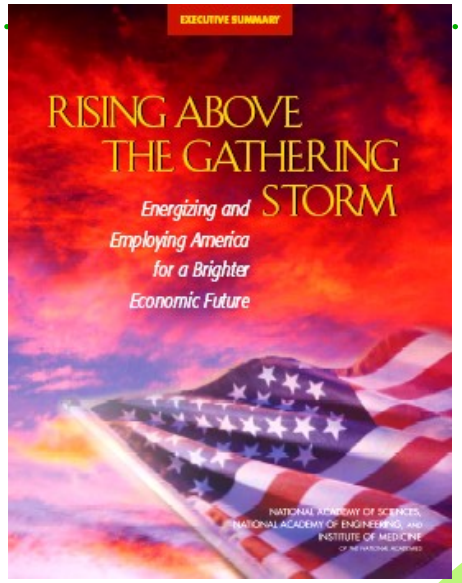
Overview of ARPA-E:
A New Paradigm in Energy Research

Eric Toone, PhD
ARPA-E Deputy Director of Technology

Role of Information Sciences and Engineering in Sustainability Workshop

February 3, 2011

Creation & Launching of ARPA-E



2009
American Recovery and Reinvestment Act
($400M appropriated for ARPA-E)

2007
America COMPETES Act

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

2006
Rising Above the Gathering Storm
(National Academies)

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

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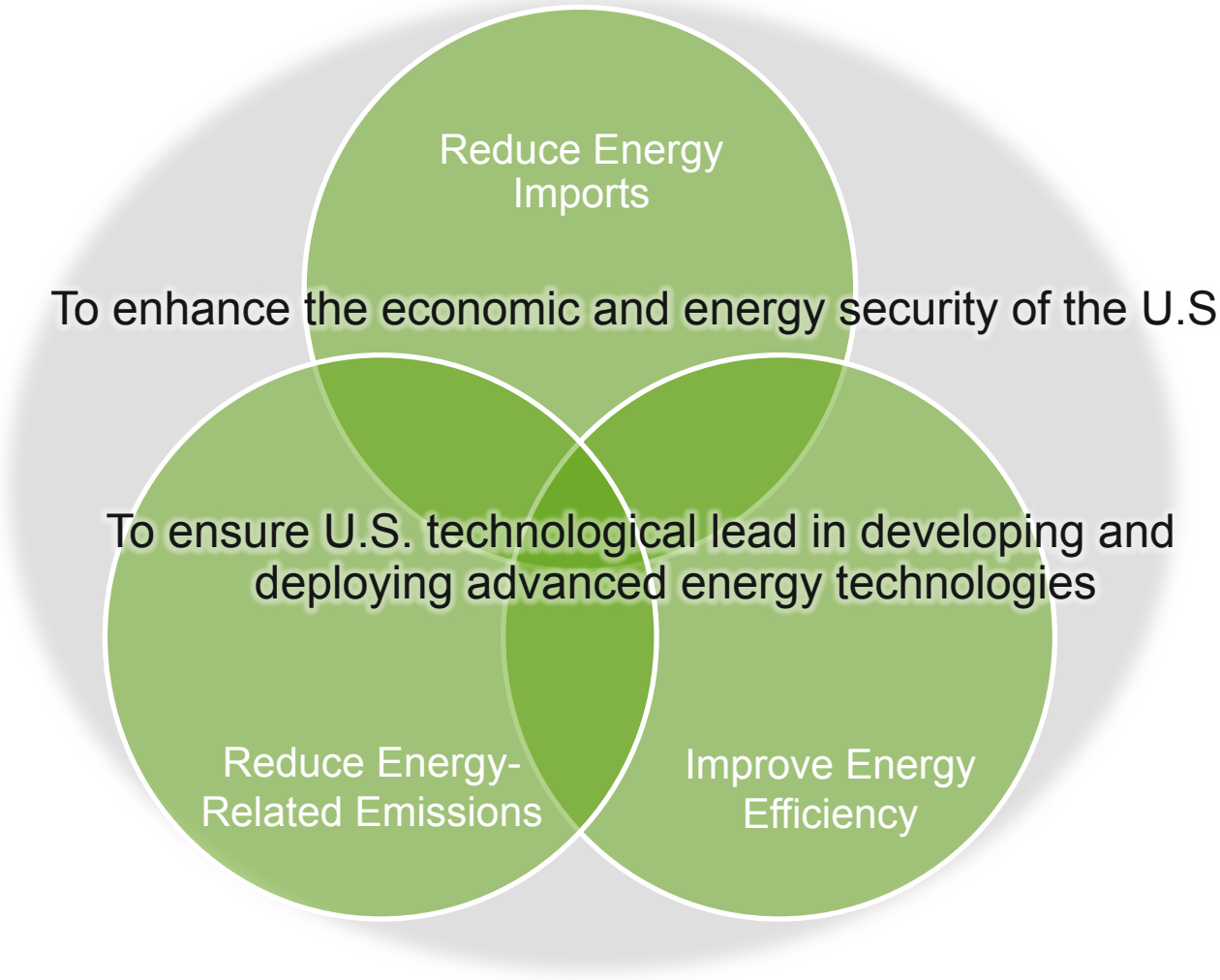
ARPA-E's Mission



