Advanced Buildings Workshop

Jointly hosted by ARPA-E & EERE

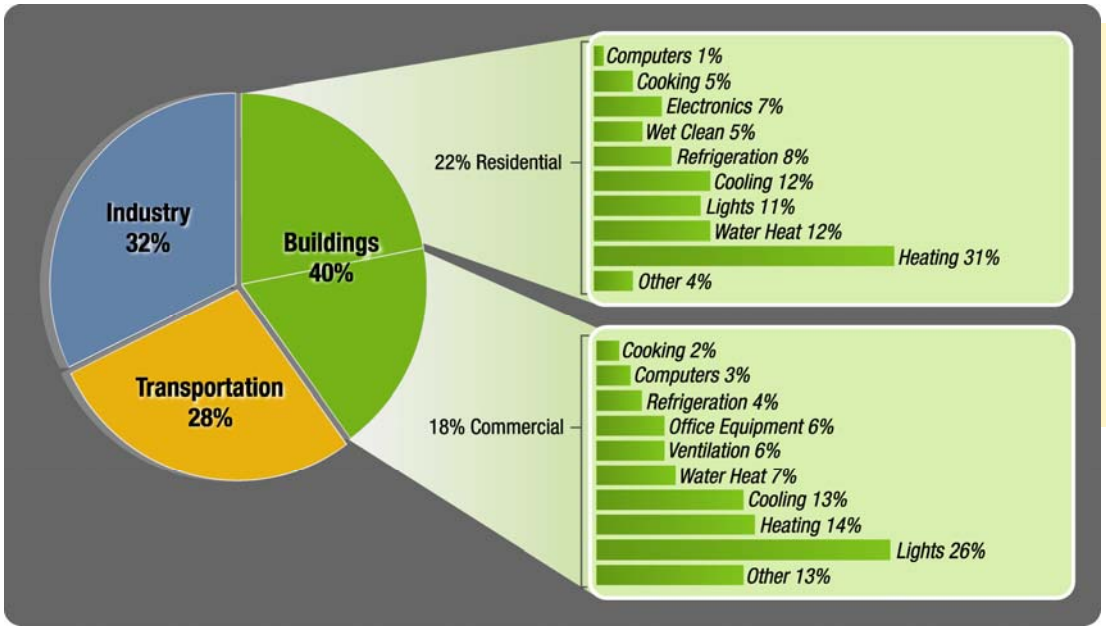
Arun Majumdar
Director, ARPA-E

Tuesday, December 15, 2009

Buildings Matter

Buildings construction/renovation contributed **9.5% to US GDP** and employs approximately **8 million people**. Buildings' utility bills totaled **$370 Billion** in 2005.

Buildings use 72% of nation's electricity and 55% of its natural gas.



By 2030, Business as Usual

- 16% growth in electricity demand
- Additional 200 GW of electricity at cost of $500-1000B, or $25-50B/yr

Buildings Can Provide Grid-Level Storage

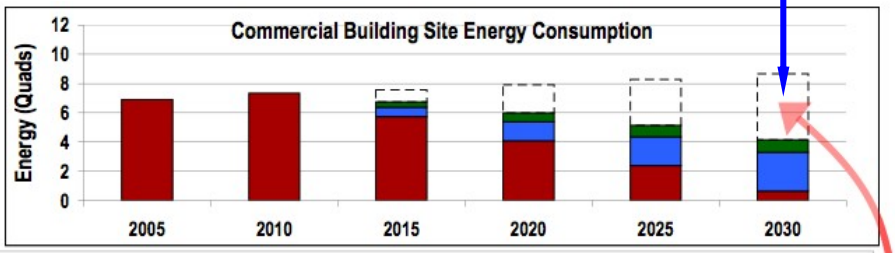
Source: *Buildings Energy Data Book 2007*

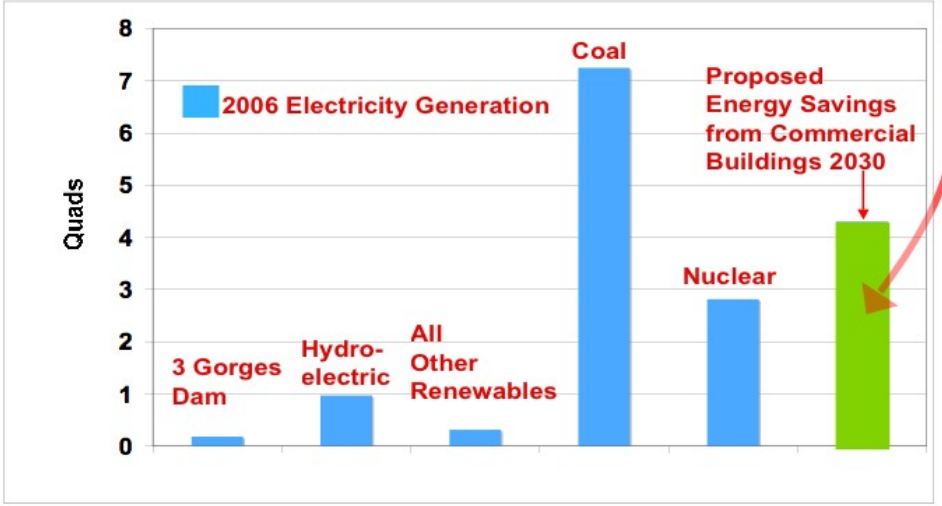
The Opportunity

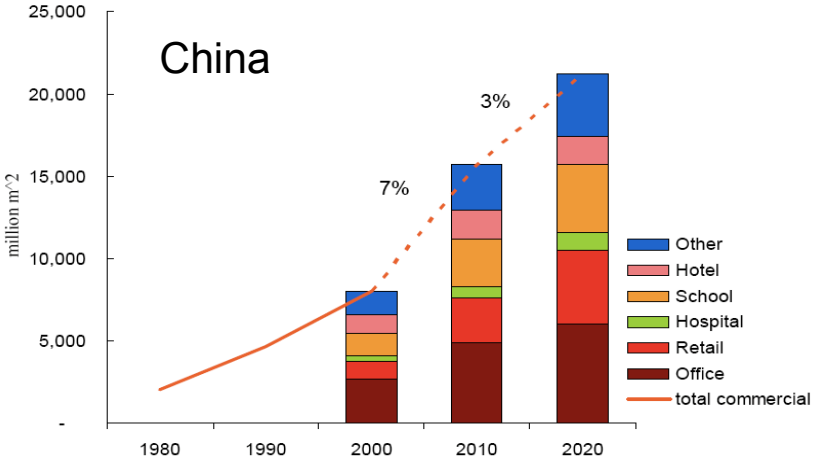
Zero Net Energy Commercial Buildings Initiative

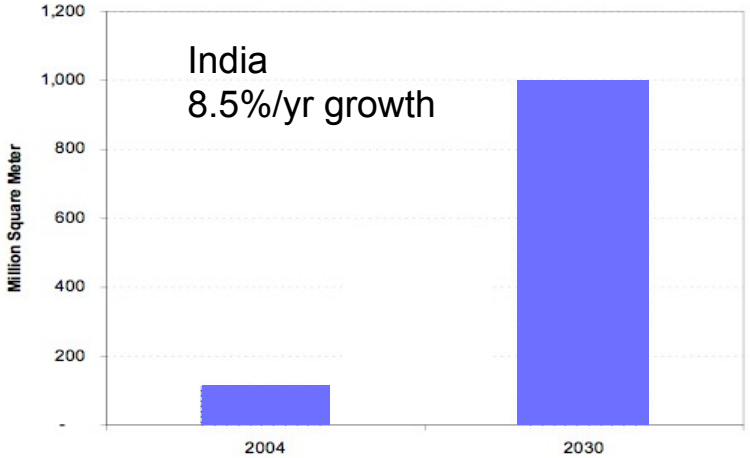
Energy Independence and Security Act of 2007

