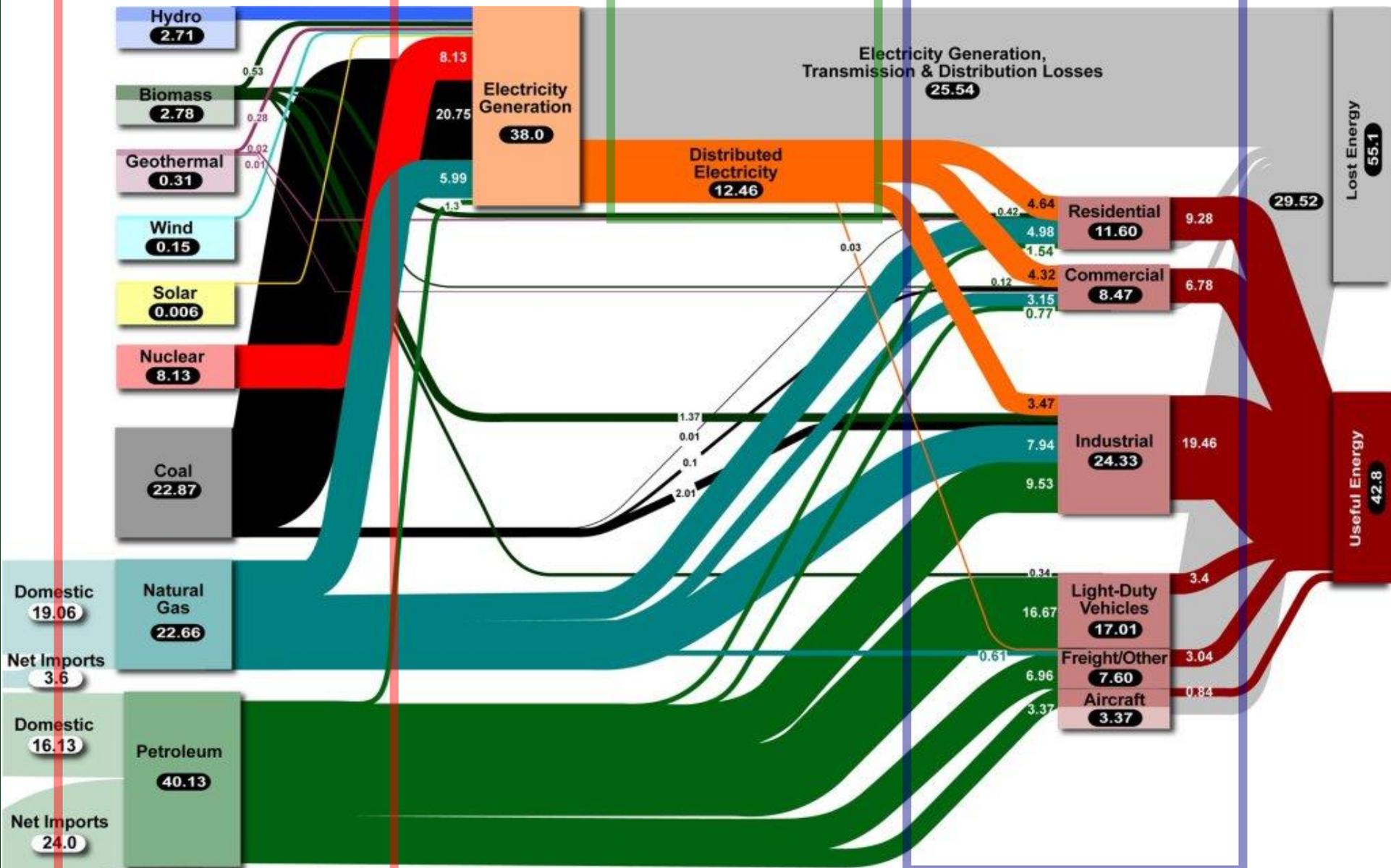
THREE SPUTNIKS OF OUR GENERATION



Supply

Transmission & Distribution

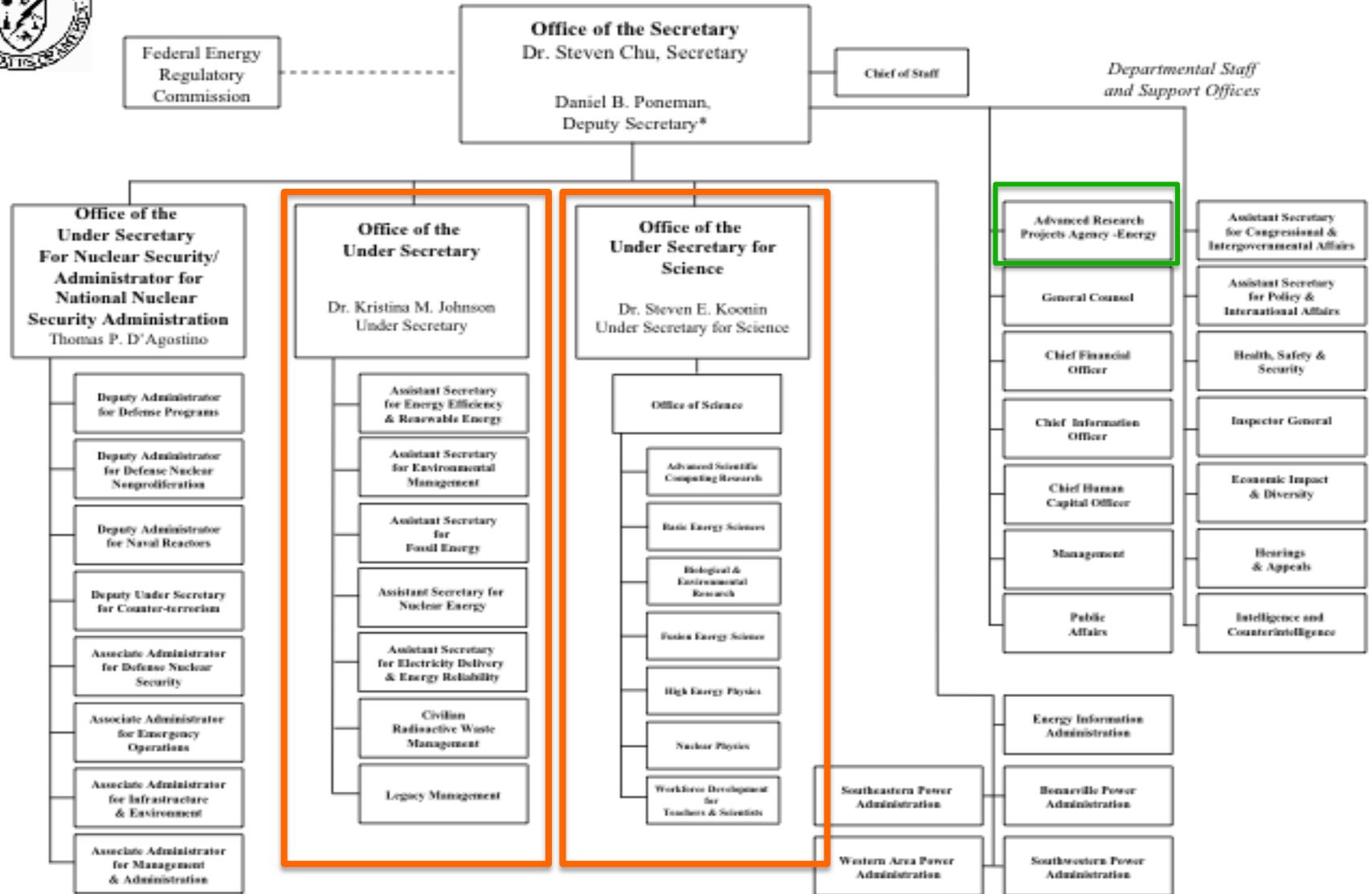
Demand



Courtesy: Lawrence Livermore National Lab.



DEPARTMENT OF ENERGY



* The Deputy Secretary also serves as the Chief Operating Officer

PURPOSE OF SUMMIT



- **Define the ARPA-E DNA**
 - Vision and mission
 - How do we operate (scientifically, administratively)?
 - What are we looking for (technical, people, ...)?
 - What are our metrics of success?
- **Engage with the community**
- **Showcase ARPA-E funded projects**
- **Showcase projects that ARPA-E could not fund and expose them to other funding sources**
- **Engage all stakeholders to discuss how to foster and scale innovations in energy technologies**
 - **Technical community, small/large business, investment community, policy community, federal agencies, Congress, White House**



- **Program Directors (Max. 4 yrs):** Active researchers who have one foot in science & engineering and the other in technology development and business