What is an ARPA-E Project?

IMPACT

If successful, project could have:

- High impact on ARPA-E mission areas
- Large commercial application

BREAKTHROUGH TECHNOLOGY

Technologies that:

- Do not exist in today's energy market
- Are not just incremental improvements; could make today's technologies obsolete

ADDITIONALITY

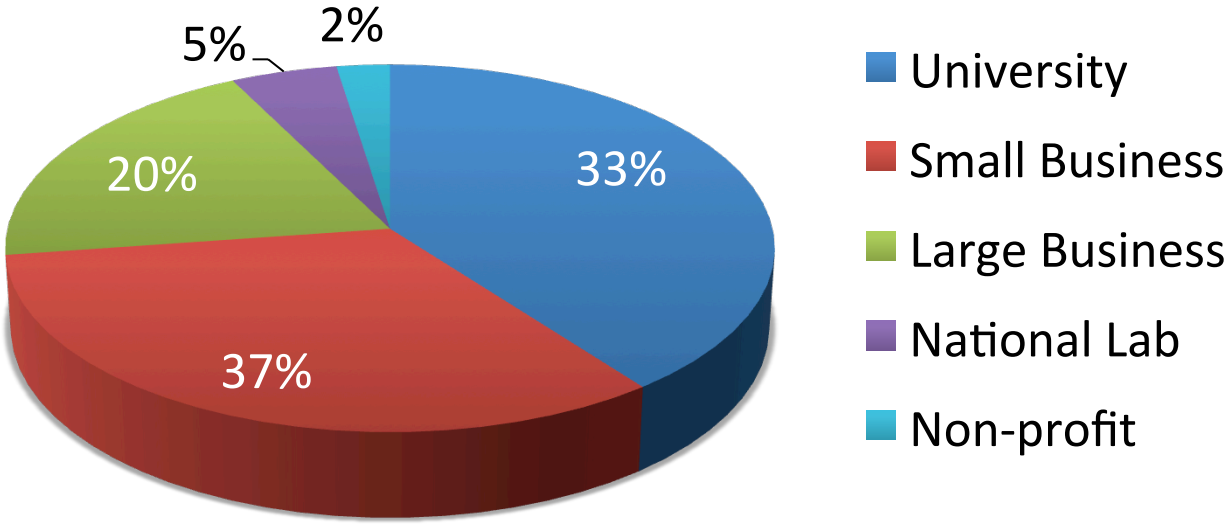
- Difficult to move forward without ARPA-E funding
- But able to attract cost share and follow-on funding
- Not already being researched or funded by others

PEOPLE

- Best-in-class people
- Teams with both scientists and engineers
- Brings new people, talent and skill sets to energy R&D

