

Advanced Buildings Workshop

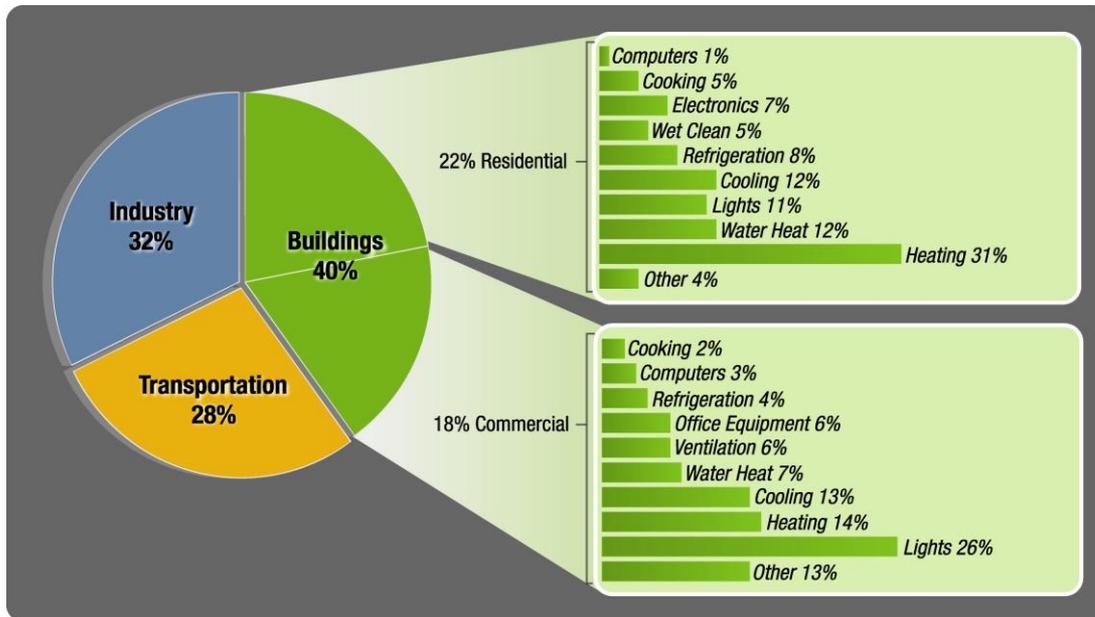
Jointly hosted by ARPA-E & EERE

Arun Majumdar
Director, ARPA-E

Tuesday, December 15, 2009

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

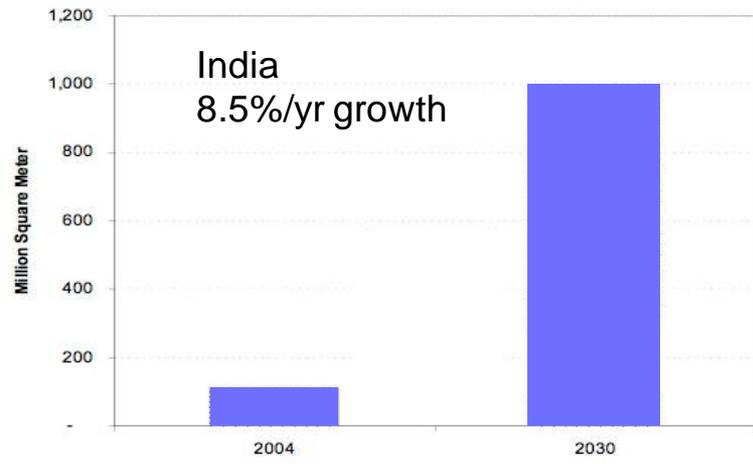
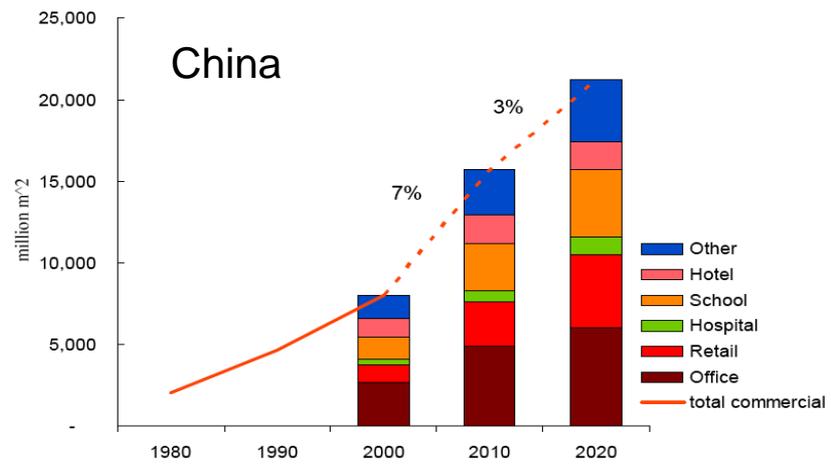
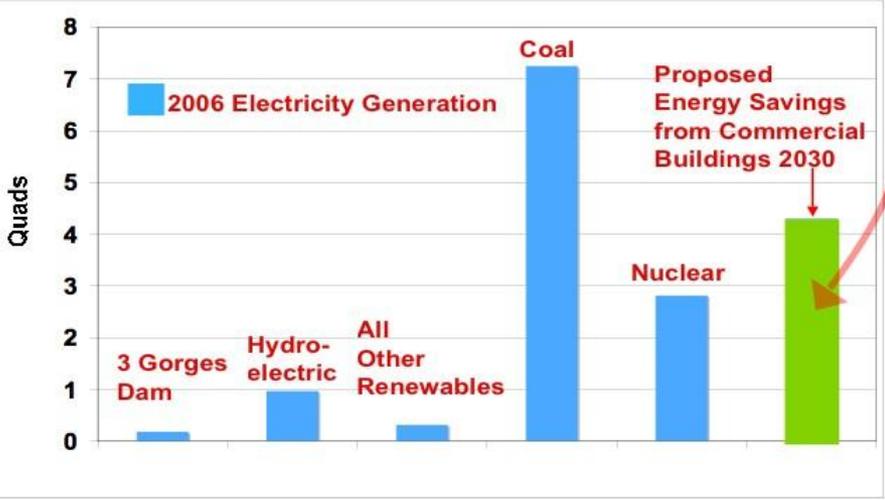
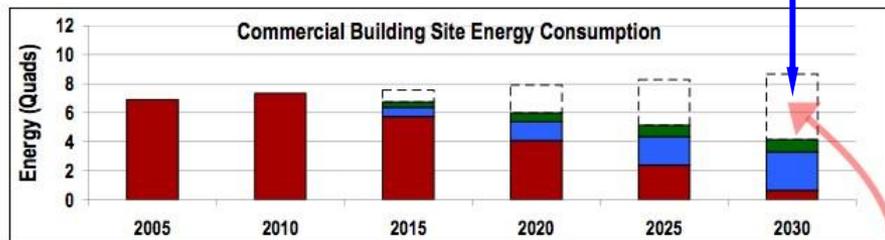
Buildings Can Provide Grid-Level Storage