 - Active academics or national lab researchers who have started businesses or who actively work with industry
 - Researchers from the industry who are active in research & technology development (publishing, patents, etc) and who have participated in business

- **ARPA-E Fellows (Max. 2 yrs):** Best and the brightest scientists, engineers and technical entrepreneurs to form a think tank - identify challenges, opportunities, and new approaches to address energy technologies.
 - Fellows < 3 years after PhD
 - Senior Fellows > 3 years after PhD

PLAN FOR THE DAY



- **ARPA-E Past and Present**
- **Morning Panels on Commercialization**
 - Energy Technology Commercialization
 - How to Take Advantage of SBIR
- **Report of Recent ARPA-E Workshops**
 - Grid-Scale Electrical Energy Storage
 - Building Energy Efficiency
 - Power Electronics
 - Energy from Wastewater
- **Afternoon Panels**
 - Best Practices in Technology Transfer
 - Next Generation Energy Entrepreneurs
- **Technology showcase**

ARPA-E Past and Present

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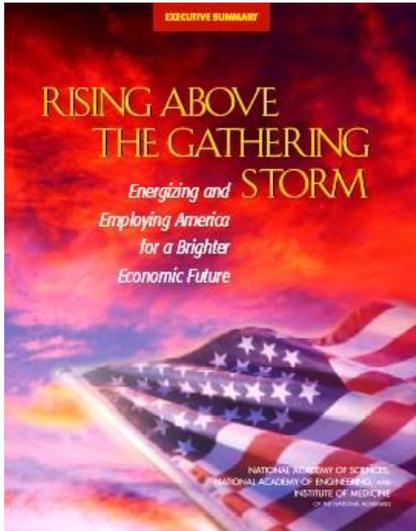
The Brief History of ARPA-E