Funding Breakdown

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

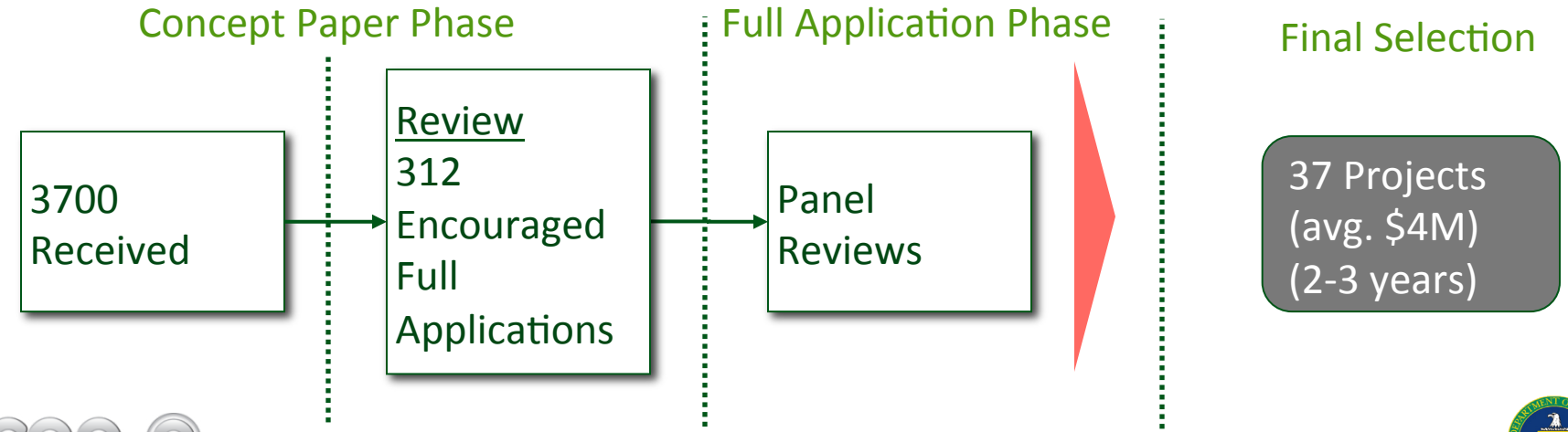


*Total Value of Awards = $357 million

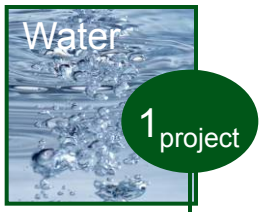
FOA Round 1

- ARPA-E's First Funding Opportunity
  - Announced April 2009, Selections Oct 2009
  - 3,700 proposals to 37 project selections ($151M)

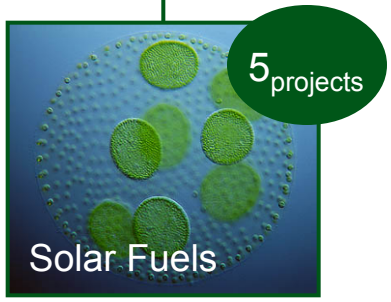
- As ARPA-E's inaugural program, this funding opportunity was open to all energy ideas and technologies, but focused on applicants who already had well-formed research and development plans for potentially high-impact concepts or new technologies



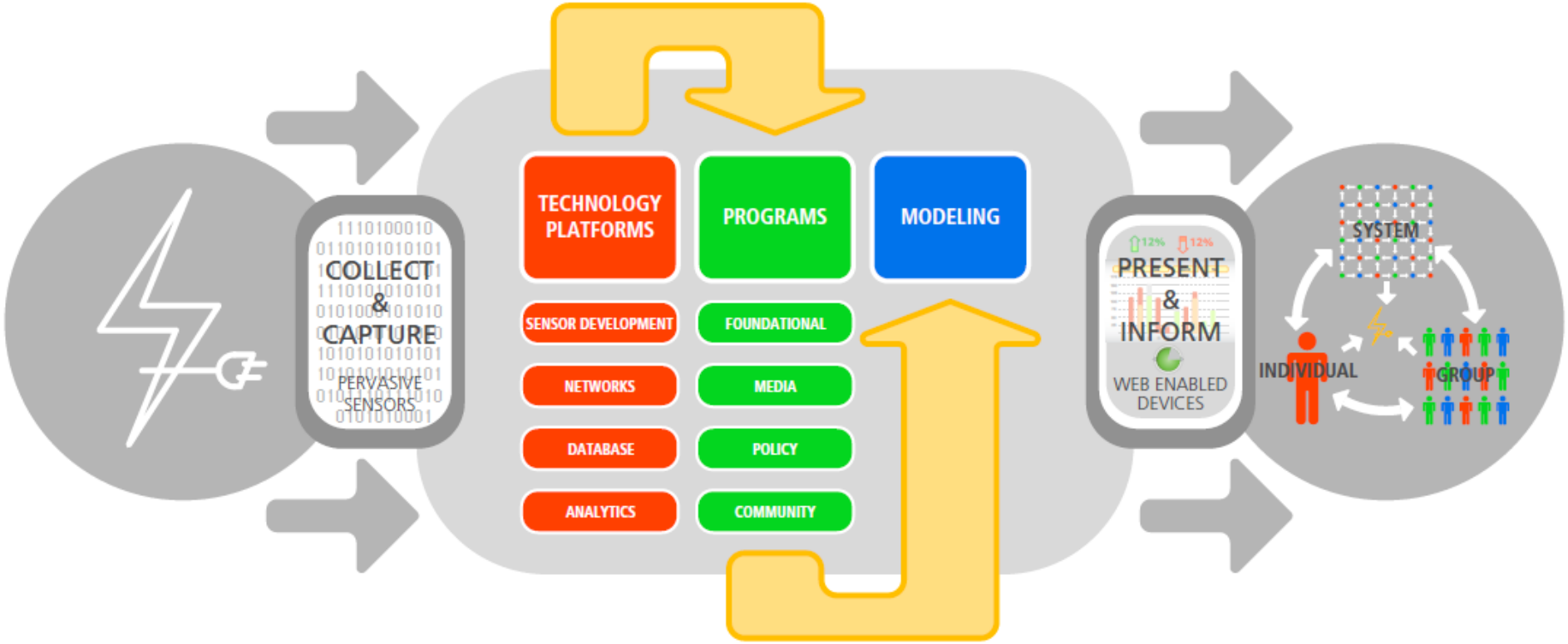
ARPA-E FOA 1 projects can be categorized into one of ten energy technology areas