The Opportunity

Zero Net Energy Commercial Buildings Initiative

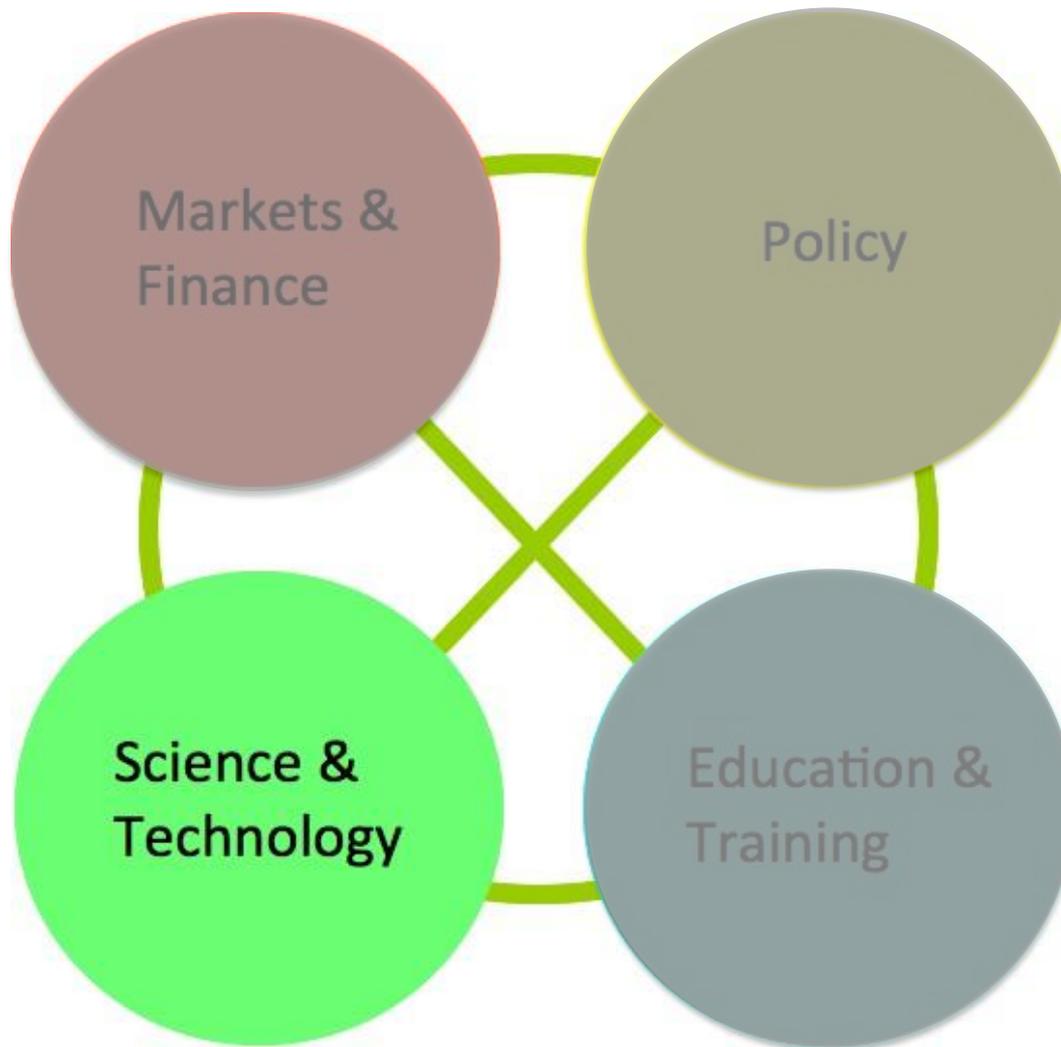
Energy Independence and Security Act of 2007

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
- National Science Foundation
- Dept of Commerce (NIST)
- White House (OSTP)
- General Services Administration

