

# Research Overview: Environmental Energy Technologies Division, LBNL

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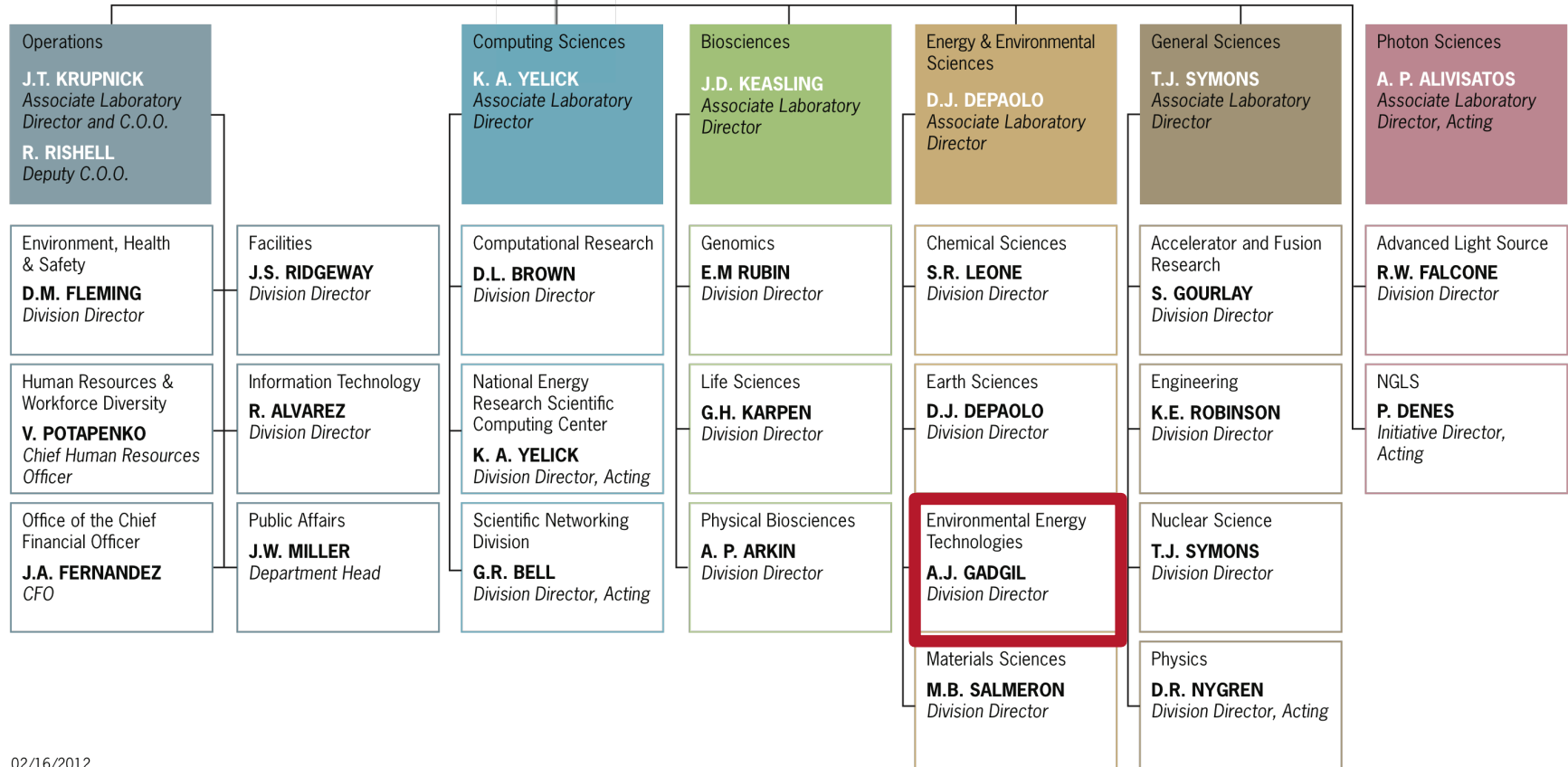


# Lawrence Berkeley National Laboratory 2013

\$800M budget, 4000 employees, 16 research divisions

## Lawrence Berkeley National Laboratory University of California

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# EETD Vision



To be a global innovation hub for science, technology, and policy solutions to the world's most critical energy and environment challenges

# EET Division Profile

- Largest research division at LBNL
- About 12% of Lab in budget; 15% in staffing
- Total staff and visiting researchers
  - 2009: ~390; 2010: ~470; 2011: ~600
- Total funding 2012: \$98M
- 96 research sponsors
- Multidisciplinary research staff includes 94 principal investigators: architects, electrical engineers, mechanical engineers, physicists, chemists, chemical engineers, economists, policy analysts
- Draws on students and recent graduates from UC and other academic institutions for postdoctoral appointments and research assistants
- Some joint appointments at UC Berkeley and UC Davis campuses

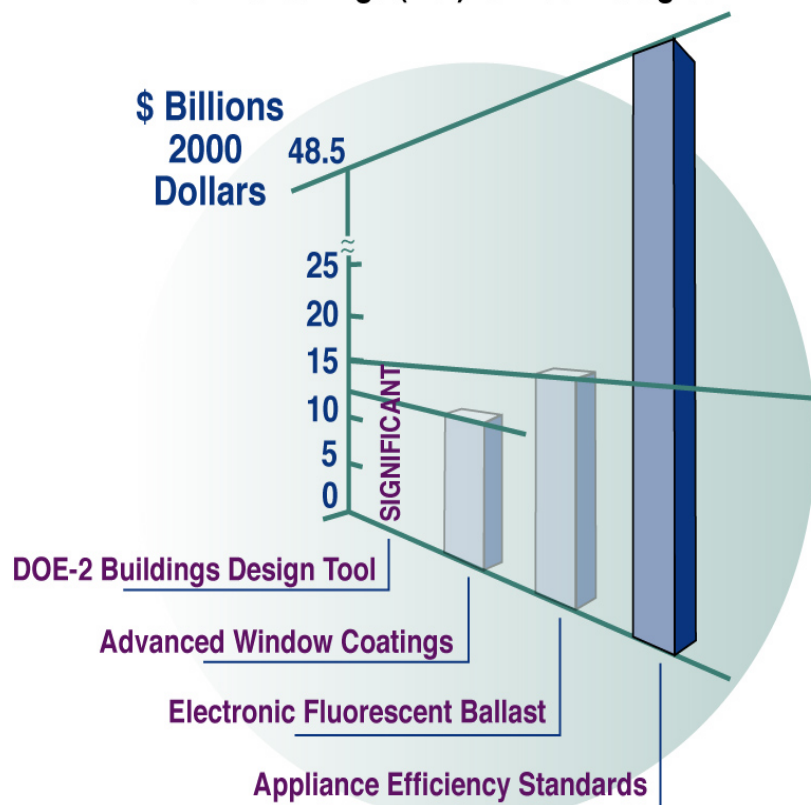


# Prior Impacts of EETD's Efficiency R&D

From National Academy of Sciences Report (2001)\*

## Estimate of Economic Benefits

Lifetime Savings (Net) for Technologies\*



NAS estimate of economic benefits of EE R&D assigns \$23 of \$30 billion in savings to LBNL - derived technologies