FOA 1



Large-scale energy reductions through sensors, feedback, & information technology - Stanford University



Multidisciplinary project to improve the interface between humans and energy sensing technologies such as smart meters

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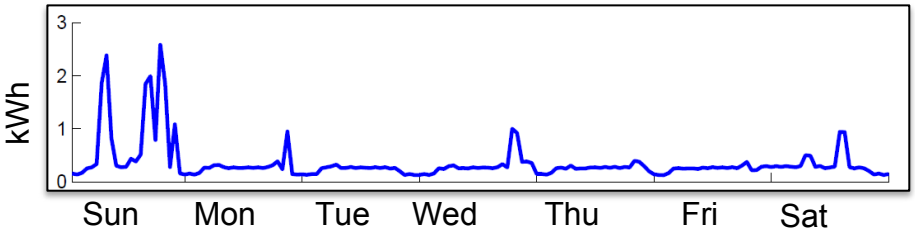
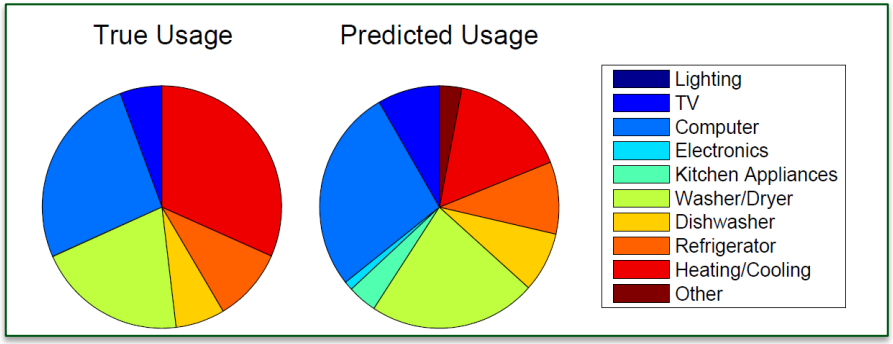
Examples of the research thrusts

Understanding human motivations to save energy

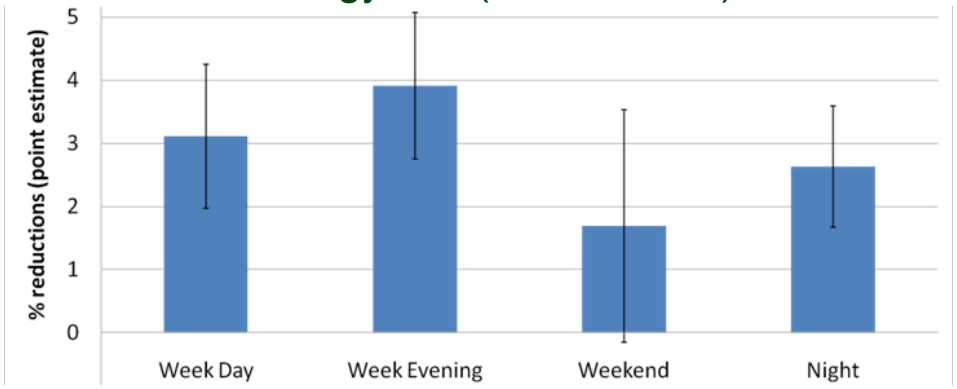
Improving disaggregation algorithms for appliance-specific feedback