What is an ARPA-E Project

Representative ARPA-E FOA 1 Projects

ARPA-E: Moving Forward

ARPA-E'S ORIGIN



American Recovery and Reinvestment Act of 2009 (Recovery Act)

2007
America COMPETES Act

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

2006
Rising Above the Gathering Storm
(National Academies)



ARPA-E'S MISSION



“Identify and promote revolutionary advances in fundamental sciences”

“Translate scientific discoveries and cutting edge inventions into technological innovations”

To enhance the economic and energy security of the U.S.

“Accelerate transformational technologies”

To ensure U.S. technological lead in developing and deploying advanced energy technologies

Mission

ARPA-E'S CULTURE



- **Excellence:** Recruit all-star team to ARPA-E; thought leadership; focus on potentially game-changing ideas; enable creation and support of the best teams
- **Openness:** Open to best ideas regardless of origin; sharing and partnership with Congress and other stakeholders; public understanding of value of technology for society
- **Integrity:** New program creation and proposal review process
- **Speed:** Streamline transactions; accelerate science to market; respond to community input
- **Metrics Driven:** Operations and program management driven measurable targets
- **Flat and Nimble...**

ARPA-E AS AN ORGANIZATION IS INTENDED TO BE NIMBLE AND FLAT



Dr. Arun Majumdar
ARPA-E Director

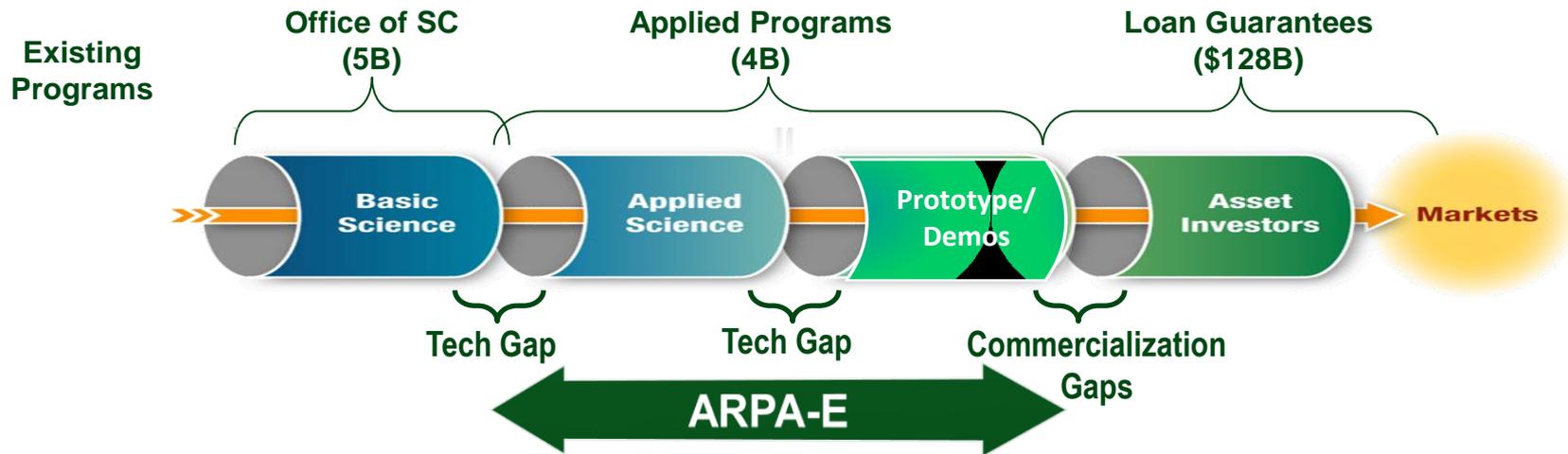
Shane Kosinski
Deputy Director for Operations

Operations Team

**Commercialization & Stakeholder
Engagement Team**

Program Team

ARPA-E WAS CREATED WITH A VISION TO BRIDGE GAPS IN THE ENERGY INNOVATION PIPELINE



what ARPA-E will do

- Seek high impact science and engineering projects
- Invest in the best ideas and teams
- Will tolerate and manage high technical risk
- Accelerate translation from science to markets
- Proof of concept and prototyping

what ARPA-E NOT will do

- Incremental improvements
- Basic research
- Long term projects or block grants
- Large-scale demonstration projects

FUNDING OPPORTUNITY ANNOUNCEMENT - ROUND 1



FOA 1 – Open to all energy technologies; yet required to be game changing/high impact (Announced April `09, selections Oct `09)