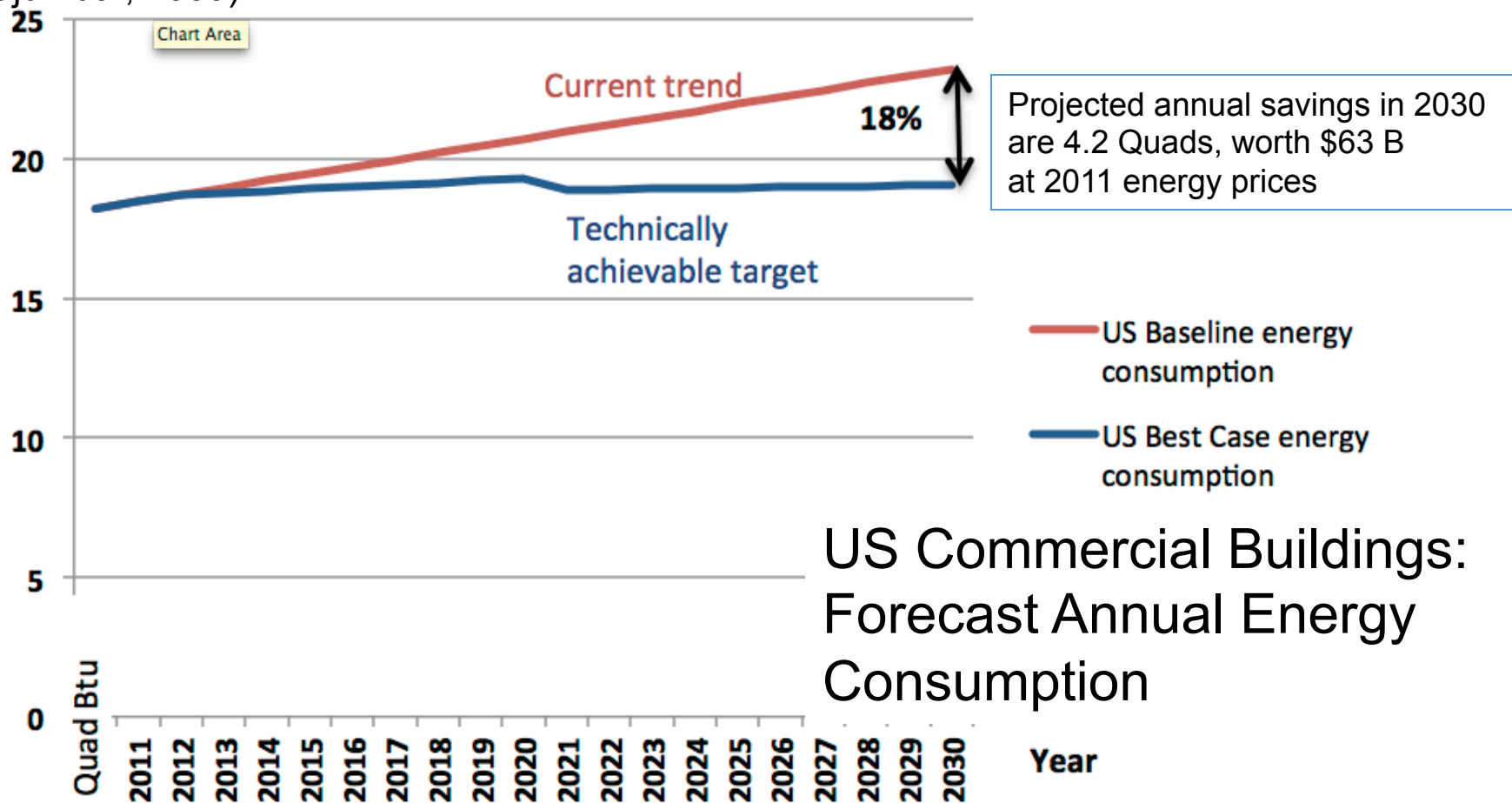
Additional \$48 billion in savings from energy efficiency standards for 9 residential products

*Primary Energy Savings*  
**= 9% of 2025 residential energy use**  
*Carbon Reductions in 2025*  
**= 132 million metric tons CO<sub>2</sub>/year**

# Future Potential Impacts of EETD's Energy Efficiency R&D

## One example: U.S. Energy Use in Commercial Buildings

Buildings use 40% of all US energy and 70% of all US electricity — highest of all sectors, and increasing faster than others (Coffey, 2009; Majumdar, 2009)



# EETD Values and Mission Areas

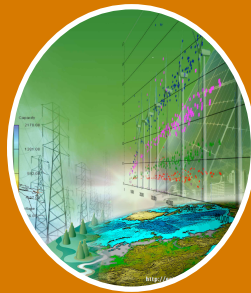
Values

Scientific Integrity  
Innovation  
Impact  
Sense of Urgency  
Collaboration and Partnership

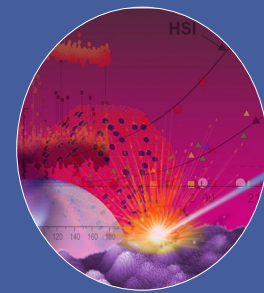
Mission Areas



Buildings and Urban  
Systems



Energy Analysis &  
Environmental Impacts



Energy Storage and  
Distributed Resources

# Major EETD Research Areas

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Highlights



# Building Technologies

**Commercial Buildings:** Advanced Commercial Building Systems & Simulation Research • Demand Response • Commissioning, Fault Diagnostics & Energy Information Systems • High Technology Buildings  
**Building Technologies:** Cool Roofing Materials & Urban Heat Islands • Windows, Daylighting & Lighting Controls • Modeling & Simulation of Building Energy & Control Systems • Building User Test Beds • HES-Pro

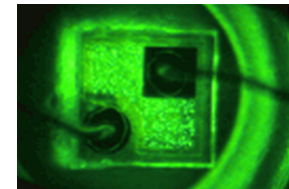
DEMAND RESPONSE

DRRC  
Demand Response Research Center



CLIR  
CLIENT & LOGIC WITH INTEGRATED RELAY

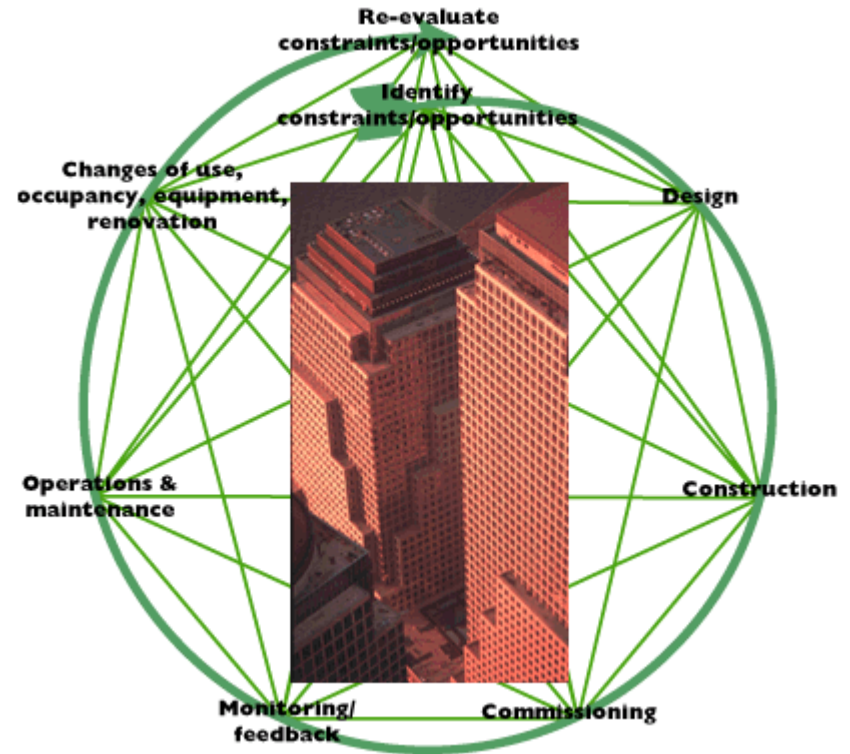
et  
EnergyPlus



# Energy Efficient Building Systems

*Enable energy efficient buildings with comfortable, healthy and productive environment*