Data from Plugwise

Quantifying effects of TED feedback on energy use (PowerMeter)



Data from Google

ARPA-E Programs

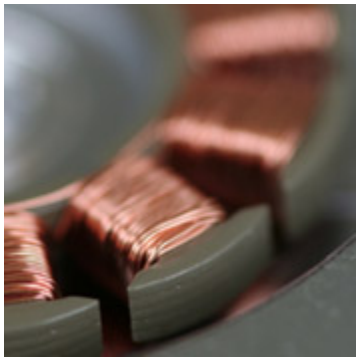
FOA1

Electrofuels

BEEST

IMPACCT

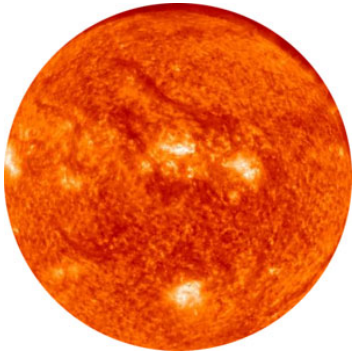
ADEPT



BEETIT

GRIDS

Electrofuels program seeks to address U.S. oil dependence more efficiently than other biofuels



Photosynthesis

Electrons/
Reducing equivalents

Biomass

Algae

Chemical Catalysis

Biological Catalysis

EtOH Advanced biofuels

Pyrolysis oils

Biodiesel Advanced biofuels

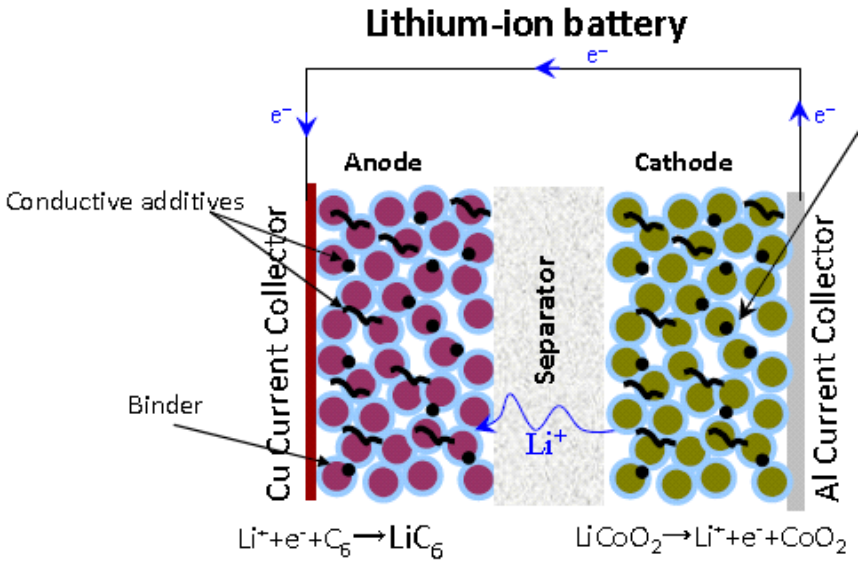
Syngas
CH_3OH
CH_4
Advanced fuels?

Advanced Fuels

Batteries for Electrical Energy Storage for Transportation (BEEST)

The Need: Development of novel battery storage technologies that enable U.S. manufacturing leadership in the next generation of high performance, low cost EV batteries.