New: 80% reduction
Existing: 50% reduction



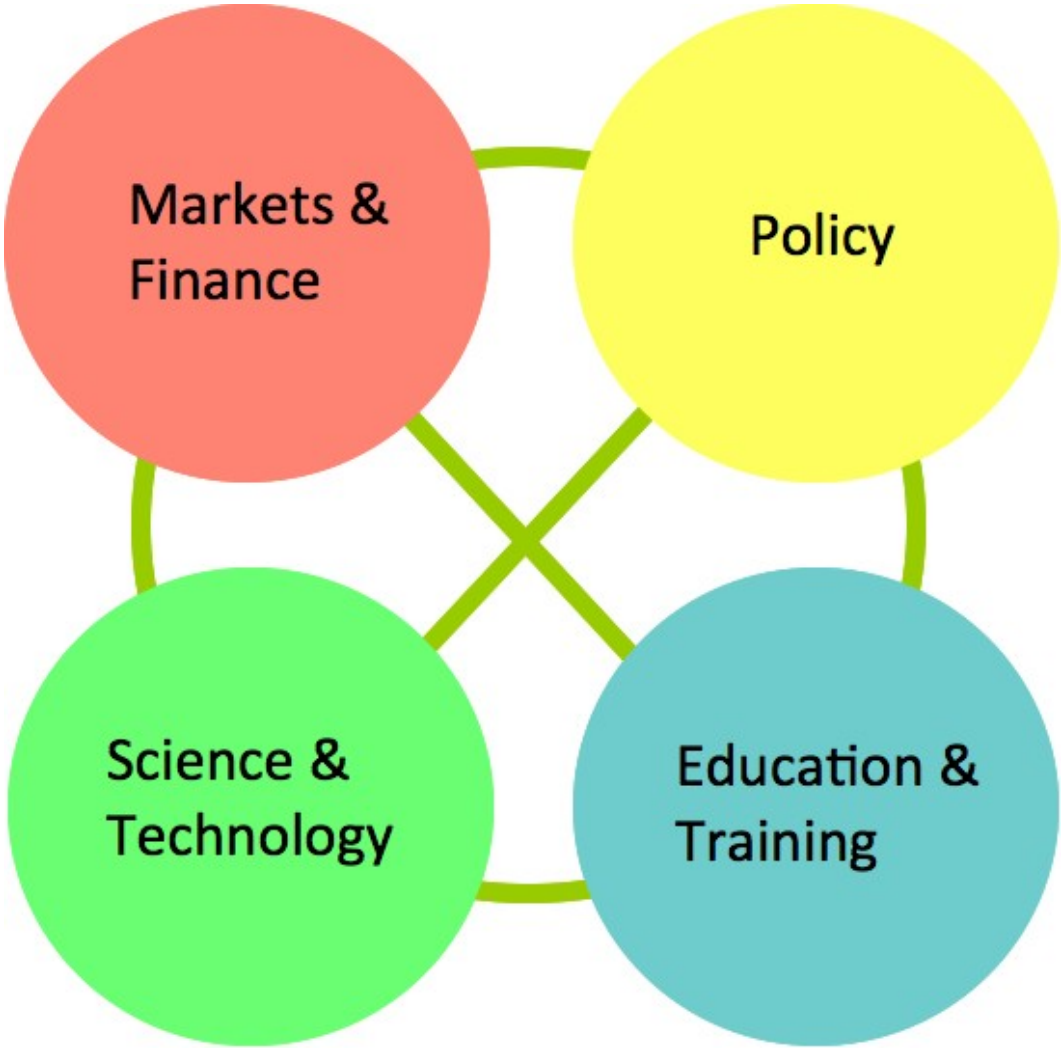






What is needed?

An aggressive strategy that coordinates, integrates, aligns and leverages



Purpose

- Community Building: Develop partnerships & form teams to address complex and large challenge

- Community to DOE: Topics, metrics, targets….

- DOE to Community: How can we help?

Agencies & Offices

- Dept of Energy (ARPA-E, EERE, ASCR, BES)
- Dept of Defense (Pentagon, DARPA)
- National Science Foundation
- Dept of Commerce (NIST)
- White House (OSTP)
- General Services Administration

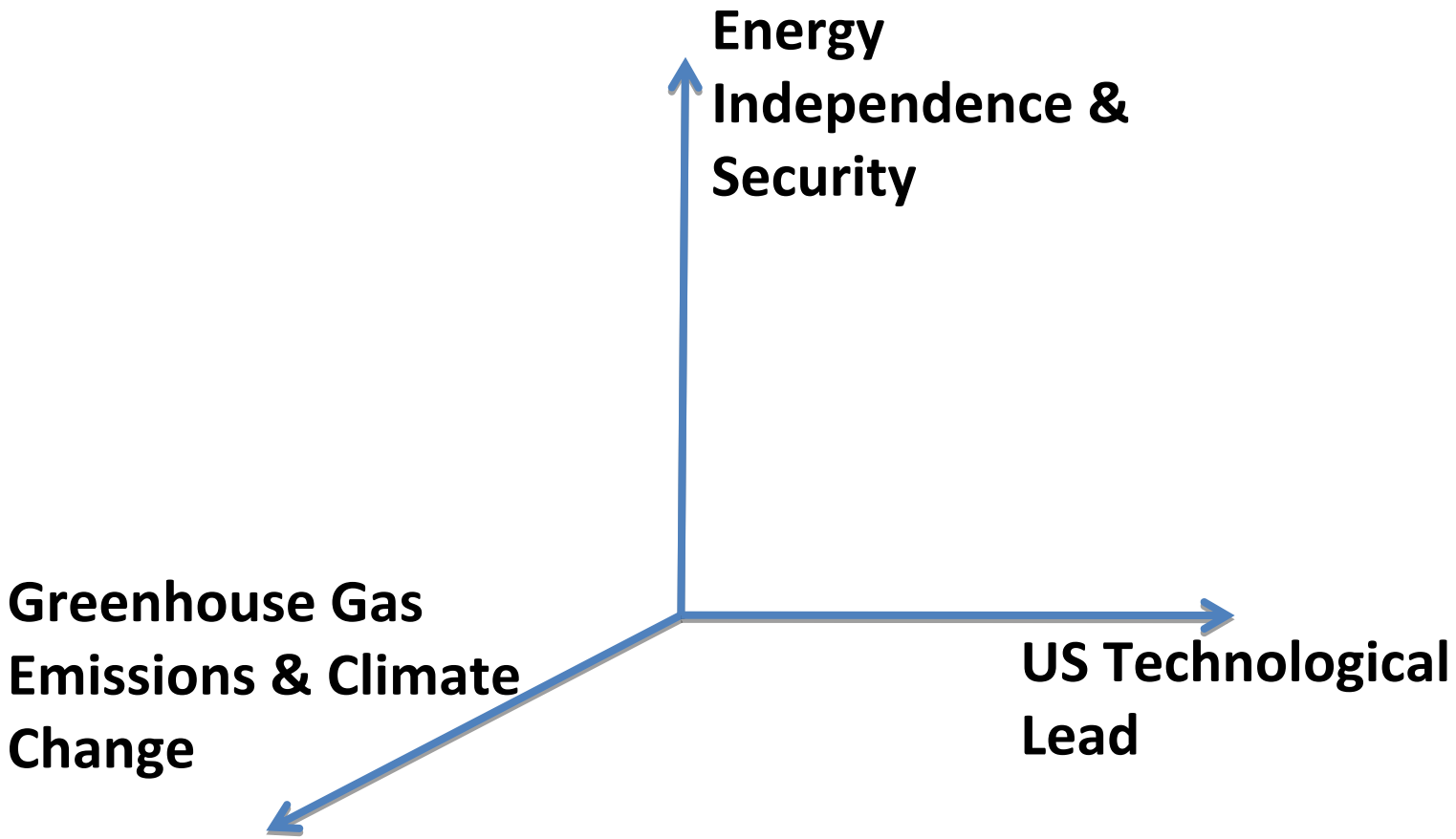
Key Challenges

- Measurements
- Systems integration
- Efficient heating and cooling

Advanced Research Projects Agency – Energy (ARPA-E)