- Major Program Areas:
  - Integrated commercial and residential research
    - Smart controls
    - Technologies (windows, HVAC, lighting, etc.)
    - Software tools
    - Deep energy retrofits
  - Cool Roofs and engineered surfaces
  - Human behavior impacts on performance
  - Collaboration with overseas partners
  - Technical assistance, education and training



## Major New Initiative:

- ❖ Building User Test Facility- *Awarded FY2010*
  - Test integration of building components and control systems
  - Cooperation with public/private sector
  - Jointly staffed with LBNL and visiting scientists from industry

# Building Technology and Urban Systems Department

## Commercial Buildings

Advanced Commercial Building Systems & Simulation  
Research • Demand Response • Commissioning, Fault  
Diagnostics & Energy Information Systems • High  
Technology Buildings

## Building Technologies

Cool Roofing Materials & Urban Heat Islands • Windows,  
Daylighting & Lighting Controls • Modeling & Simulation of  
Building Energy & Control Systems • Building User Test Beds  
• HES-Pro

## FLEX Lab



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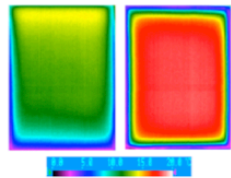
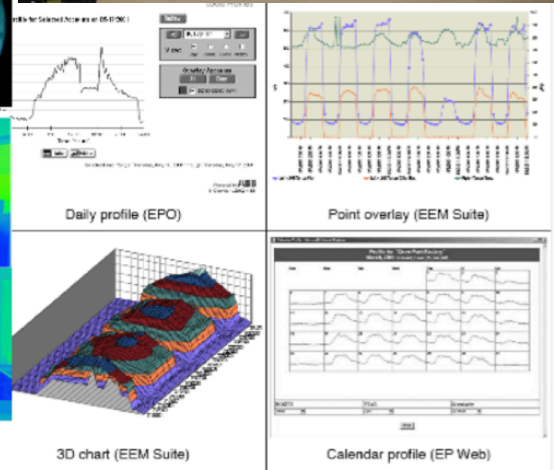
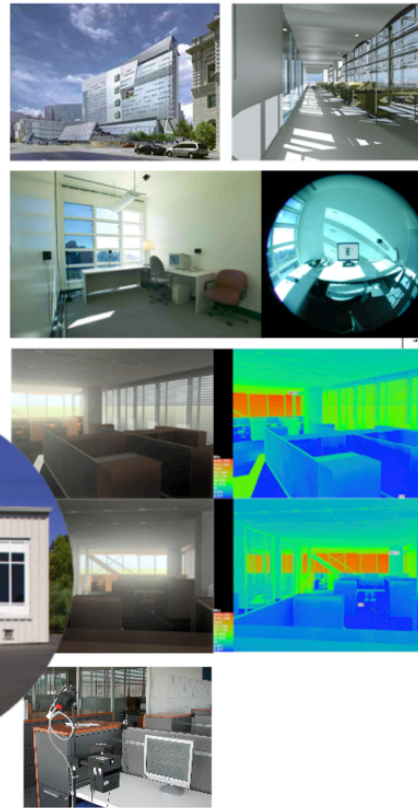
**R&D 100**

**Home Energy Saver & Hohm**

are free online Web tools that help consumers identify the best, most cost-effective ways to save energy and reduce greenhouse gas emissions from their homes.

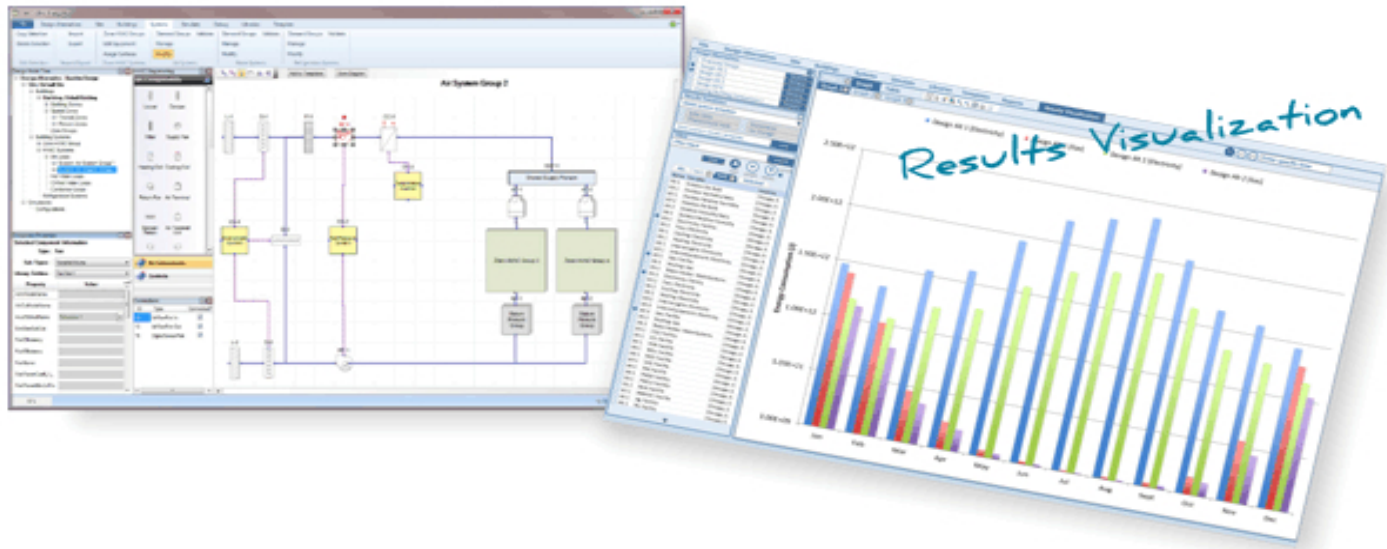
2010 R&D 100 Award

DOE ENERGY Microsoft

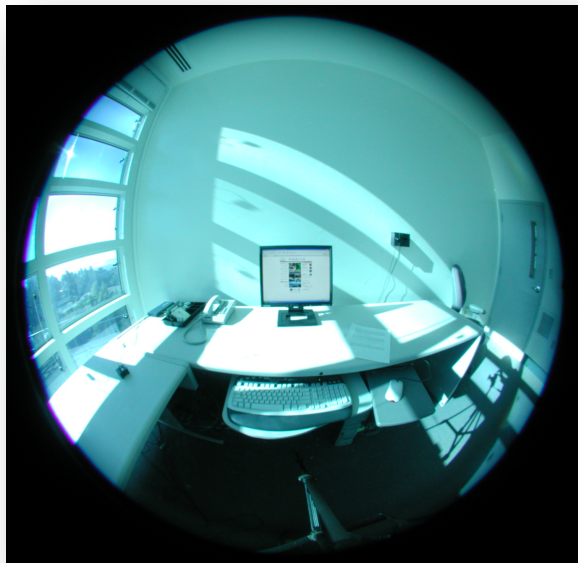
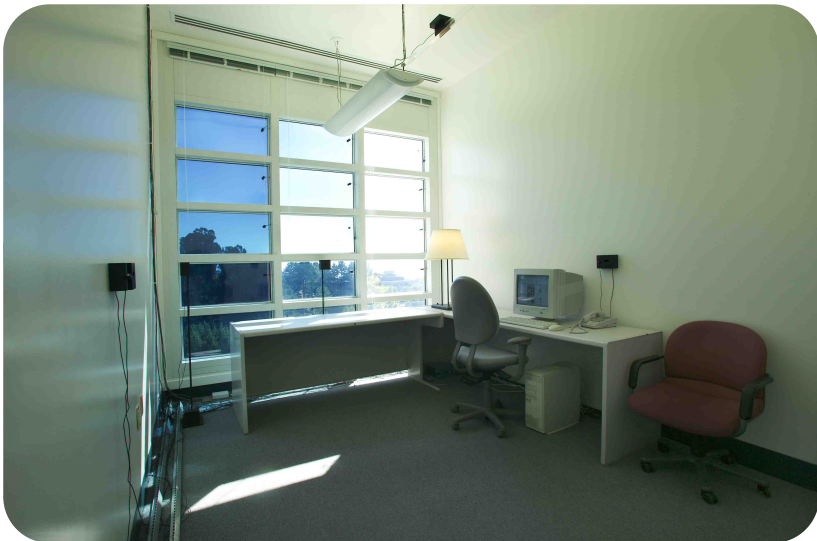