System Level	Now	BEEST Goals	Multiple
Energy Density (Wh/kg)	100	200	2X
Cost ($/kWh)	1000	250	4X



Example areas of interest

- Advanced Lithium-ion batteries that exceed energy density of traditional Li-ion systems
- Li-sulfur battery approaches that address the low cycle life and high self-discharge of existing state of the art technology
- Metal air battery approaches that address the low cycle life, low power density, and low round trip efficiency of current approaches

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Innovative Materials & Processes for Advanced Carbon Capture Technologies (IMPACCT)

Capture	Transport	Storage
Post Combustion	Pipelines	Saline Aquifers
Oxy-fuel	Tankers	EOR
Pre Combustion		Deep Sea

~80% of CCS capital costs arise from the capture process

- ~25-30% parasitic power load on a coal-fired power plant
- Cost of Capture: $70-100/ton CO_2
- Levelized cost of electricity increases by ~80%

DOE's CO_2 Capture Goals:
35% increase in the levelized cost of electricity for 90% CO_2 capture

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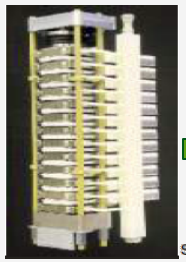
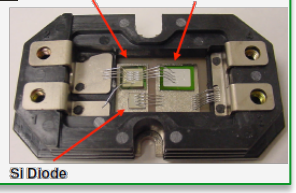
Agile Delivery of Electrical Power Technology (ADEPT)