**Concept
Papers
~3700 Received**

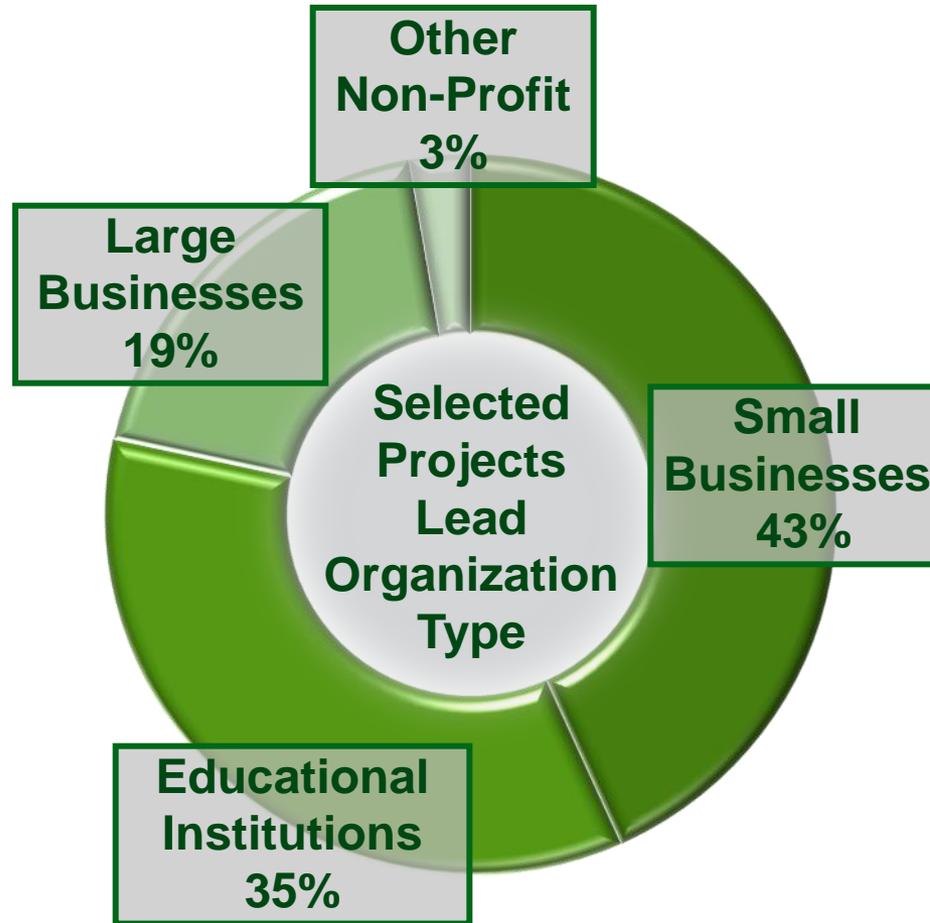
**Full
Applications
~338 Received**

Senior Panel

**37
Projects
~\$151
Million**

- Rigorous review process with assistance from academia, industry and government
- Secretary Chu called for Nation's experts assist with reviews
- The Nation responded - Over 500 reviewers participated
 - All reviewers vetted by senior DOE leadership
 - 8,694 review hours; 4.18 person years

DIVERSE PROJECT LEADS FOR FOA 1





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WHAT ARPA-E IS LOOKING FOR



High Impact on ARPA-E Mission Areas –

- Reduction in energy imports
- Improvement in energy efficiency
- Reduction in energy-related emissions, including greenhouse gasses
- To “ensure” U.S. “technological lead in developing and deploying advanced energy technologies

Disruptive, Innovative Technical Approach –

- ARPA-E is focused on high risk/high reward R&D
- Interested in –
 - New technical approaches that move to entirely new learning curves
 - Fundamentally new areas of research with uncharted white space

Best-in-class People & Teams

- Complementary, cross-discipline skill sets
- Strong interest to bring in new, talented scientists and engineers to energy technology research
- Break down barriers between science and engineering

Strong Impact of ARPA-E Funding Relative to Private Sector –

- Invest in areas too risky for the private sector
- ARPA-E investments derisk technologies and catalyzes follow on private sector investments