# Simergy Simulation Interface

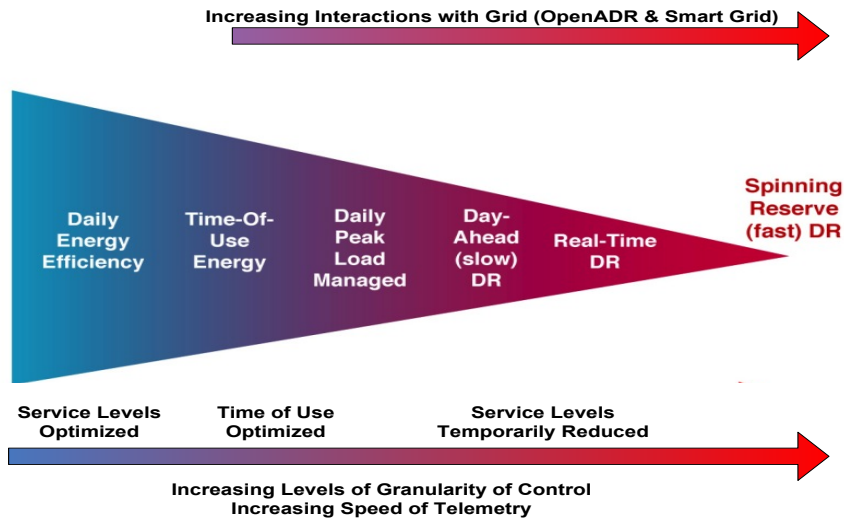
*HVAC System Design*



## Advanced Windows

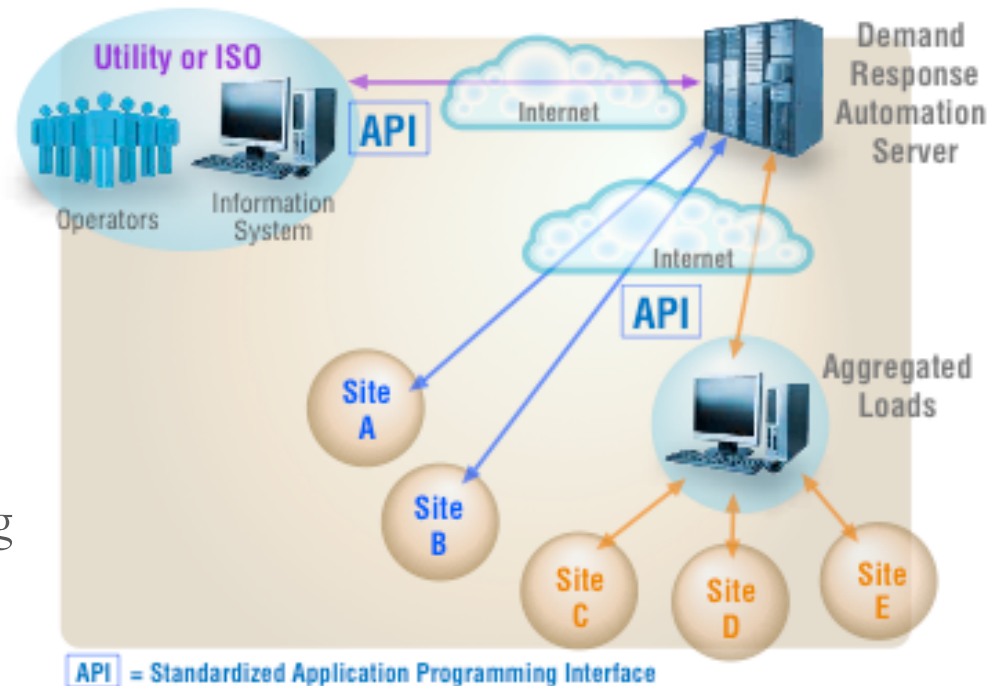


# Demand Response – Buildings to Grid



LBNL Demand Response Research Center: developed and demonstrated technology to allow building loads to provide a portfolio of flexible electric demand at low cost

- Provides non-proprietary, open standardized DR interface
- Allows electricity providers to communicate DR signals directly to existing customers
- Uses common XML language and existing communications network



# Electric Energy Storage and Conversion



R&D portfolio dominated by energy storage, particularly **Lithium-based batteries** for vehicles. **Focus:** Higher energy chemistries

Significant activity in **Fuel Cells** (Proton Exchange Membrane and Solid Oxide).  
**Focus:** Durability and cost



Fuel Cell expertise leveraged to investigate **Flow Batteries** for grid storage.  
**Focus:** Low cost

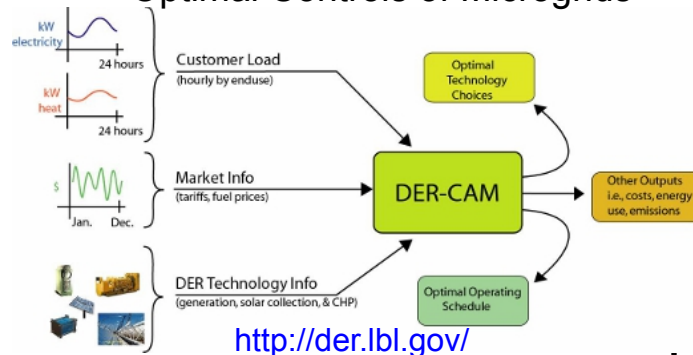
# Grid Integration

## Electrochemical Systems



- Batteries and Fuel cells for transportation
- Batteries for grid scale storage

## Optimal Controls of Microgrids

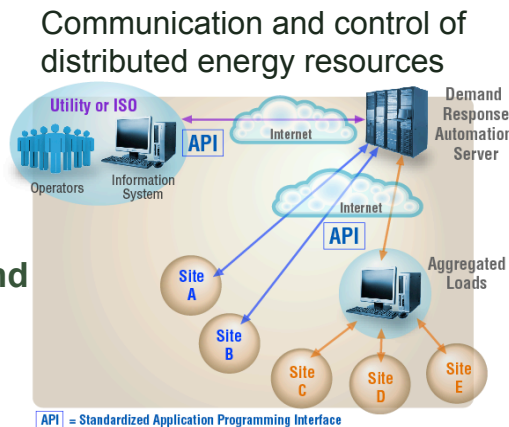


## Grid Integration



- Demand response
- Automation, control, communication, and telemetry
- Vehicle-to-grid and fast demand response demonstration projects
- Building simulation
- Consortium for Electric Reliability Technology Solutions