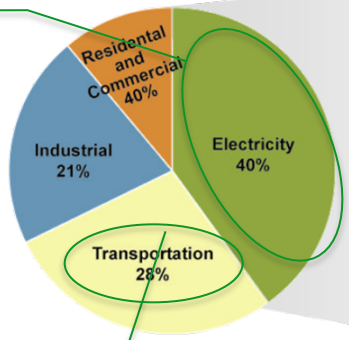
Distribution & Transmission



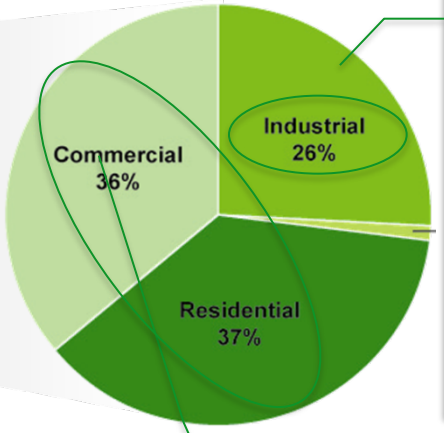
>13 kV, 50kHz SiC transistors



Primary Energy Use by Sector, 2008

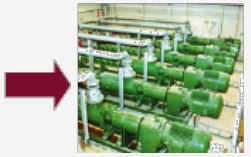


Share of Electricity Consumed by Major Sectors of the Economy, 2008



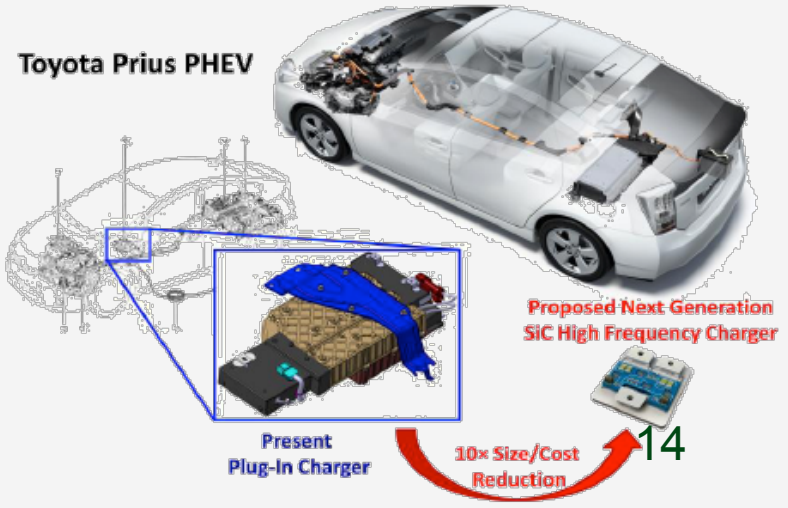
Industrial

Inverter drives motor



Automotive

Toyota Prius PHEV



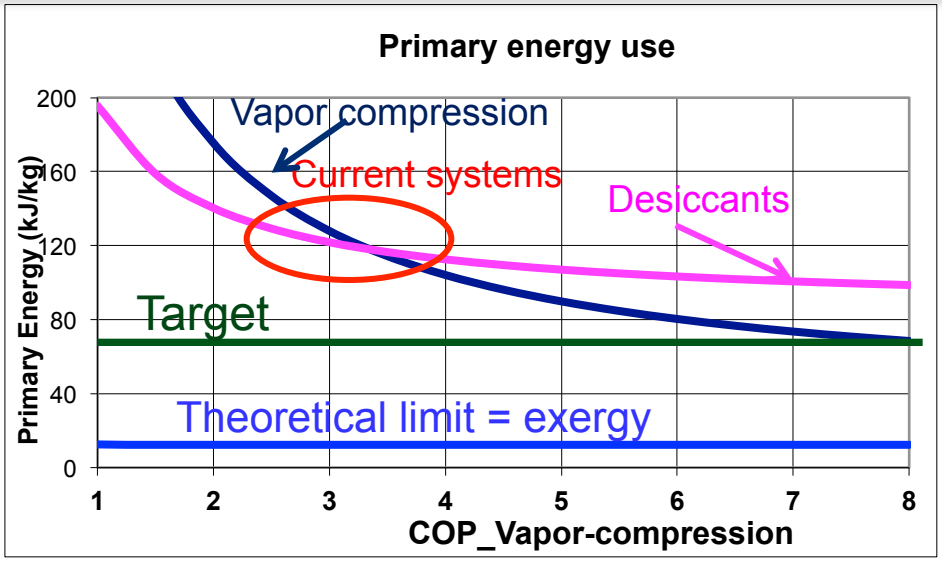
Lighting

Existing 25 W AC-DC SSL Driver

130 mm x 45 mm x 25 mm

300X reduction in power stage volume

Building Energy Efficiency Through Innovative Thermodevices (BEETIT)

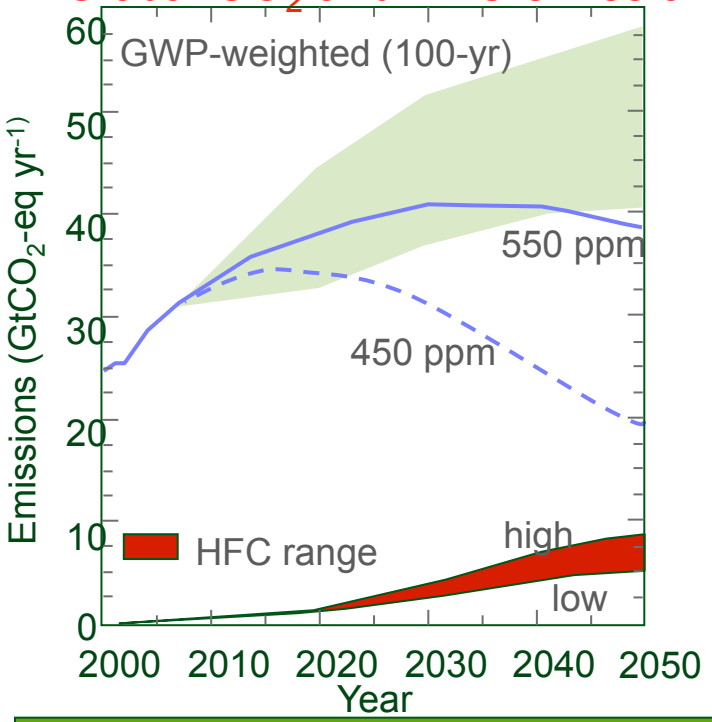


Theory Limit=cooling & gas separation

Reduce primary energy consumption by ~ 40 - 50%

- *Current refrigerants have GWP over 1000 x of CO_2*

Global CO_2 and HFC emissions

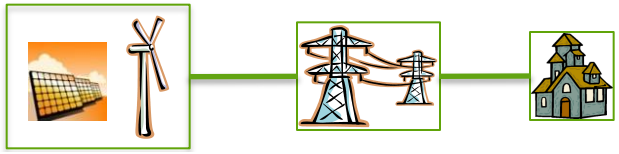


Achieve COP > 4 for GWP ≤ 1

Source: Velders et al, PNAS 106, 10949 (2009)

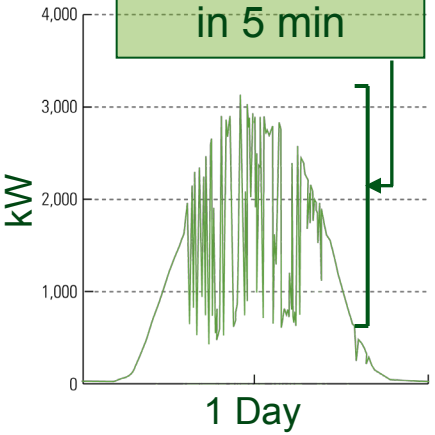
Grid-Scale Rampable Intermittent Dispatchable Storage (GRIDS)