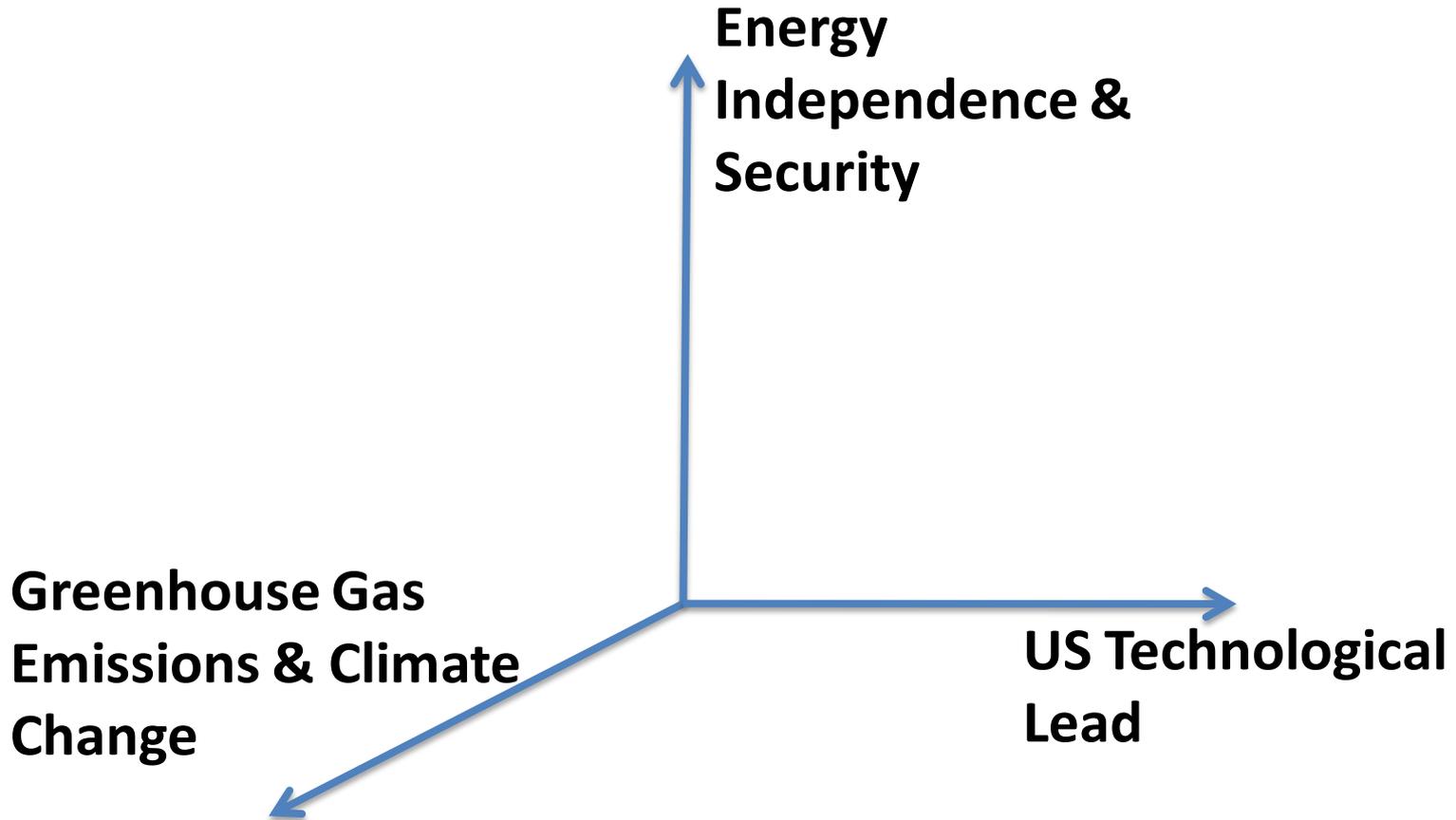
Key Challenges

- Systems integration
- Measurements

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



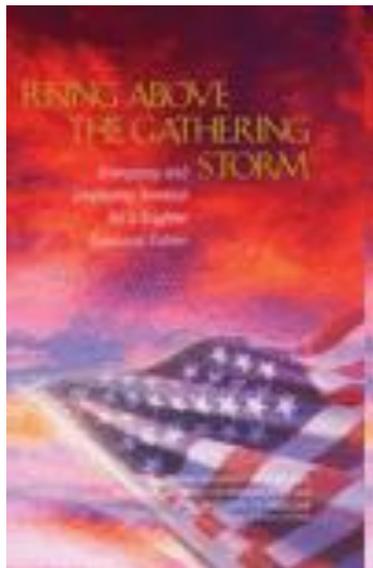
Game Changers from 20th Century

- 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**



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)

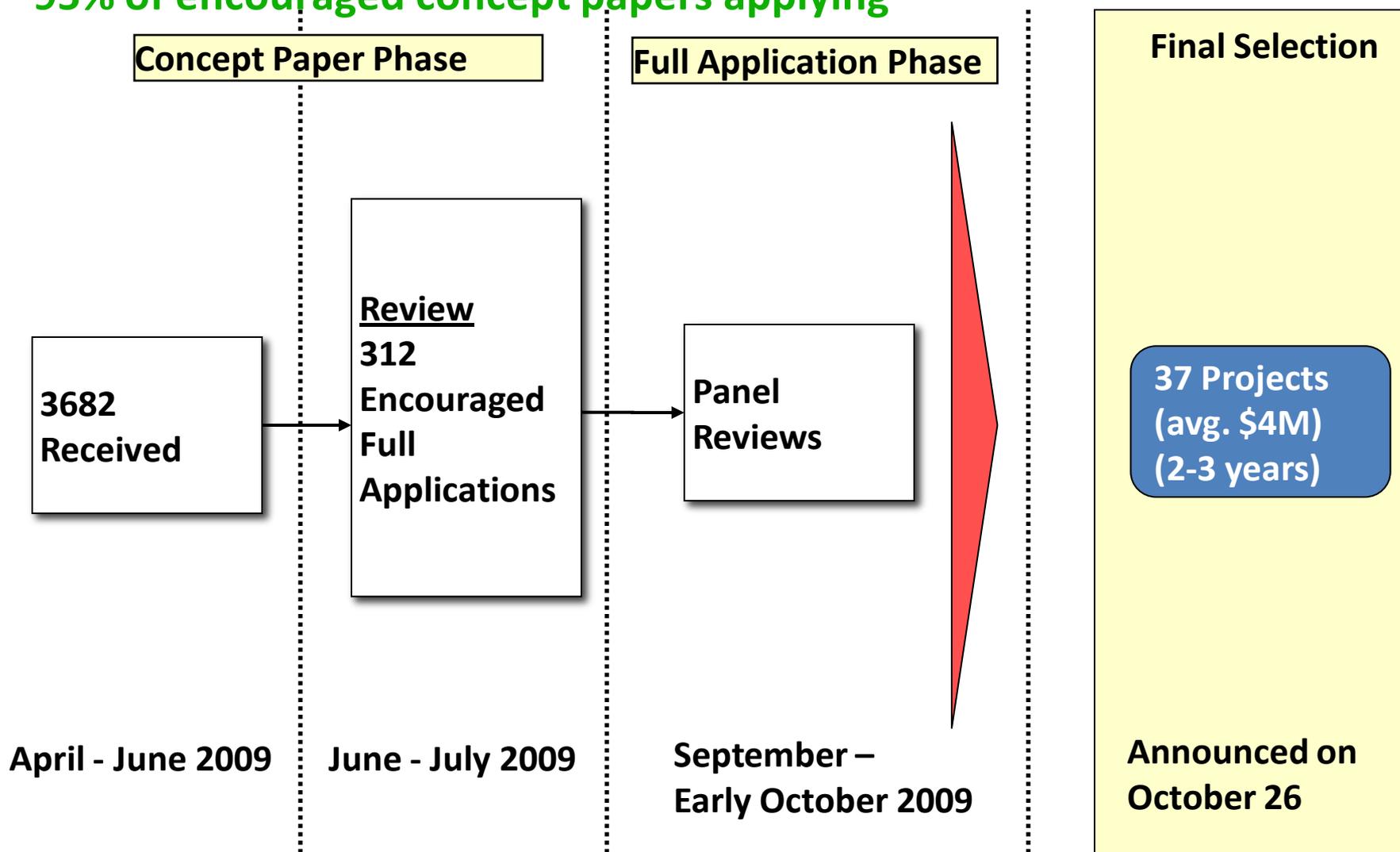
- \$400M provided for ARPA-E
- President Obama launches ARPA-E in a speech at NAS on April 27, 2009