## Open Automated Demand Response (OpenADR)



## Electricity Markets and Policy



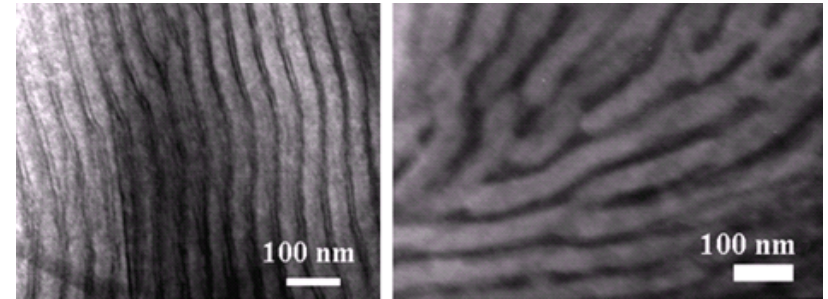
- Renewable costs, markets, policies
- Renewable integration – operational and reliability impacts
- Regional resource and transmission planning
- Demand response markets, regulation, and policy

# Energy Storage and Distributed Resources Department

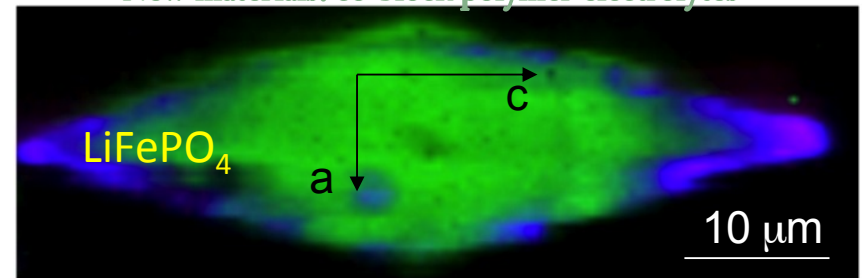


*Enable a paradigm shift in energy storage and transmission*

- Major Program Areas:
  - Batteries for Advanced Transportation Technologies
    - Cutting edge long-term research
    - Remedy life and performance limitations
  - Advanced Battery Research Program
    - Overcome barriers for high power Li-ion batteries
    - Technical assistance to battery developers
  - Energy Frontier Research Centers
    - Understand principles that govern EES devices
    - Enable breakthroughs in fundamental sciences
  - Demand Response & Distributed Energy
  - Fuel cells
    - Development a new class of non-Pt catalysts
    - Theoretical modeling and systems engineering



**New materials: co-block polymer electrolytes**



**State-of-the-art diagnostics**

## Major New Initiatives:

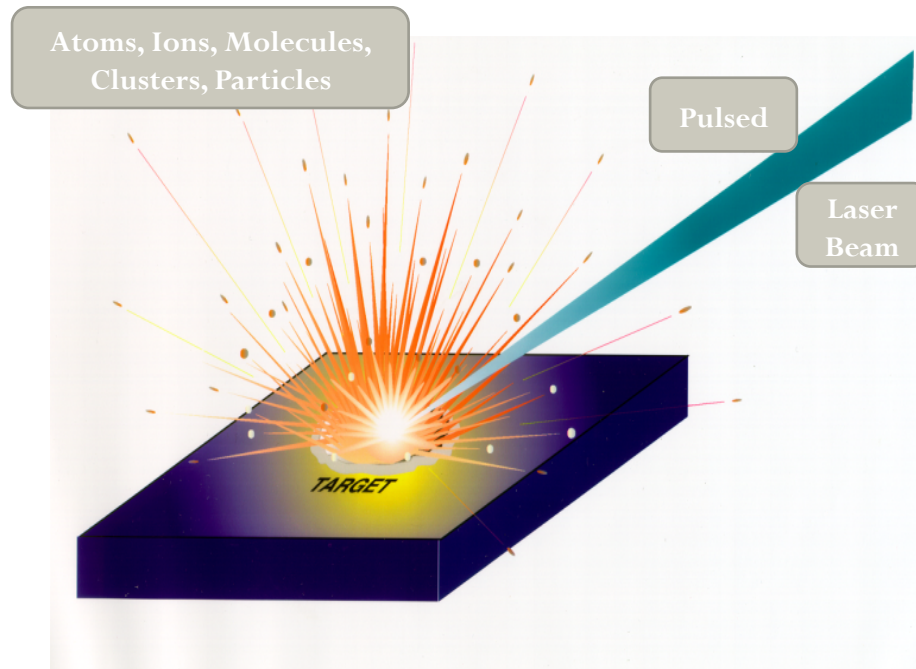
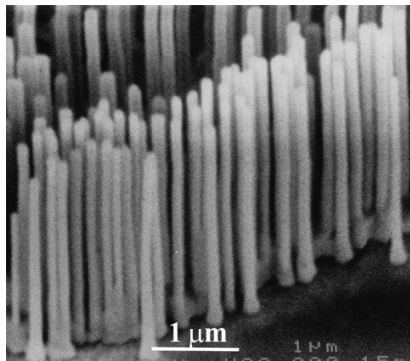
- ❖ Integrated Laboratory/Industry Research Program:
  - Expand vehicle batteries research into high-energy systems
  - Stationary energy storage program for grid & renewable applications
  - Cooperation with industry
- ❖ Energy Storage Hub (JCESR) in collaboration with ANL



# Advanced Energy Technologies

## *Physical science research in support of energy technologies*

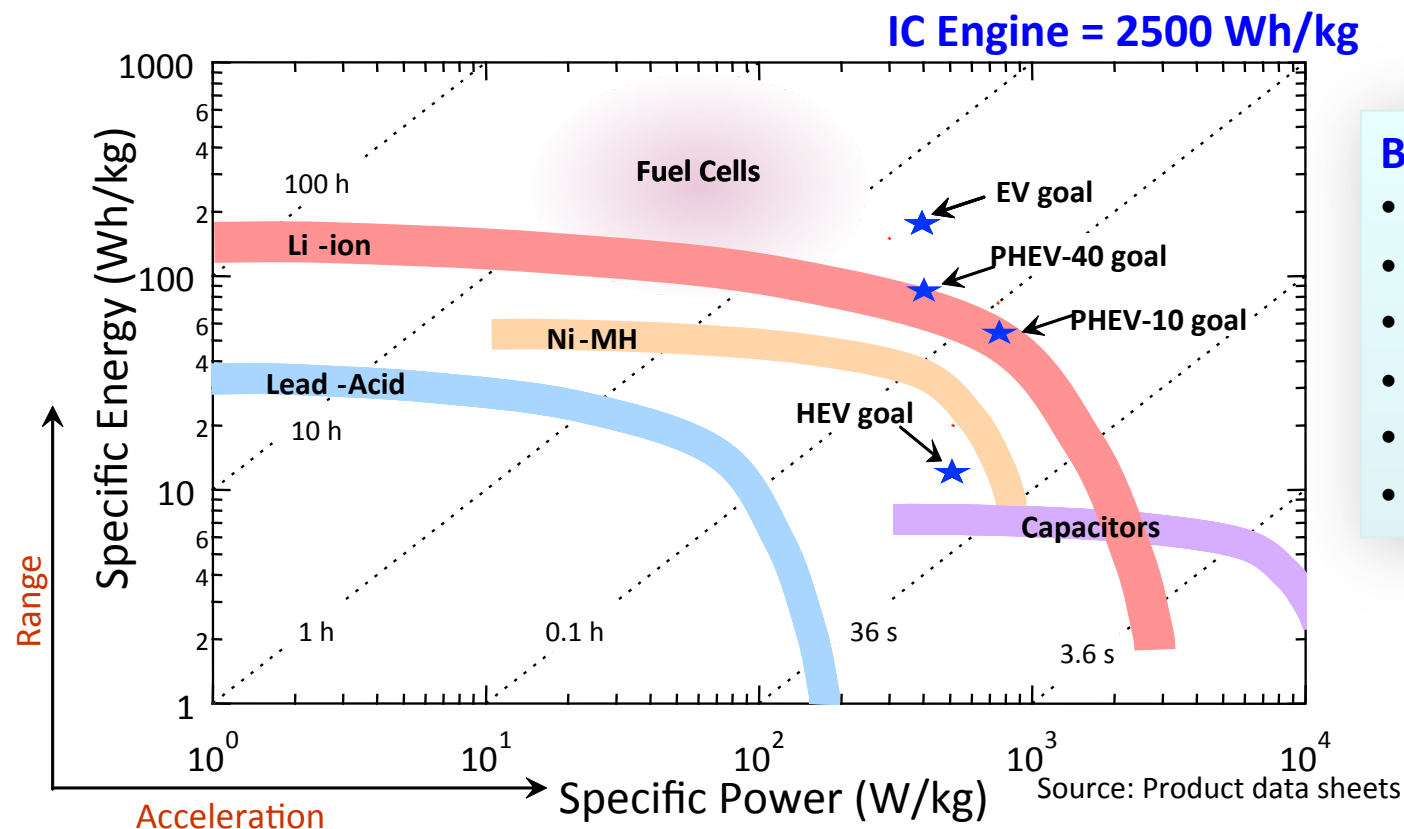
- Major Program Areas:
  - Advanced laser spectroscopy and imaging diagnostic tools
    - Photovoltaics
    - Energy storage
    - Fuel Cells
    - Biology
  - Nano-engineering new materials and architectures for clean energy systems