Arun Majumdar
Director, ARPA-E

Three Sputniks of our Generation



Pace and Scale of Innovations Needed in Energy Technologies

Game Changers from 20th Century

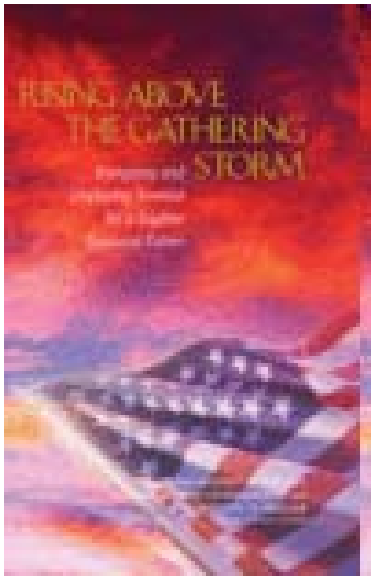
- Artificial Fertilizers
- Green Revolution
- Transistor
- Aeroplanes
- Electrification
- Polio Vaccination
- Antibiotics
- Nuclear Energy
- Integrated Circuits
- Fiber Optic Communication
- CCD cameras
- Wireless Communication
- Internet

Imagine all of this happening in a span of 10-20 years…

That is what we need now to address the biggest challenge of our lifetimes…

Identify and support today's Haber, Bosch, Borlaug, Bardeen, Shockley, Brattain, Salk, Wright brothers, Kilby, Noyce, Gates, Jobs, Page, Brin of the energy field

Background on ARPA-E



Rising Above the Gathering Storm, 2006 (National Academies)

- Establish an Advanced Research Projects Agency for Energy (ARPA-E)
- "Creative, out-of-the-box, transformational" energy research
- Spinoff Benefit – Help educate next generation of researchers
- Secretary Chu (then Director of Berkeley National lab) on committee

America COMPETES Act, 2007

- Authorizes the establishment of ARPA-E

American Recovery and Reinvestment Act of 2009 (Recovery Act)

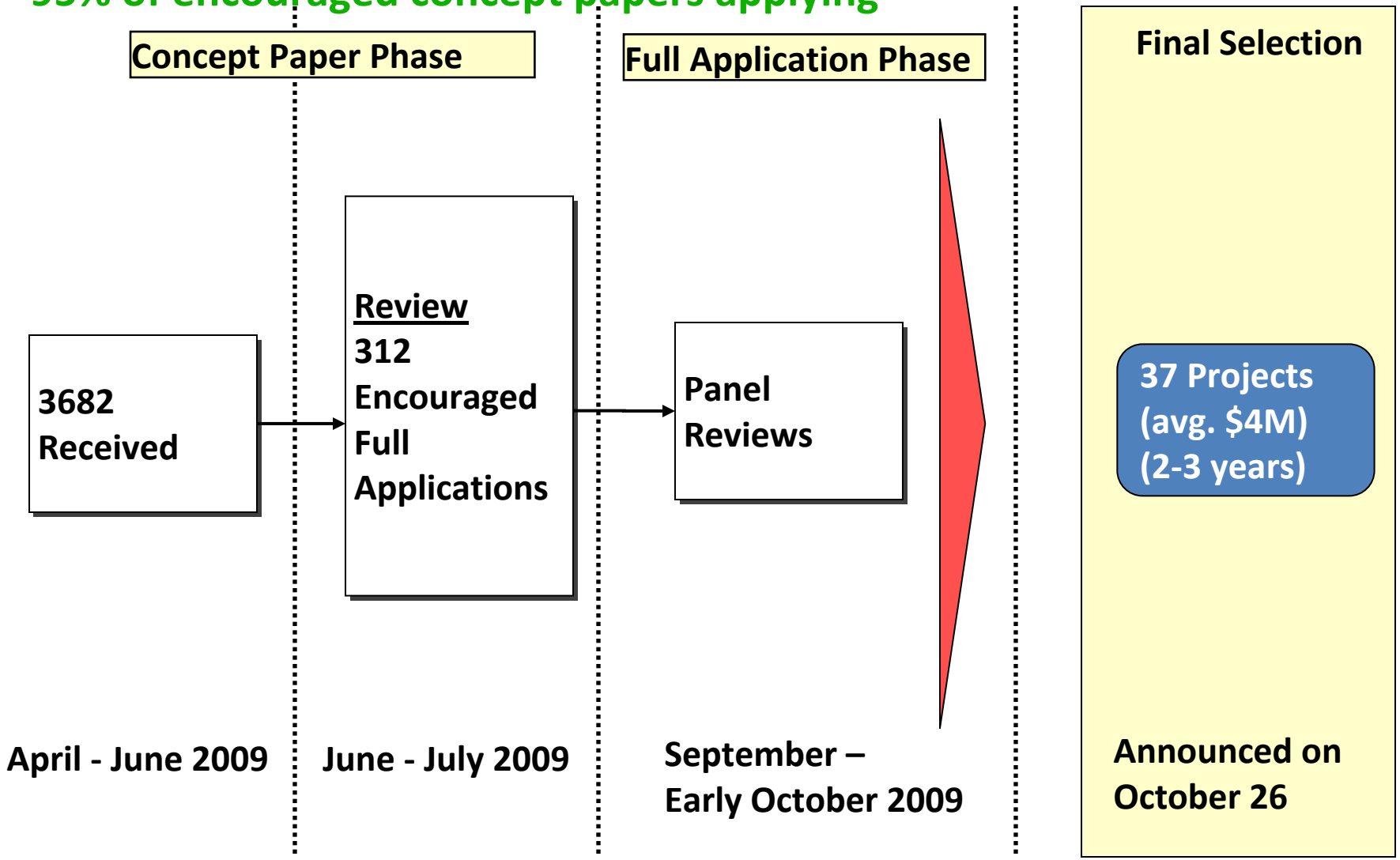
- $400M provided for ARPA-E
- President Obama launches ARPA-E in a speech at NAS on April 27, 2009

America's Strengths

- Best R&D infrastructure in the world
- Best innovation ecosystem in business and entrepreneurship
- Highly energized youth, ready to step up and engage
  - ARPA-E Fellows Program (Launched Dec 8th at MIT Energy Club): bring best and brightest recent PhDs in to ARPA-E; form internal think-tank to identify barriers & opportunities & map out global energy landscape