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

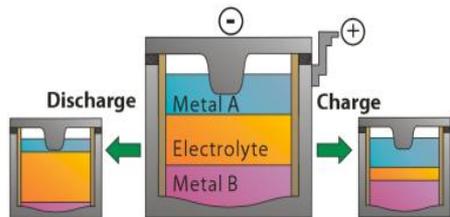
Ultimately 338 full applications were received and processed with 95% of encouraged concept papers applying



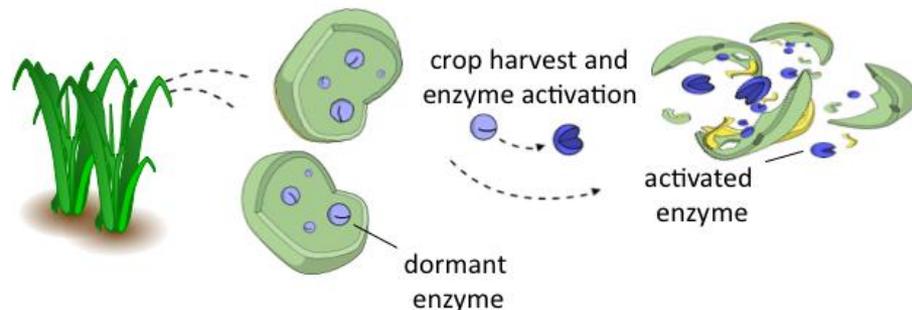
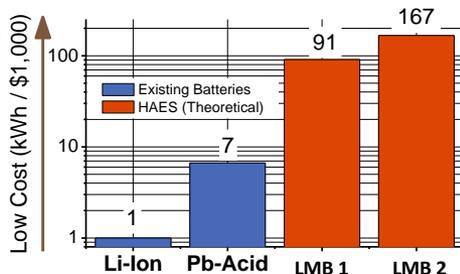
High Amperage Energy Storage Device: Energy Storage for the Neighborhood –MIT

Proposed Technology vs. State of the Art

A new approach: Liquid Metal Battery (LMB)



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

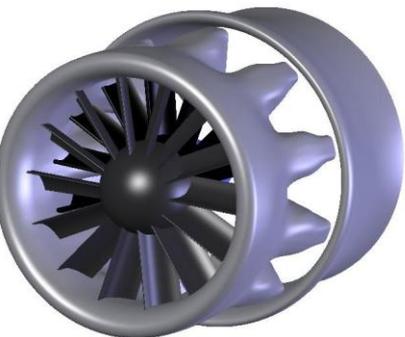


Trigger biomass breakdown using plants' own genes

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

FloDesign Wind Turbine Corp.

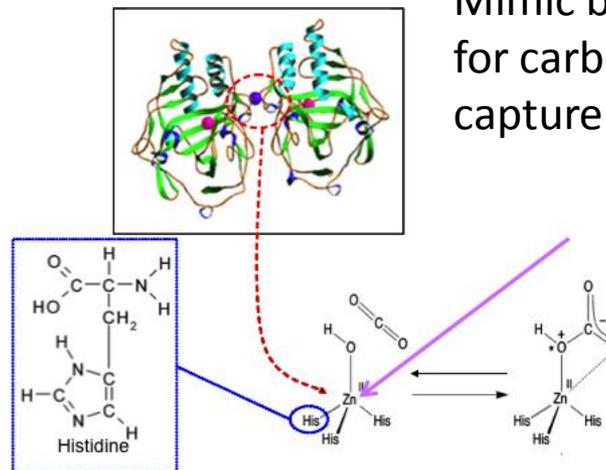
Proposed Technology vs. State of the Art