### **Major New Initiatives:**

- ❖ CO<sub>2</sub> capture with engineered ceramic membranes
- ❖ Long life radiation-enabled power source
- ❖ Networked sensors

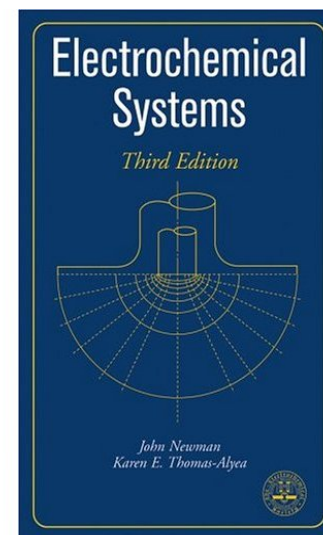
# Relative Performance of Various Electrochemical Energy-Storage Devices



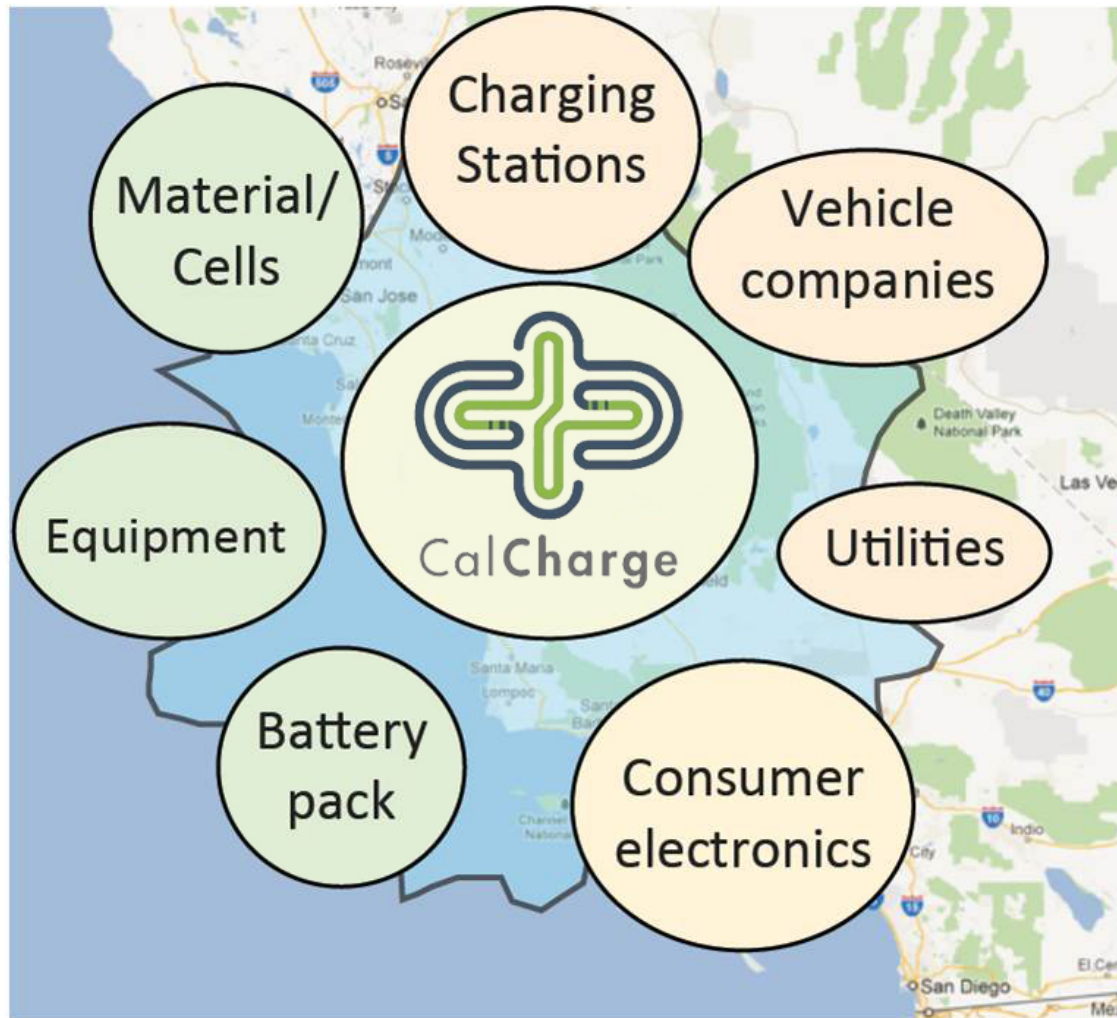
# Batteries for Advanced Transportation Technologies Program



- **Berkeley has a long history of research in batteries**
  - G. N. Lewis's pioneering research on Li batteries in 1912
  - Charles Tobias performed the first experiments in the 1950s on non-aqueous electrolytes
  - John Newman's model for lead-acid batteries published in late 1970s.
  - DOE-sponsored battery consortium established at LBNL in 1979
  - Two battery companies formed with IP from the lab.