Report on First Funding Opportunity Announcement

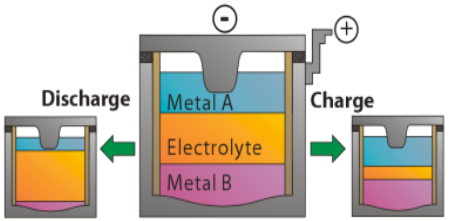
Ultimately 338 full applications were received and processed with 95% of encouraged concept papers applying



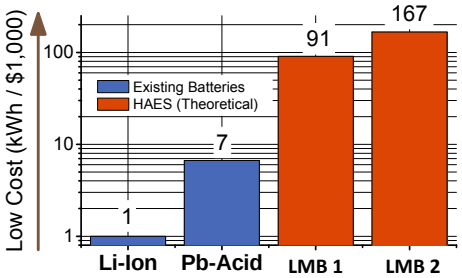
High Amperage Energy Storage Device: Energy Storage for the Neighborhood – MIT

Proposed Technology vs. State of the Art

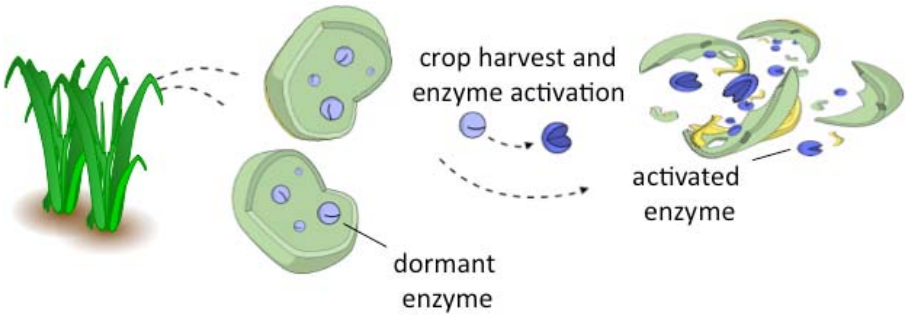
A new approach: Liquid Metal Battery (LMB)



More energy than Li-ion, cheaper than Lead-Acid



Agrivida GreenGenes™ Technology



Trigger biomass breakdown using plants' own genes

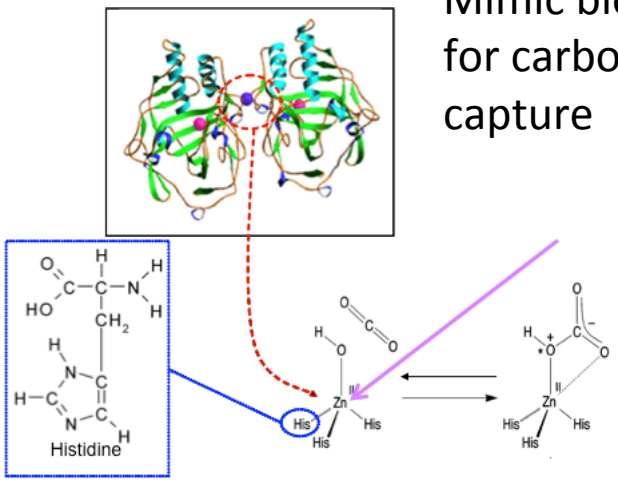
Breakthrough High Efficiency Mixer/Ejector Wind Turbine (MEWT) – FloDesign Wind Turbine Corp.

Proposed Technology vs. State of the Art

- Mimic jet engines, not proppelers for wind turbine
- 40% lower cost expected vs. horizontal axis wind turbines (HAWT)

CO_2 Capture using a Synthetic Analogue of Carbonic Anhydrase - UTC

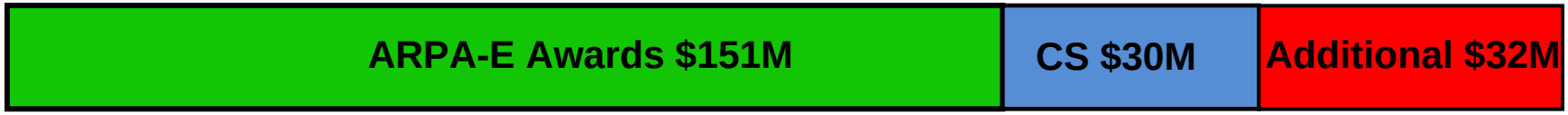
Mimic biology for carbon capture



Early Traction

ARPA-E Commitment (FOA-1) of $151M leveraged by additional $62M

Total = $213M

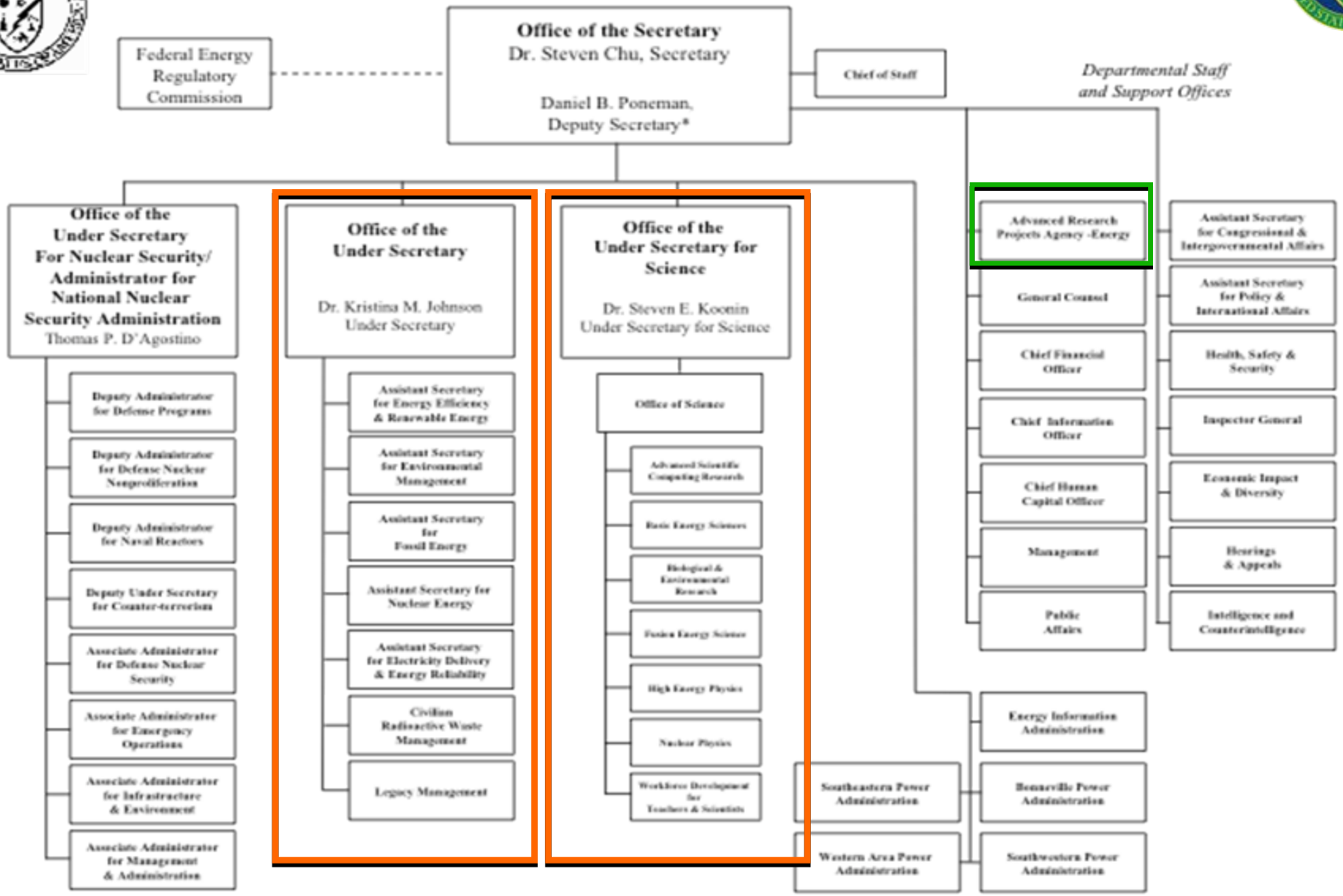


Second Round Funding Opportunities

Announced Dec 7, 2009

- Electrofuels
- BEEST: Batteries for Electrical Energy Storage for Transportation
- IMPACCT: Innovative Materials and Processes for Advanced Carbon Capture Technologies