FOA 1 PROJECTS CAN BE CATEGORIZED INTO ONE OF TEN ENERGY TECHNOLOGY AREAS



Energy Storage



6 projects

Biomass Energy

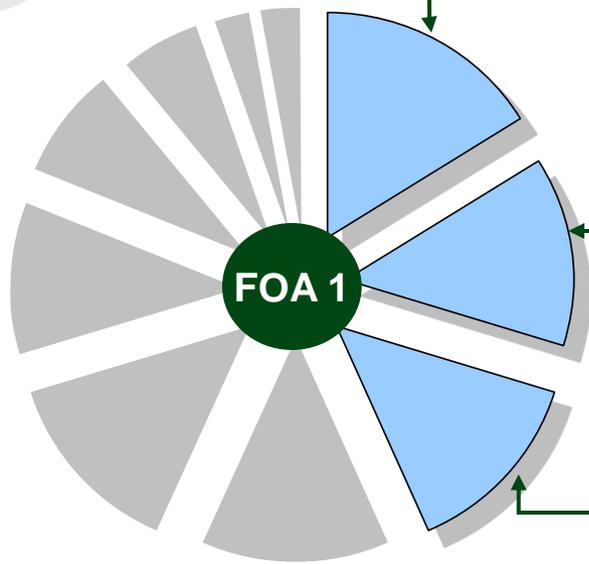


5 projects

Carbon Capture



5 projects



FOA 1 PROJECTS CAN BE CATEGORIZED INTO ONE OF TEN ENERGY TECHNOLOGY AREAS



Renewable Power

4 projects



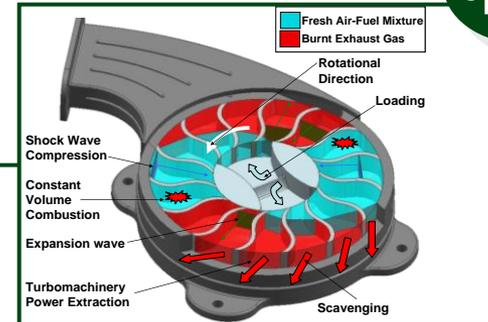
Solar Fuels

5 projects



Vehicle Technologies

5 projects



FOA 1

FOA 1 PROJECTS CAN BE CATEGORIZED INTO ONE OF TEN ENERGY TECHNOLOGY AREAS



Waste Heat Capture

2 projects



Conventional Energy

1 project



FOA 1

Water

1 project



Building Efficiency

3 projects





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ARPA-E: Moving Forward

RTI WILL DEVELOP A NOVEL CATALYTIC BIOMASS PYROLYSIS PROCESS TO PRODUCE STABLE BIO-CRUDE

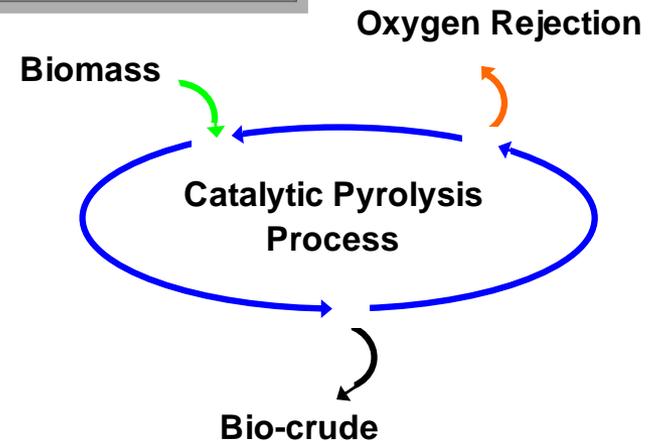


Goal: A novel process that uses multi-functional catalysts for controlling and optimizing biomass pyrolysis chemistry to produce an intermediate that can be integrated with the existing transportation fuel production and distribution infrastructure



Project Objectives:

- Develop multi-functional catalysts with selective oxygen removal and cracking functionalities for producing a pyrolysis product similar to crude oil
- Develop a biomass pyrolysis process that optimizes carbon conversion, catalyst performance, and cost
- Establish solid foundation for process scale-up, catalyst scale-up, bio-crude upgrading to fuels to accelerate technology transition and commercialization activities



Team Members: ADM, Conoco Phillips, Albemarle Corp.



BIO-CRUDE WILL BE FABRICATED AS AN INTERMEDIATE FOR FUEL PRODUCTION WITH TAILORED PHYSICAL AND CHEMICAL PROPERTIES



Biomass

High impact biomass feedstocks such as agricultural residues

Catalyst Development and Novel Reactor Concepts

Catalytic Pyrolysis



Bio-crude



Fuel Upgrading

Minimal H₂

Hydrotreating/Hydrocracking
Petroleum refinery co-feed
Infrastructure compatibility

**Bio-gasoline
Green Diesel**



RTI
INTERNATIONAL

Mission impact: this program aims to reduce the dependence on foreign oil and lower GHG emissions through the displacement of fossil fuels with biofuels

ITN ENERGY SYSTEMS WILL DEVELOP ELECTROCHROMIC WINDOWS FOR ACTIVE CONTROL OF SOLAR HEAT AND LIGHT TRANSMISSION



Goal: Overcome manufacturing cost challenges that have prevented widespread adoption by fabricating electrochromic films on plastic substrates in a roll-to-roll process



- Buildings account for 40% of U.S. energy use
- Windows alone account for 4 quadrillion BTUs (quads)
- Modeling shows that electrochromic windows can reduce electricity use by 20-40%*

High Transmission State (Clear)

Low Transmission State (Dark)



Light and Solar Energy **Transmitted**

Light and Solar Energy **Rejected**

* "Early Market Study of Electrochromic Windows"
Lawrence Berkeley Laboratories for California
Energy Commission