# CalCharge launched on May 3, 2013



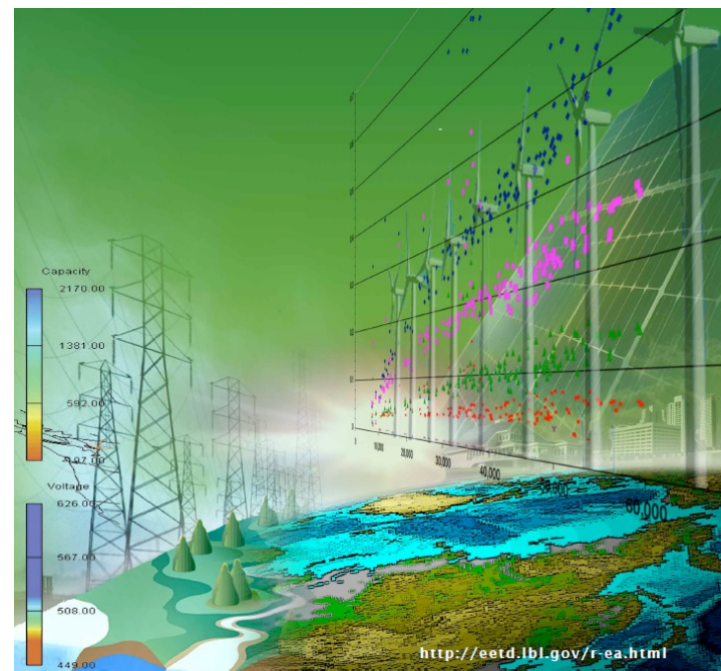
- We have an existing cluster of 30+ venture-funded battery companies

# Energy Analysis and Environmental Impacts Department



*Analyze and design effective energy and environmental approaches*

- Major Program Areas:
  - Appliance Energy Standards
  - Indoor Environment
  - Technology, Sustainability, and Impact Assessment
  - Energy Markets and Policy
    - Electricity markets
    - Consortium for Electric Reliability Technology Solutions (CERTS)
    - Renewable energy markets
  - Next generation analysis tools
    - Web-based tools for consumers
    - Non-technology factors in markets
    - Databases, statistical analysis, other models
  - International programs



## Major New Initiatives:

- ❖ New Technologies Assessment for CC2.0
- ❖ Super Efficient Appliance Deployment (SEAD) for global appliance efficiency push
- ❖ Life cycle assessments for energy and health
- ❖ Major expansion of Appliance Standards work



# Energy Efficiency Standards (EES) Group

## Mission:

- Provide comprehensive, unbiased analysis of the energy savings, economic, and environmental impacts of energy efficiency standards
- Develop new analytical approaches to address:
  - Increased energy savings potential from technology innovation
  - Stakeholder and agency concerns and evolving policy needs
- Create, maintain and distribute the analysis tools and documentation critical to building consensus within DOE's efficiency standards stakeholder community



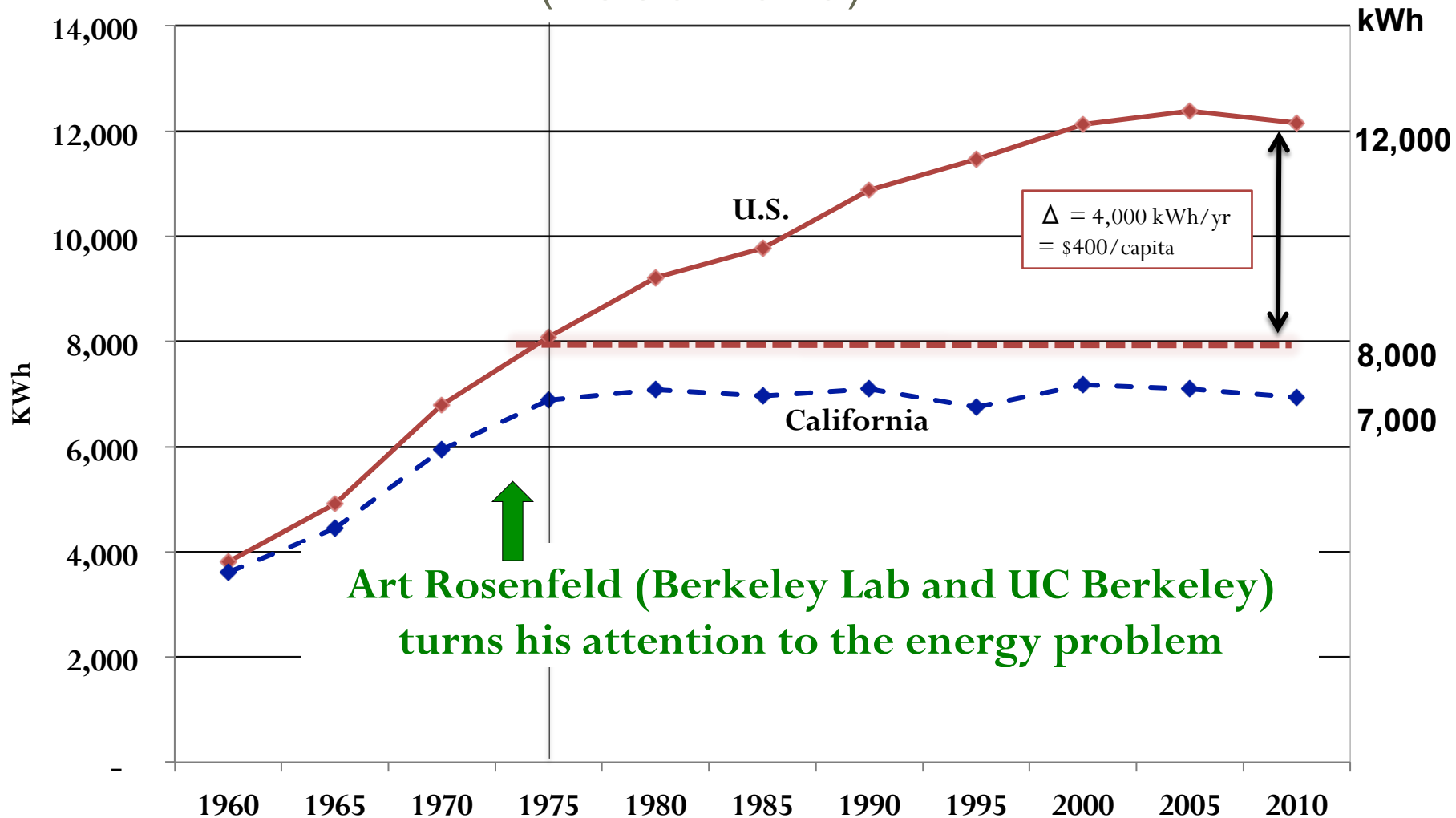
## Unique Role:

- Supported DOE's efficiency standards program since inception
- Several of the core analyses were developed exclusively at LBNL

## Expertise:

- World leader in practical, data-driven analysis methods for standards
- Experience in every aspect of the rulemaking process