Renewables Today



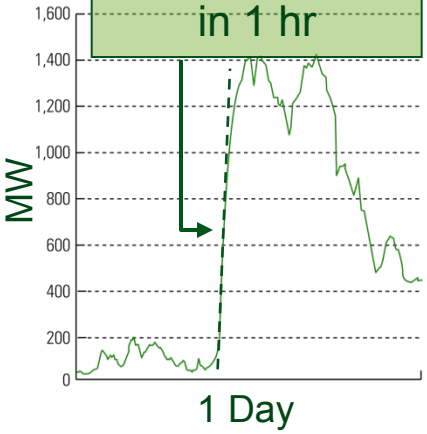
Solar PV in AZ (TEP)

80% Change in 5 min



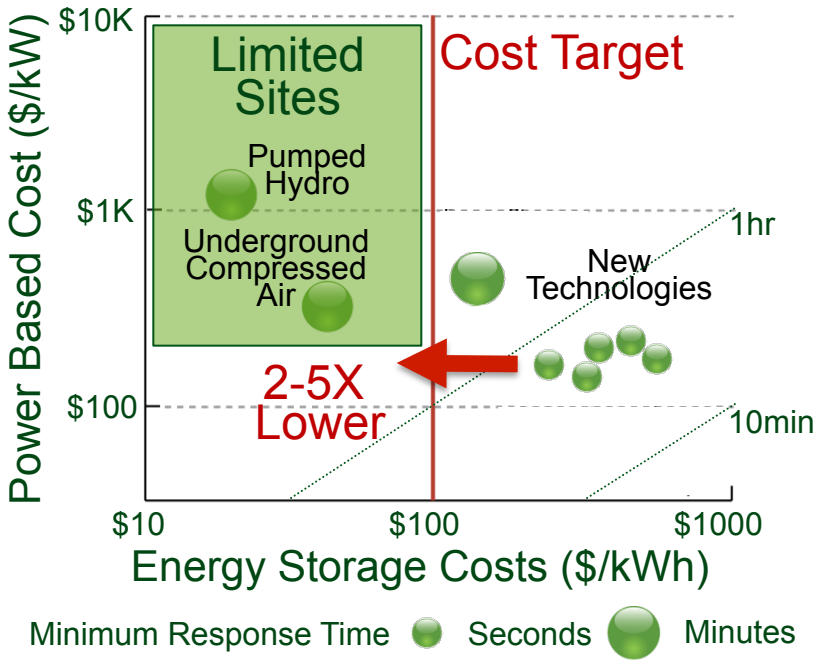
Wind in OR (BPA)

1 GW Change in 1 hr



Problem:
Minutes-to-Hours Changes in Power

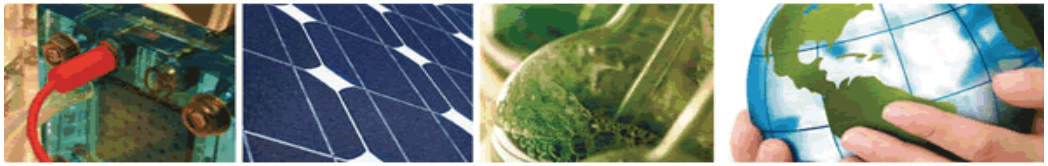
Storage for Renewables Tomorrow



Need: Innovative Technologies for Cost-Effective Energy Storage

Goal: Grid storage that is dispatchable and rampable
ARPA-E Focus: Transformational approaches to energy storage to enable wide deployment at very low cost

ARPA-E ENERGY INNOVATION SUMMIT
MARCH 1ST – 3RD, 2010
GAYLORD CONVENTION CENTER
WASHINGTON, DC



- 2 months preparation
- 1700 attendees
- Integrating relevant communities
  - *Scientists & engineers*
  - *Technology entrepreneurs*
  - *Other DOE Offices and federal agencies*
  - *Investors*
  - *State and regional clean tech incubators*
  - *White House, Congress and policy makers*

Technology Showcase

- *ARPA-E Funded technologies; AND*
- *Finalists that ARPA-E could not fund*

Feb 28-March 2, 2011

Washington, DC

arpa·e Energy Innovation Summit

Supporting America's Breakthrough Energy Innovators

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