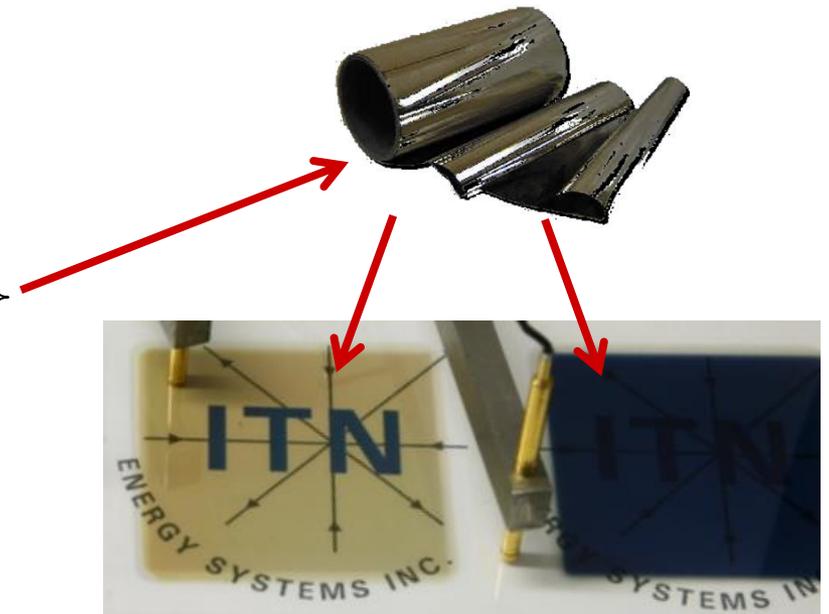
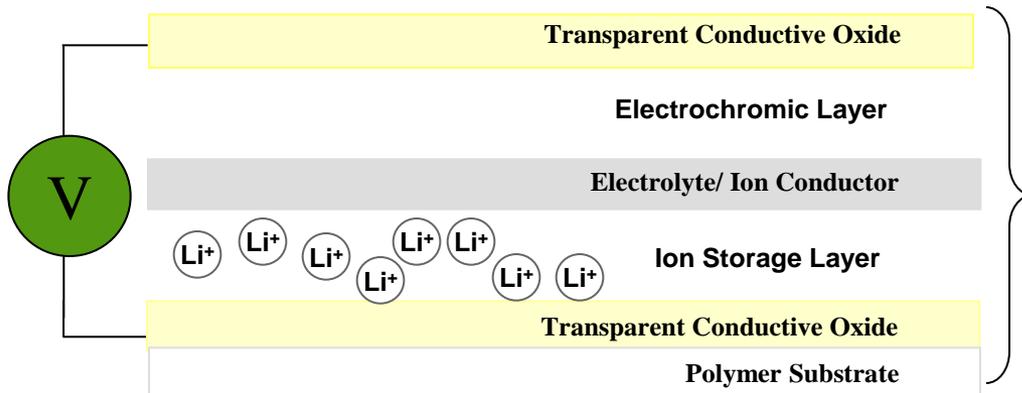
Team Members: EPRI, MAG Industrial



SOLID-STATE ELECTROCHROMIC FILMS REDUCE HEATING AND COOLING LOADS AND MINIMIZE OVERHEAD LIGHTING USE



- Tunable transmission to match variable building loads
- Achievable range: visible transmission from 2 to 70%
- Voltage required for switching only: maintains color state without power



Mission impact: adapt advanced roll-to-roll manufacturing used in thin film solar markets to enable widespread adoption of highly efficient windows

NANOASIS WILL UTILIZE CARBON NANOTUBES (CNTS) TO MAKE INDUSTRIALLY-SCALABLE REVERSE OSMOSIS (RO) MEMBRANES



Goal: Transform desalination and wastewater reuse and produce dramatic energy savings with advanced membranes and reduced capital costs

nanOasis

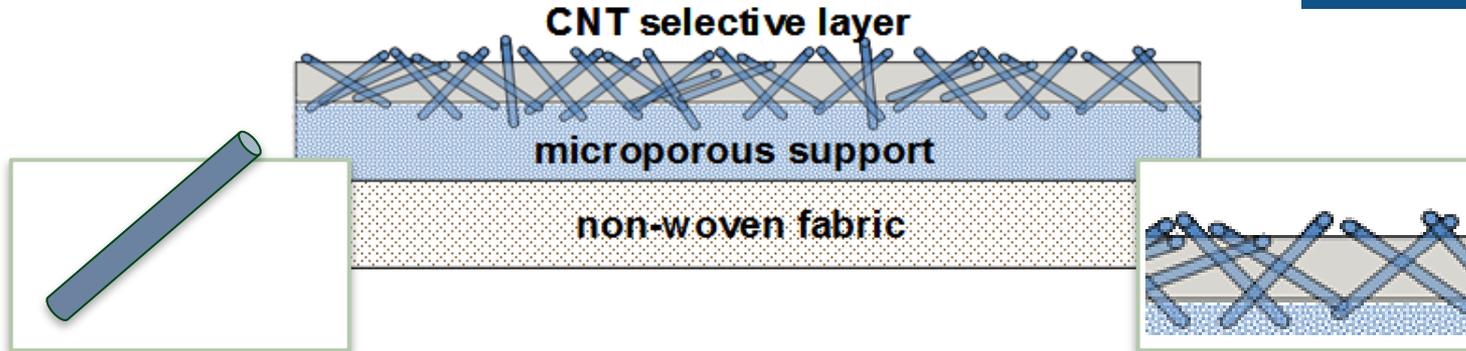


Water Passes More Freely Through the Membrane
Requiring 30-50% Less Energy

CARBON NANOTUBES WILL BE USED TO IMPROVE MEMBRANE PERMEABILITY AND REDUCE THE COST OF WATER GENERATED



nanOasis



ULTRA-HIGHLY PERMEABLE SMALL DIAMETER CARBON NANOTUBE

- Frictionless, Atomically Precise Pore
- **Enhanced Flux** 1,000-10,000X vs. Conventional Pores