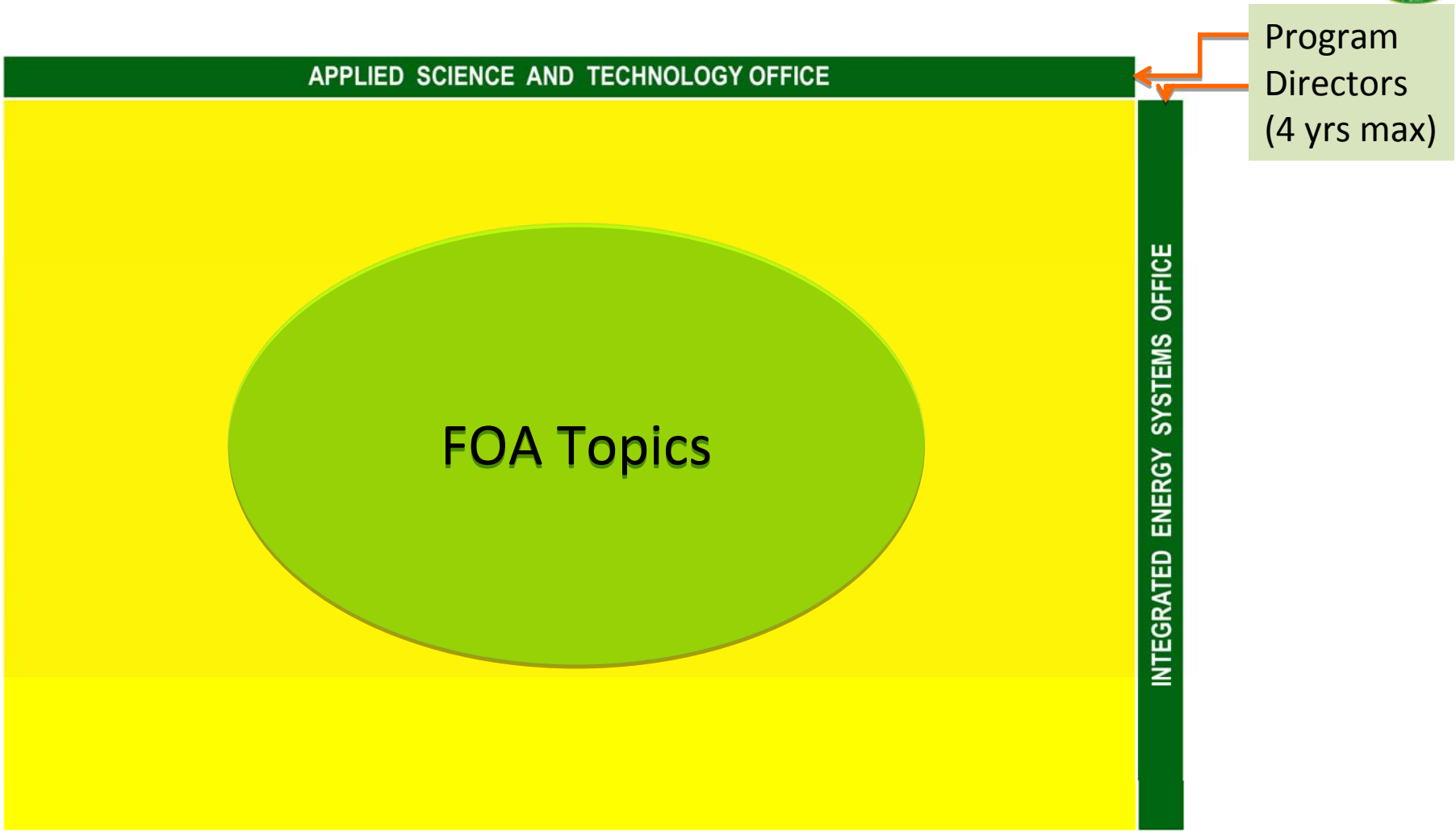
DEPARTMENT OF ENERGY



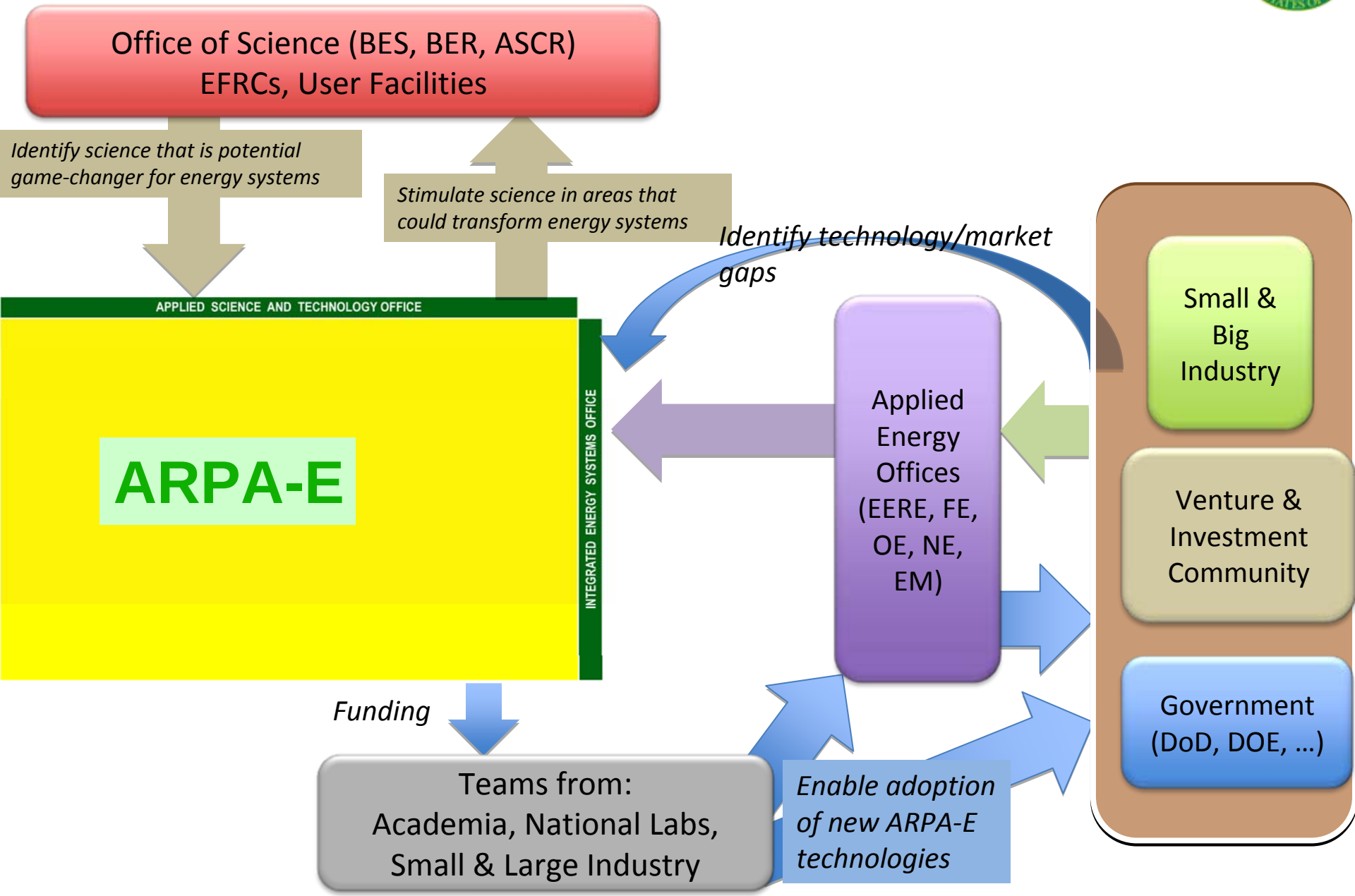
* The Deputy Secretary also serves as the Chief Operating Officer