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

CO₂ Capture using a Synthetic Analogue of Carbonic Anhydrase - UTC

Mimic biology for carbon capture



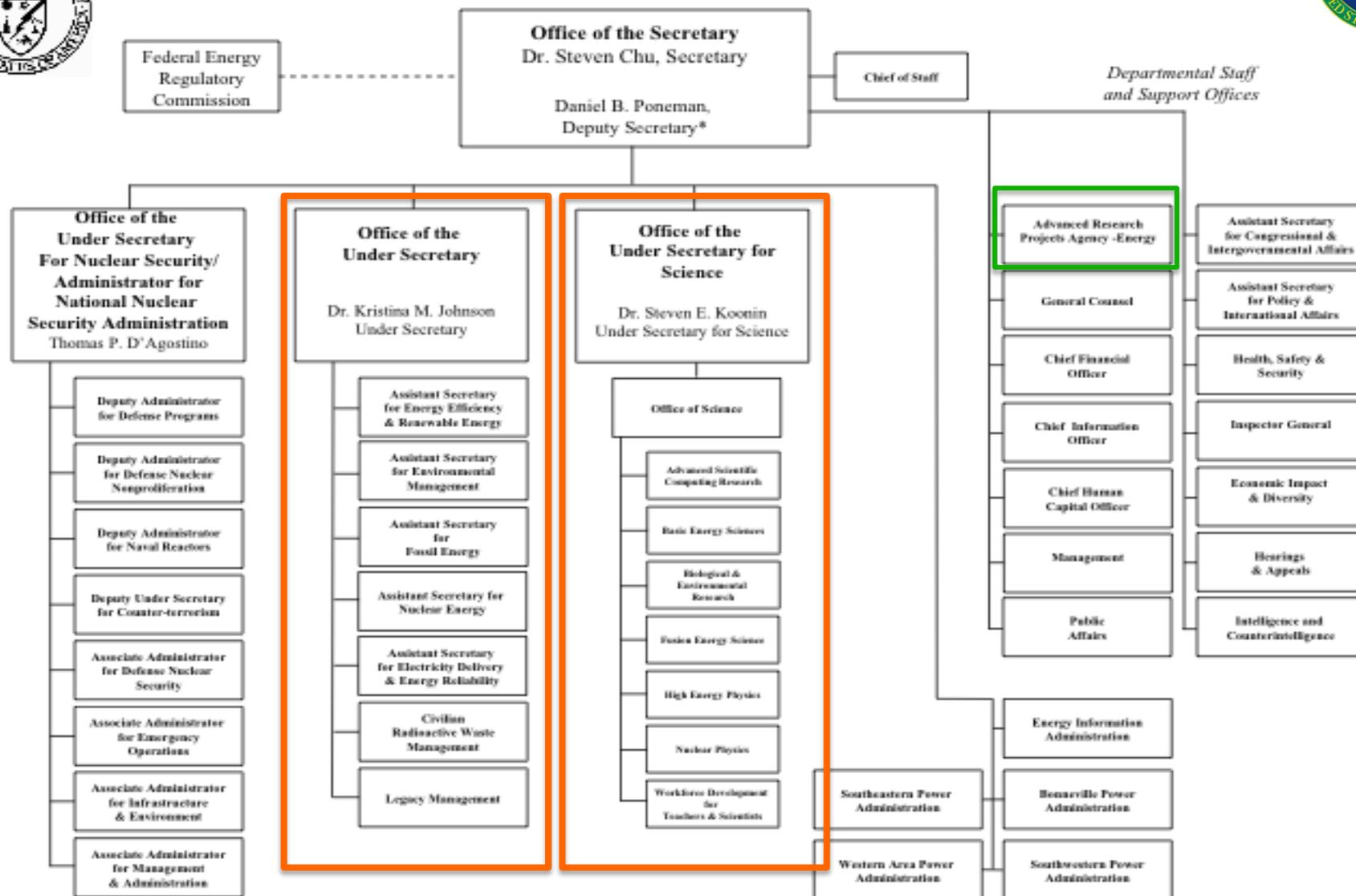
Second Round Funding Opportunities

Announced Dec 7, 2009

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

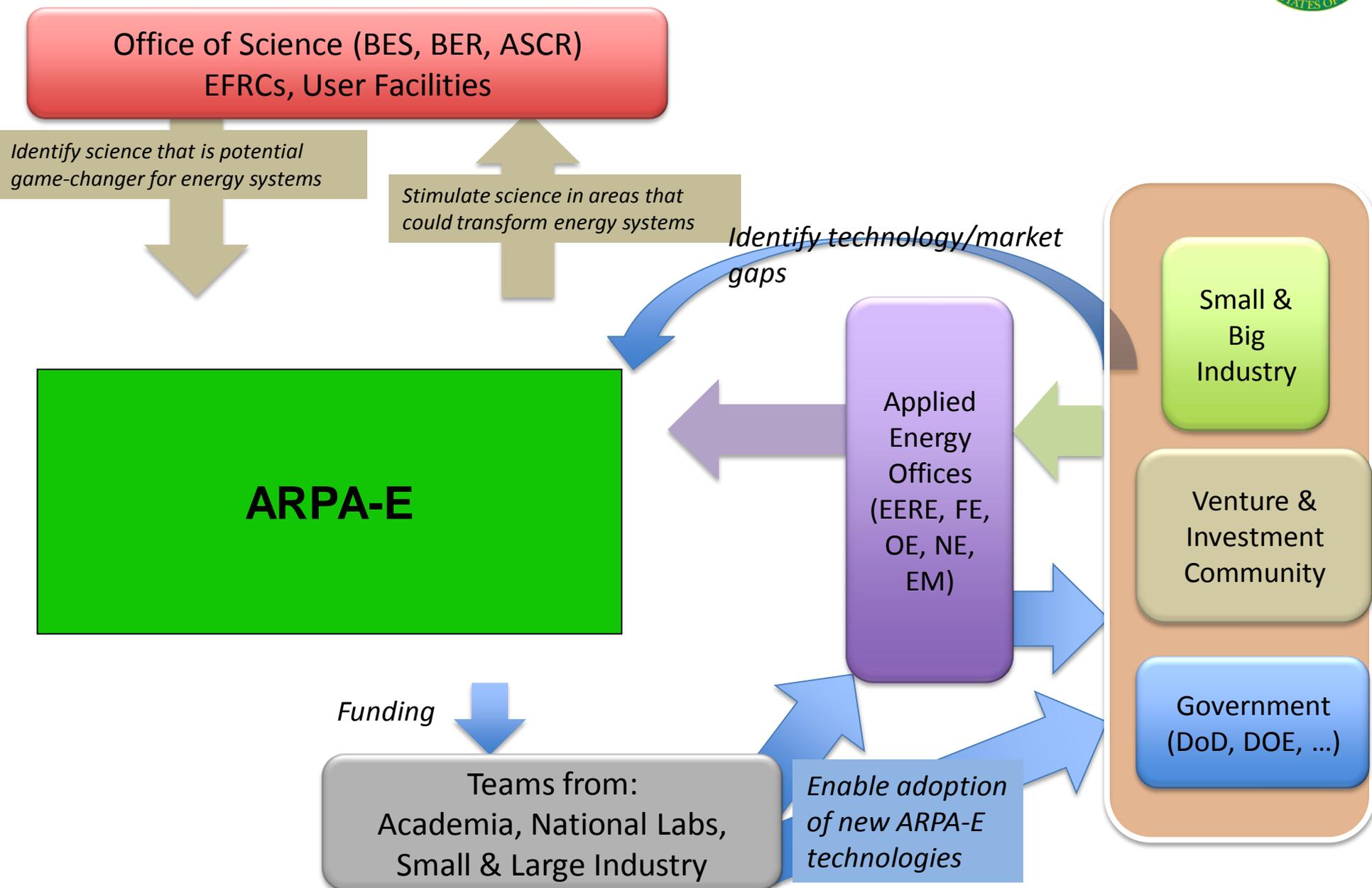


DEPARTMENT OF ENERGY



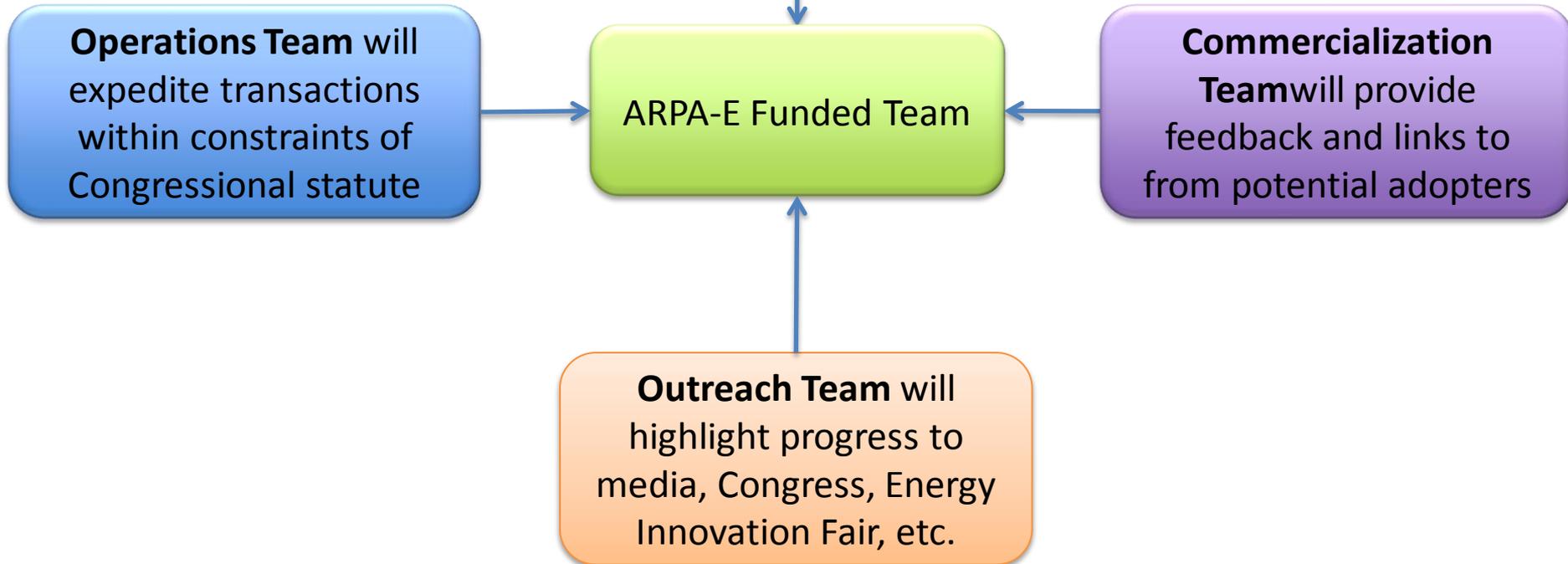
* The Deputy Secretary also serves as the Chief Operating Officer