LOW COST MEMBRANE ARCHITECTURE

- SuperFlux™
- 10X Higher Membrane Permeability vs. Today's State of the Art

Mission impact: increased membrane permeability, resulting in 30-50% energy savings and 10-23% lower capital costs for reverse osmosis plants



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ARPA-E: Moving Forward



- Project Team:
 - Program Directors Deeply Technically Engaged with Projects
 - Technical, Administrative, Contracting, Legal, Commercialization Support

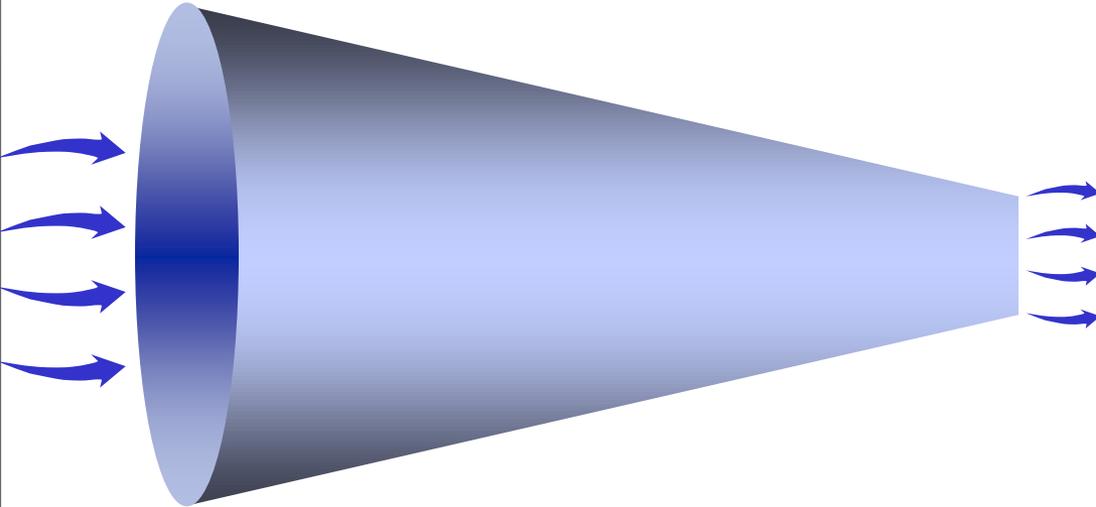
- Invested in Your Success:
 - Milestones & Deliverables Negotiated with Program Director
 - Quarterly Site Visits/Meetings
 - Aggressive, but Realistic, Annual “Go/No-Go” Decision Points
 - Re-scope or terminate non-performing projects
 - Program Flexibility
 - Can accommodate changes in approach if warranted and agreed to by all parties
 - Support in Finding Next Stage Support for Successful Projects

WIDE OPEN FOA 1 → FOCUSED PROGRAMS IN ROUNDS 2 & 3



Inputs to Focused FOA Development

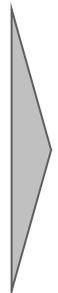
- FOA 1: Snapshot of Current U.S. Energy Technology Landscape
- 550 Responses to “Request for Information” Suggesting High Impact Program Areas
- 7 Focused Workshops



FOCUSSED FUNDING OPPORTUNITIES (\$30-\$35M programs)

Round 1

- Wide open “Early Harvest” solicitation
- Seeking to support best U.S. energy technology concepts across the board