26 May 09

ARPA-E Program Organization



ARPA-E Coordination within DOE & with Other Stakeholders



ARPA-E Organization

Director
Arun Majumdar

Deputy Director of Operations
Shane Kosinski

Operations Team

Chief Counsel
Bill Bierbower

Contracting Officer
Brad Poston

Budget Officer
Antony DiGiovanni

Program Team

Program Director
David Danielson

Program Director
Mark Hartney

Program Director
Eric Toone

……

ARPA-E Fellows Program

Commercialization & Stakeholder Engagement

Srinivas Mirmira-Com

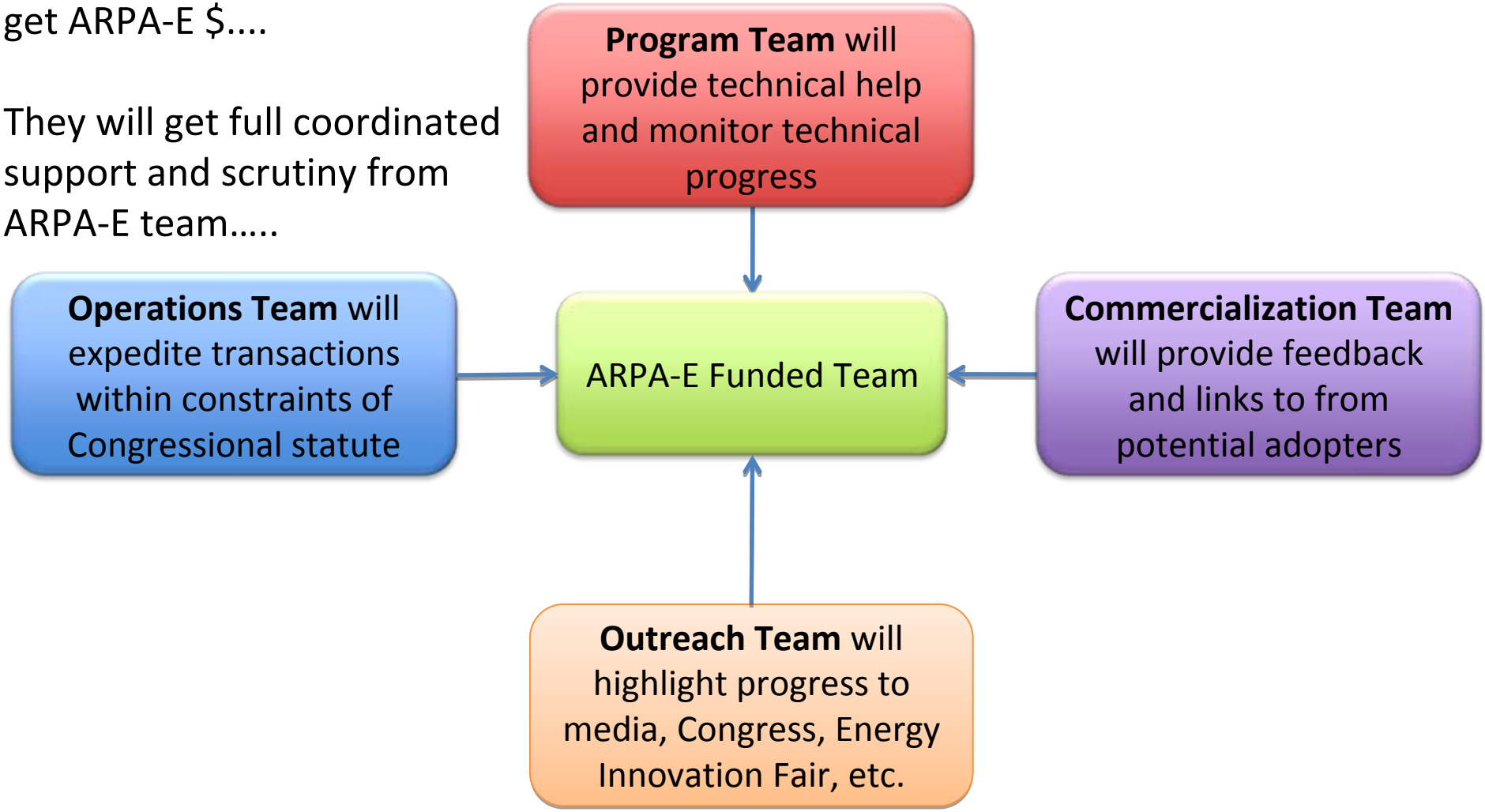
Shannon Barrett-Media

……

Value of ARPA-E Investment

The funded teams don't just get ARPA-E $....

They will get full coordinated support and scrutiny from ARPA-E team.....



Community Building & Outreach

- **ARPA-E Energy Innovation Fair (Early March)**
  - Annual Event in Washington DC
  - Purpose
    - Showcase ARPA-E technology innovations
    - Provide platform for PIs who did not get funded by ARPA-E to other potential investors
    - Build Community

- **ARPA-E Day on the Hill (Day before the Energy Innovation Fair)**
  - Explain our vision/mission and showcase ARPA-E technologies

- **ARPA-E -Venture Capital Day (Annual event)**
  - Identify strategies for leveraging
  - Identify strategies to accelerate scaling of ARPA-E technologies for market impact

ARPA-E Summary

- **3 "Sputniks" of our generation**
- **100→20: Pace & scale of innovation needed**
- **America's Strengths**
  - Best R&D Infrastructure; Best Entrepreneurship/Business Ecosystem; Most energized youth….
- **The ARPA-E Way**
  - Recruit and rotate best and brightest: All star team (including advisory committee)
  - Build on America's strengths & accelerate pace of innovation
  - Select game changing ideas and best teams
  - Organizational structure promoting collaboration and debate
  - Innovate on process (program creation, proposal review, transactions)
  - Openness: Keep stakeholders informed and engaged
  - Defined metrics of success

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First Challenge: Measured Performance