ARPA-E Coordination within DOE & with Other Stakeholders



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

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



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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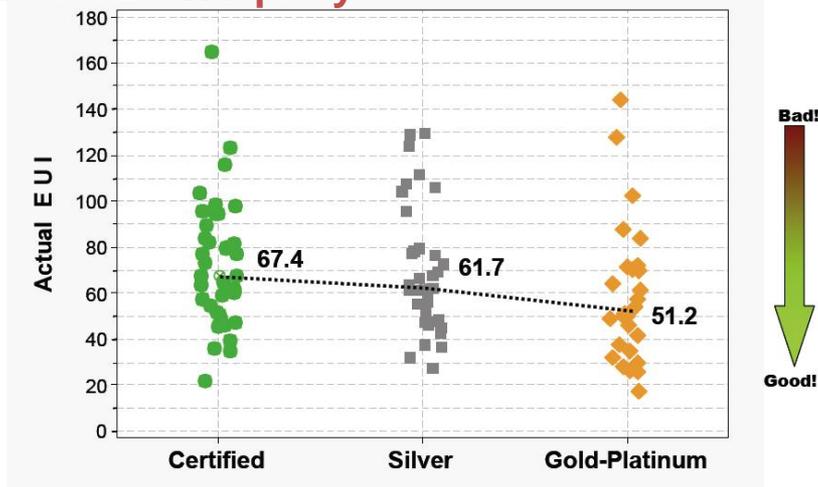
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Analysis of 121 LEED-Rated Buildings Low-to-Medium Energy Use Intensity Buildings