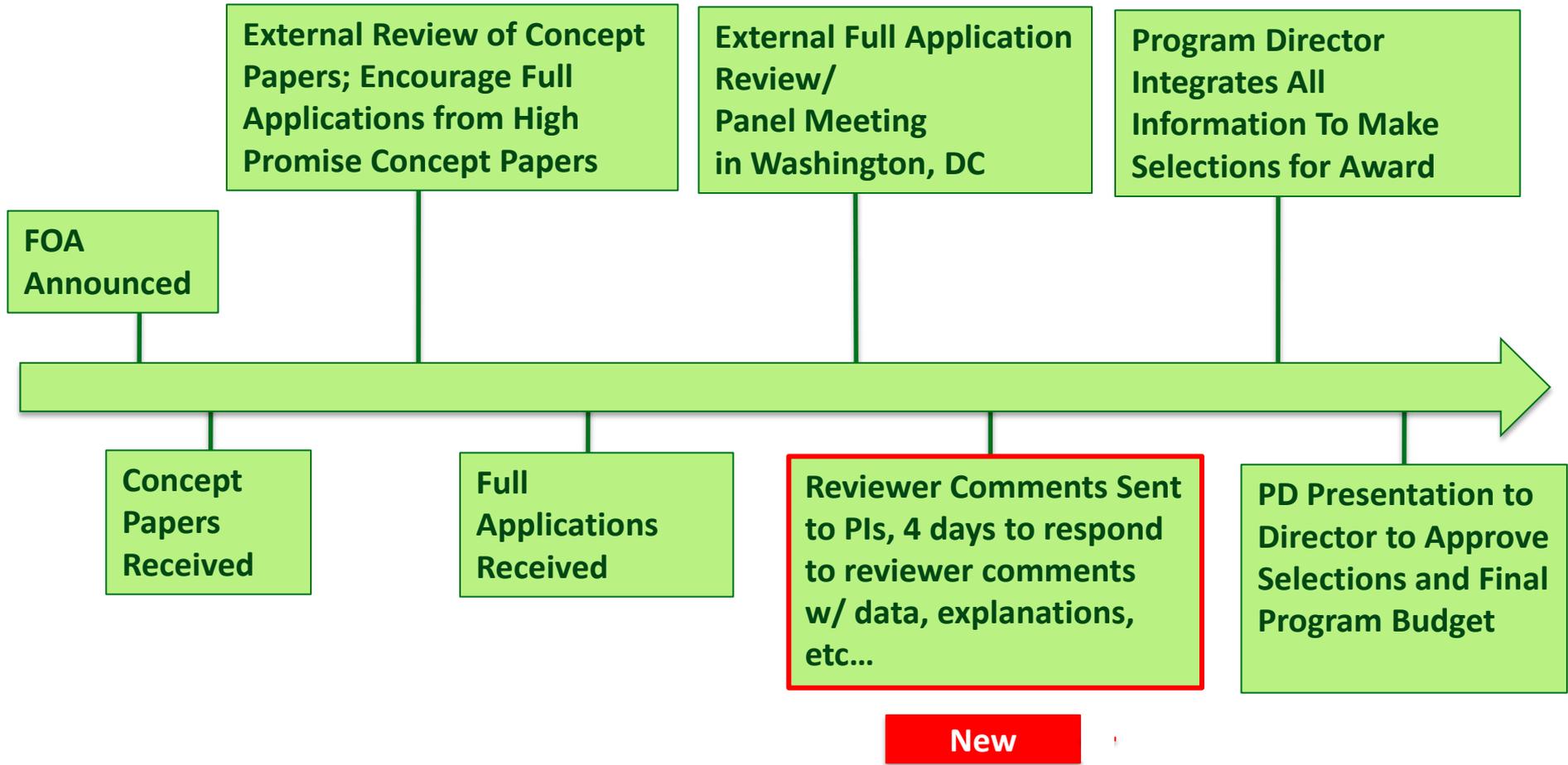
Round 2 & Round 3 FOAs

- Focused funding opportunities around a grand market or technical challenges
- Metrics driven programs with clear “over the horizon” cost and/or performance metrics

PROCESS FOR DEVELOPING FOCUSED PROGRAMS



ARPA-E REVIEW PROCESS



ARPA-E WORKSHOPS



Grid Scale Electrical Energy Storage
(Mark Johnson, David Danielson, &
Imre Gyuk)
Oct 4

Building Energy Efficiency
(Colin McCormick & Ravi Prasher)
Dec 15

Direct Solar Fuels
(Eric Toone)
Oct 21

Energy from Wastewater
(Mark Shannon)
Jan 27

Carbon Capture & Conversion
(Mark Hartney)
Oct 29

Power Technologies
(Rajeev Ram)
Feb 9

Electrical Energy Storage for Vehicles
(David Danielson)
Nov 3

ARPA-E ROUND 2 – FIRST FOCUSED FUNDING OPPORTUNITIES



- 3 Focused Programs Totaling ~\$100M; 2-3 Year Projects
- 10 – 15 Projects per Program

2 nd Round FOAs	Focus
Batteries for Electrical Energy Storage in Transportation (BEEST)	Electrical Energy Storage for PHEV-100+ and EV's > 400 Wh/kg, > 600 Wh/liter (cell) < \$250/kWh (system) Moving beyond traditional lithium ion batteries
Innovative Materials and Processes for Carbon Capture Technologies (IMPACCT)	Materials and processes for drastic reductions in energy penalty and cost of post combustion CO2 capture
Electrofuels	Develop modular non-photosynthetic, autotrophic biosynthetic systems that can assimilate energy from abundant sources for the production of energy dense liquid transportation fuels.

HOW TO PLUG INTO ARPA-E



- Join ARPA-E mailing list – <http://arpa-e.energy.gov>
- Engage ARPA-E with your ideas
- Participate in upcoming ARPA-E Workshops
- Apply to become an ARPA-E Program Director
 - <http://arpa-e.energy.gov/Jobs.aspx>
- Apply to the ARPA-E Fellows Program
 - ARPA-E-jobs@hq.doe.gov
- Submit Concept Papers to Open ARPA-E Funding Opportunities
- Participate in ARPA-E Review Process

THANK YOU FOR YOUR ATTENTION

- Q & A -



*Arun Majumdar
Shane Kosinski
Dave Danielson
Mark Hartney
Eric Toone*