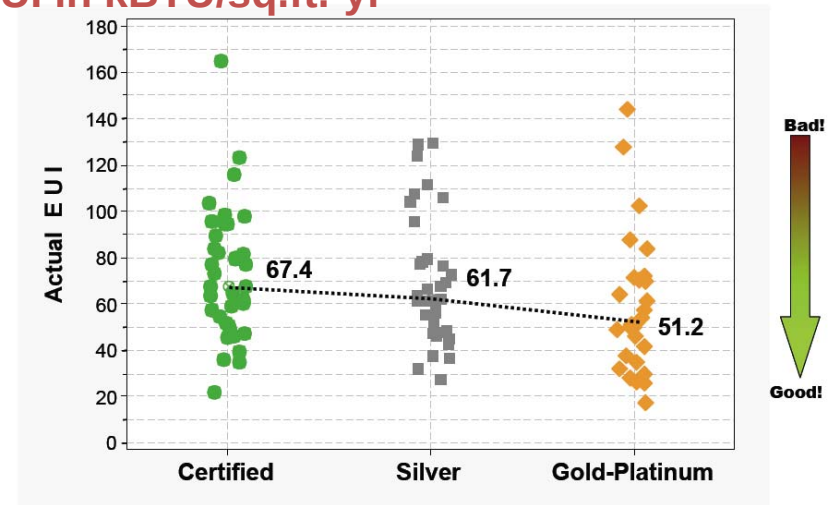
Analysis of 121 LEED-Rated Buildings

Low-to-Medium Energy Use Intensity Buildings

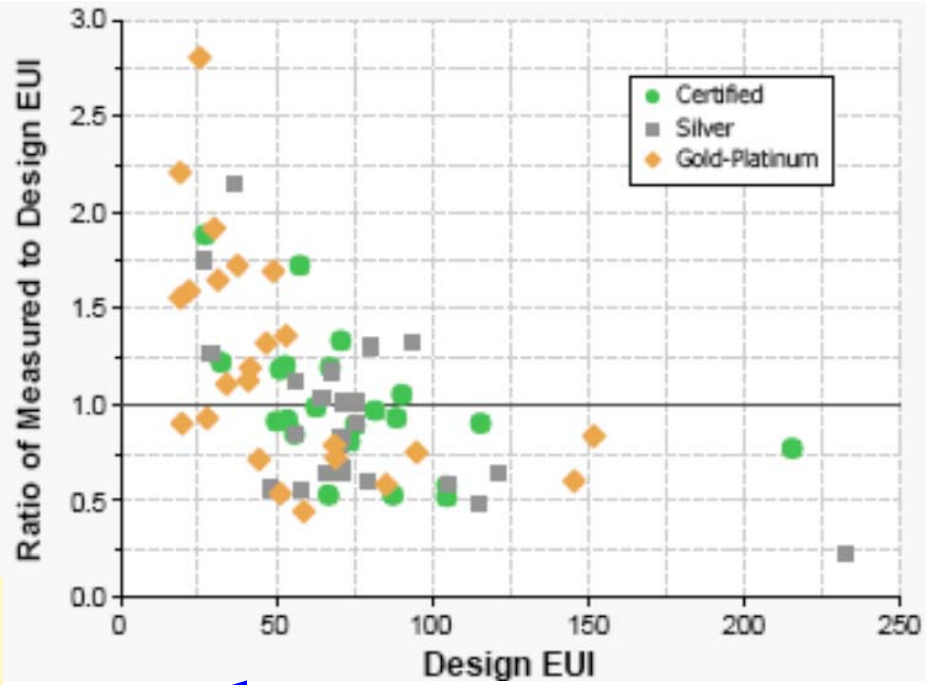
Building codes are for Design Performance, NOT based on Measured Performance.

The Spread

EUI in kBTU/sq.ft.-yr



Measured to Design Ratio



Gap

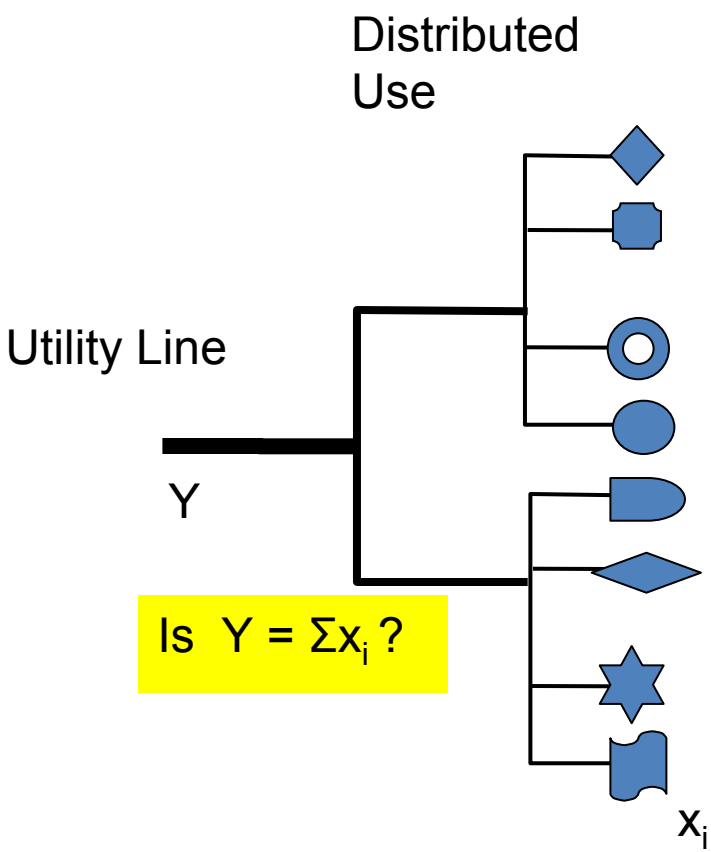
- Lack of Measurements & Policies Requiring it

Towards Zero-Net Energy

M. Frankel, "The Energy Performance of LEED Buildings,"presented at the *Summer Study on Energy Efficient Buildings, American Council of Energy Efficiency Economy*, Asilomar Conference Center, Pacific Grove, CA, August 17-22, 2008.