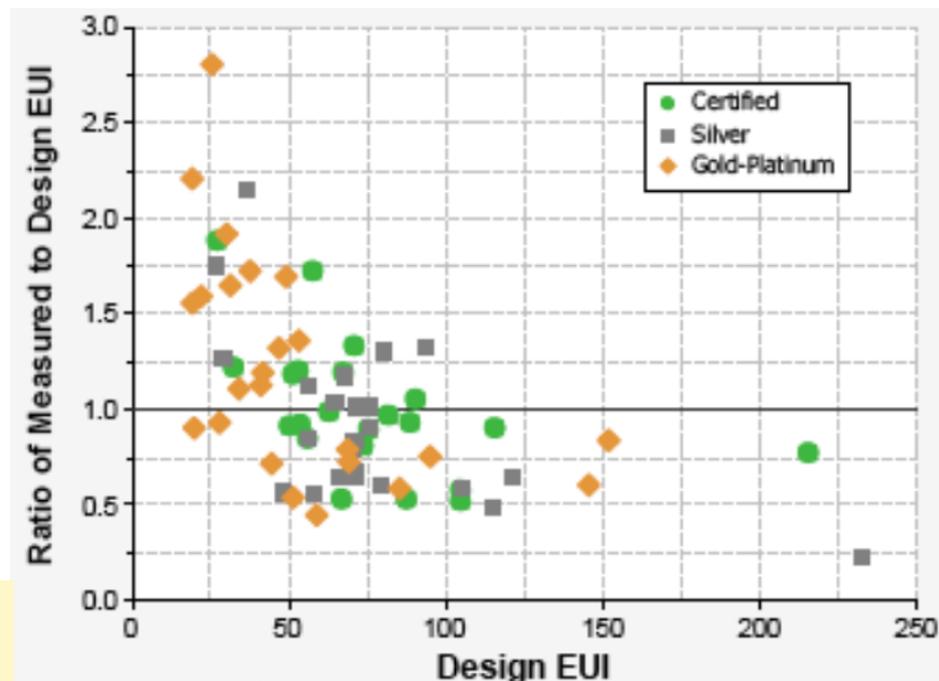
Building codes are for Design Performance, NOT based on Measured Performance.

The Spread

EUI in kBtu/sq.ft.-yr



Measured to Design Ratio



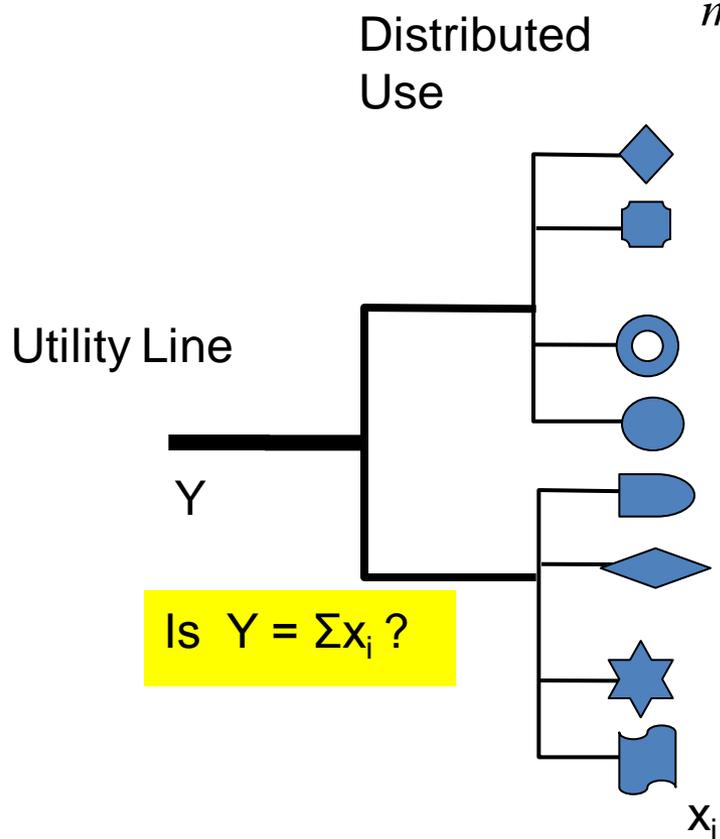
Towards Zero-Net Energy

Gap

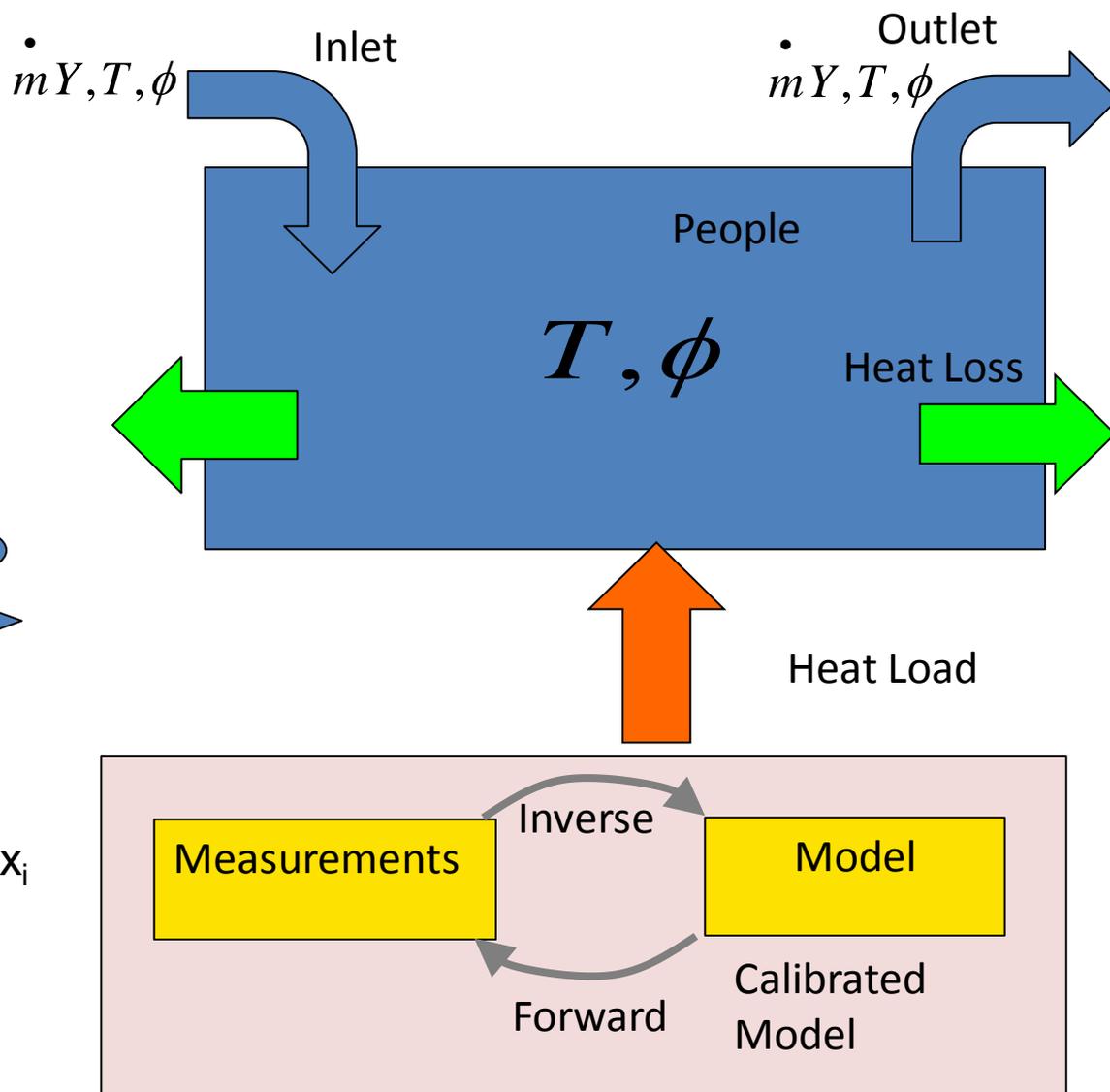
- Lack of Measurements & Policies Requiring it

First Challenge: Measurements

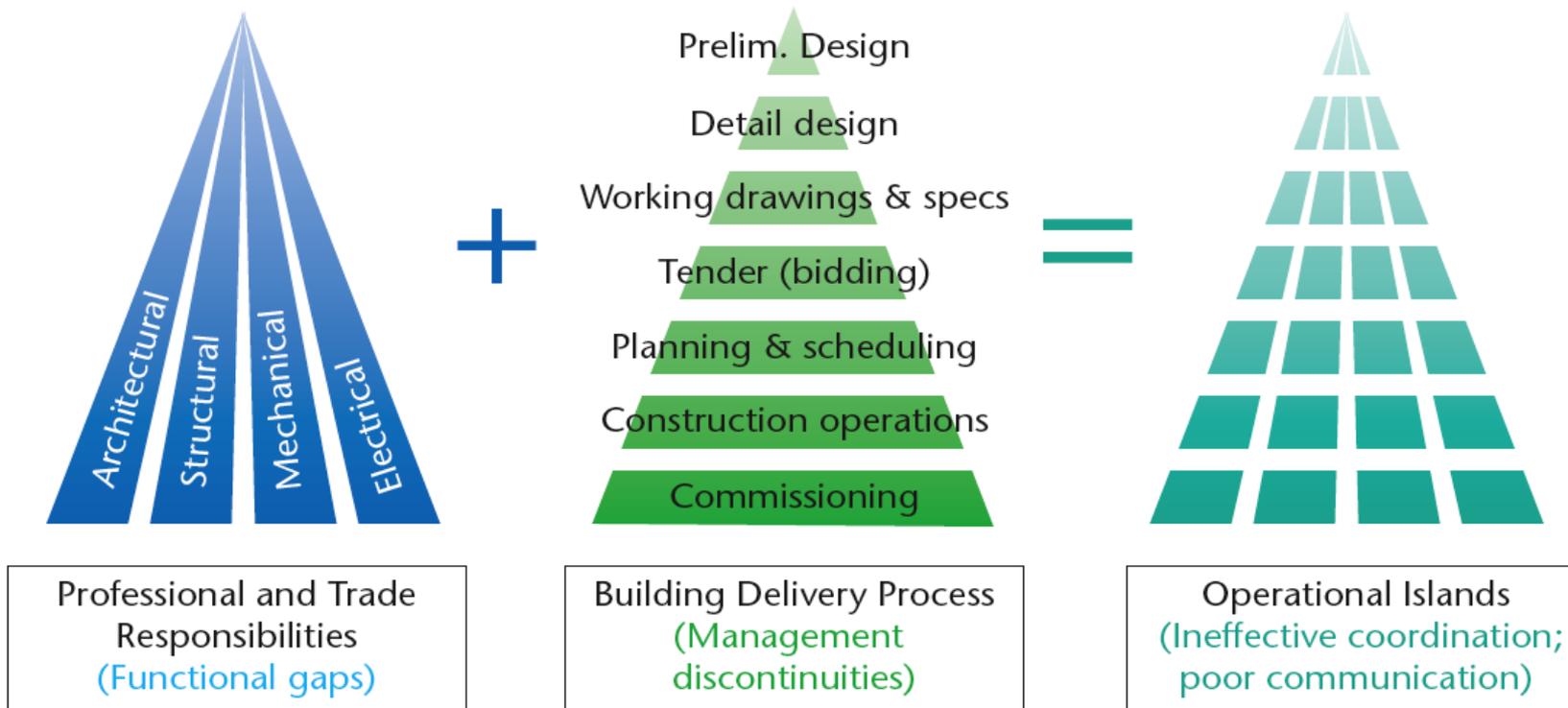
Measurement Type I – Conservation Laws



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

Breakout Sessions

- Measurement & Communication- I & II
- Simulation & Computation – I & II
- Systems Approach to Fault Diagnostics and Controls – I & II
- Active and Passive Thermal Devices & Components

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?

Post-Workshop 1-on-1 Session

- 20 min session with DOE (EERE/ARPA-E) program managers
- Ends at 10:30pm
- Can discuss approaches and ideas with DOE that cannot be discussed openly
- Location: Bar!!