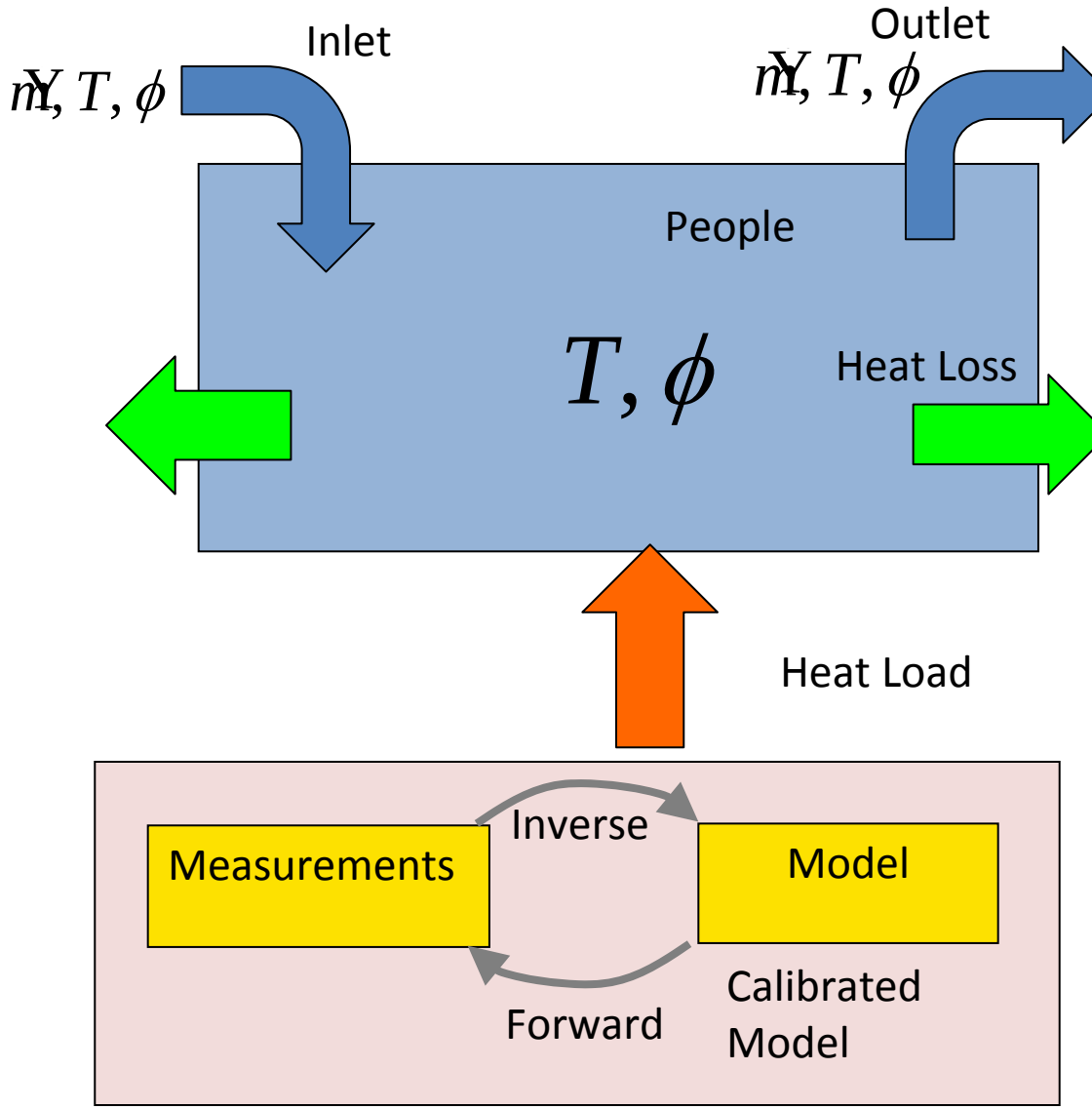
First Challenge: Measurements

Measurement Type I – Conservation Laws

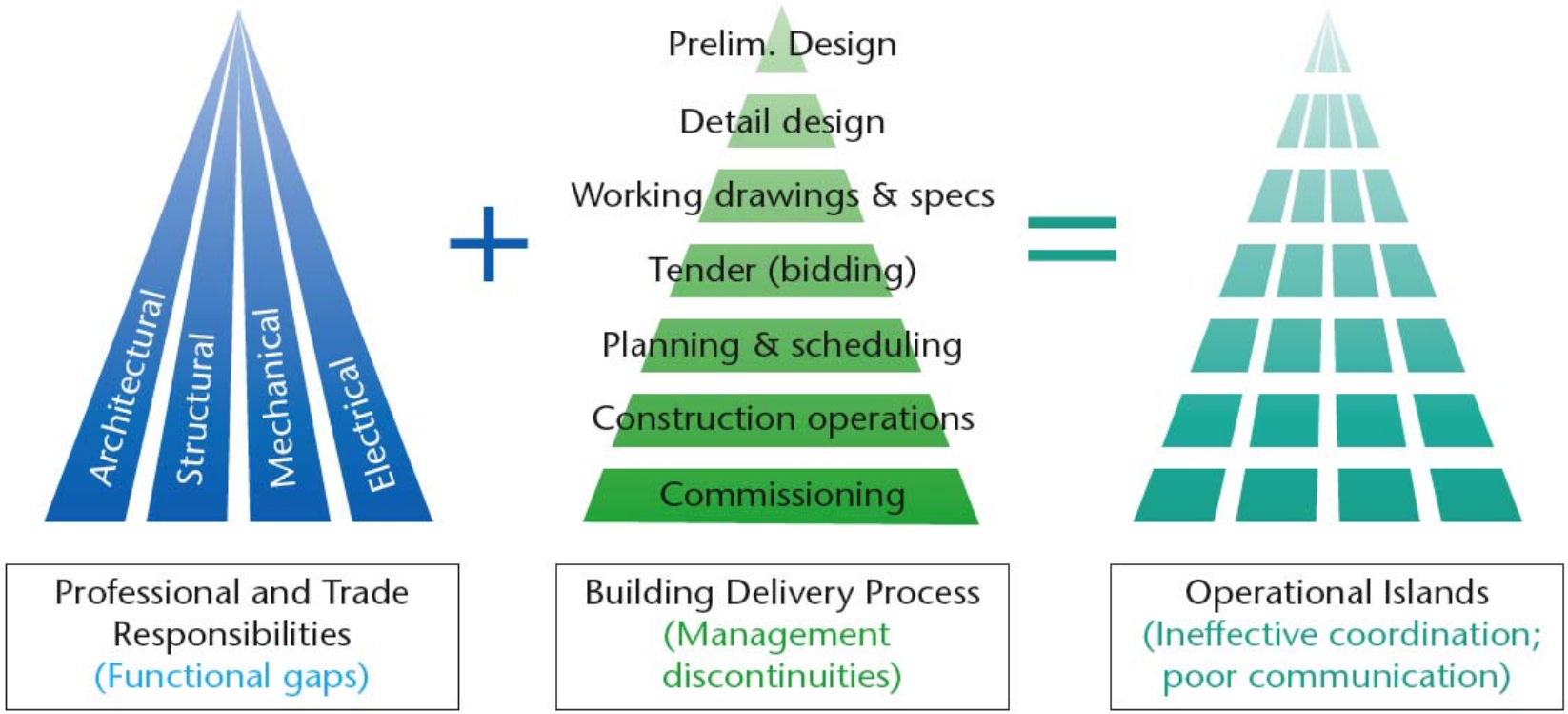


Is $Y = \Sigma x_i$?

Measurement Type II: Model Validation



Second Challenge: Fragmentation of Industry and Process



Need:

- Tools to integrate process & communities
- Tools to integrate building design and operations
- Align incentives

Courtesy: World Business Council for Sustainable Development (WBCSD) Report on Energy Efficiency in Buildings, July 2008

Heating and Cooling

- Innovations in thermal transport, storage, conversion devices that could make systems more efficient
- Waste heat recovery
- Spatial and temporal control of heating/cooling & ventilation
- ….

Breakout Sessions

- Measurement & Communication- I (Shyam Sunder) & II (David Culler)
- Simulation & Computation – I (Ron Judkoff) & II (Michael Wetter)
- Systems Approach to Fault Diagnostics and Controls – I (Scott Bortoff) & II (Srinivas Katipamula)
- Active and Passive Thermal Devices & Components – I (Ravi Prasher) & II (Sam Baldwin)

Workshop Output

- What is the state-of-the-art and where do we want to be?
- What are the gaps, challenges, barriers?
- What are the potential approaches to overcome barriers?
- What are the specific performance and cost metrics? What do we shoot for to make it the most compelling case in the absence of policy, finance, …?
- What is the time horizon for goals – short, medium, long?
- What are the challenges/barriers for validation and adoption?
- What level of investment do we need to develop these technologies? Deploy these technologies?
- What is the return on investment?