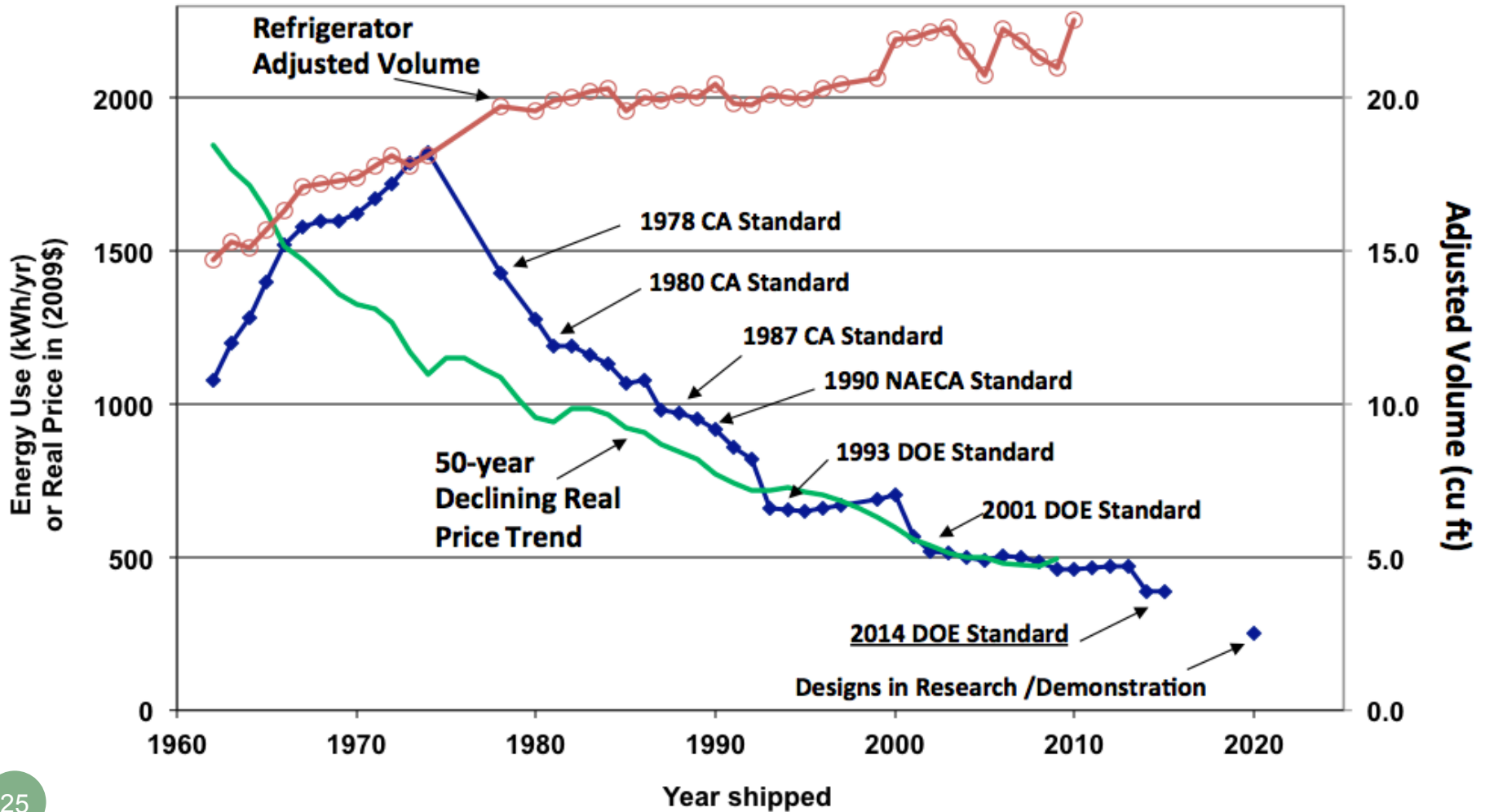
# Per Capita Electricity in the U.S. and California (1960-2010)





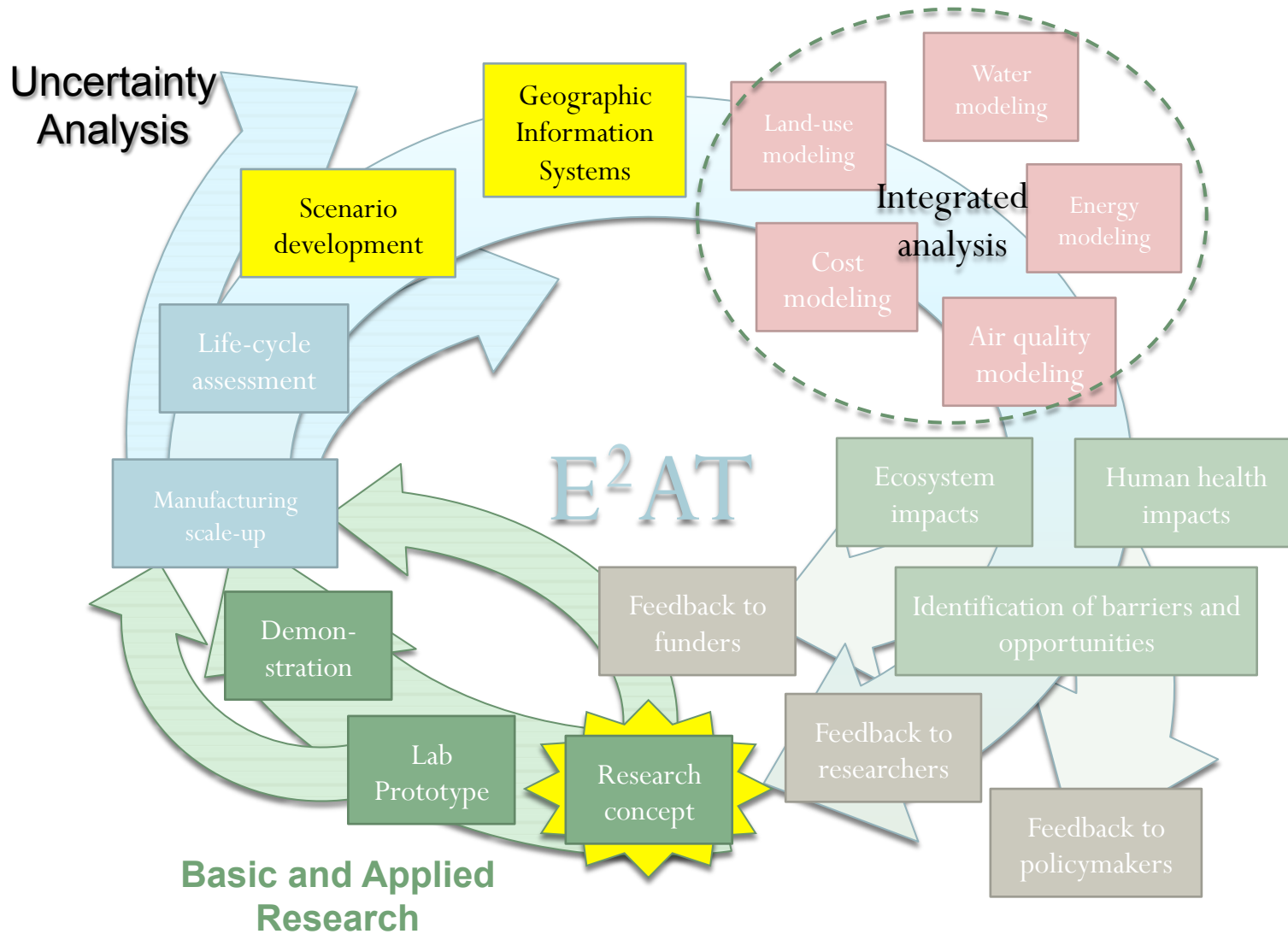
## Average Annual Energy Use, Volume and Real Price of New Refrigerators (1960-2012)

Sources: AHAM, Rosenfeld 1999, LBNL/EES and Bureau of Labor Statistics



# Energy and Environmental Analysis Team (E<sup>2</sup>AT):

Bridging basic and applied research with energy and environmental analysis



# International Energy Studies Group (IES)

Working on Industry, Appliances, Transport, Power and Forestry in 40 countries

## Project Areas:

- Super-efficient Equipment and Appliance Deployment (SEAD) Program
- Berkeley India Joint Leadership on Energy and Environment (BIJLEE) Program
  - Power Sector Energy Efficiency and Renewable Energy
  - Sustainable Cities – Cooperation between San Jose and Pune, India
- Top-down and Bottom-up Models -- Energy efficiency, renewables, and forestry; BUENAS, GCOMAP, COBRA Models
- Industrial Energy Efficiency Analysis
- Evaluation, Monitoring and Verification (EM&V) of Efficiency
- Intergovernmental Panel on Climate Change (IPCC)



# International/Developing Countries

## *Berkeley Lab projects bringing solutions to the developing world*

- Major Program Areas:
  - China Group's work on energy efficiency, industrial best practices, buildings energy standards, technical assistance
  - International Energy Group - informs and helps formulate and implement in-country energy and environmental policies
  - The Berkeley-Darfur stove, and other stoves projects



### **Major New Initiatives:**

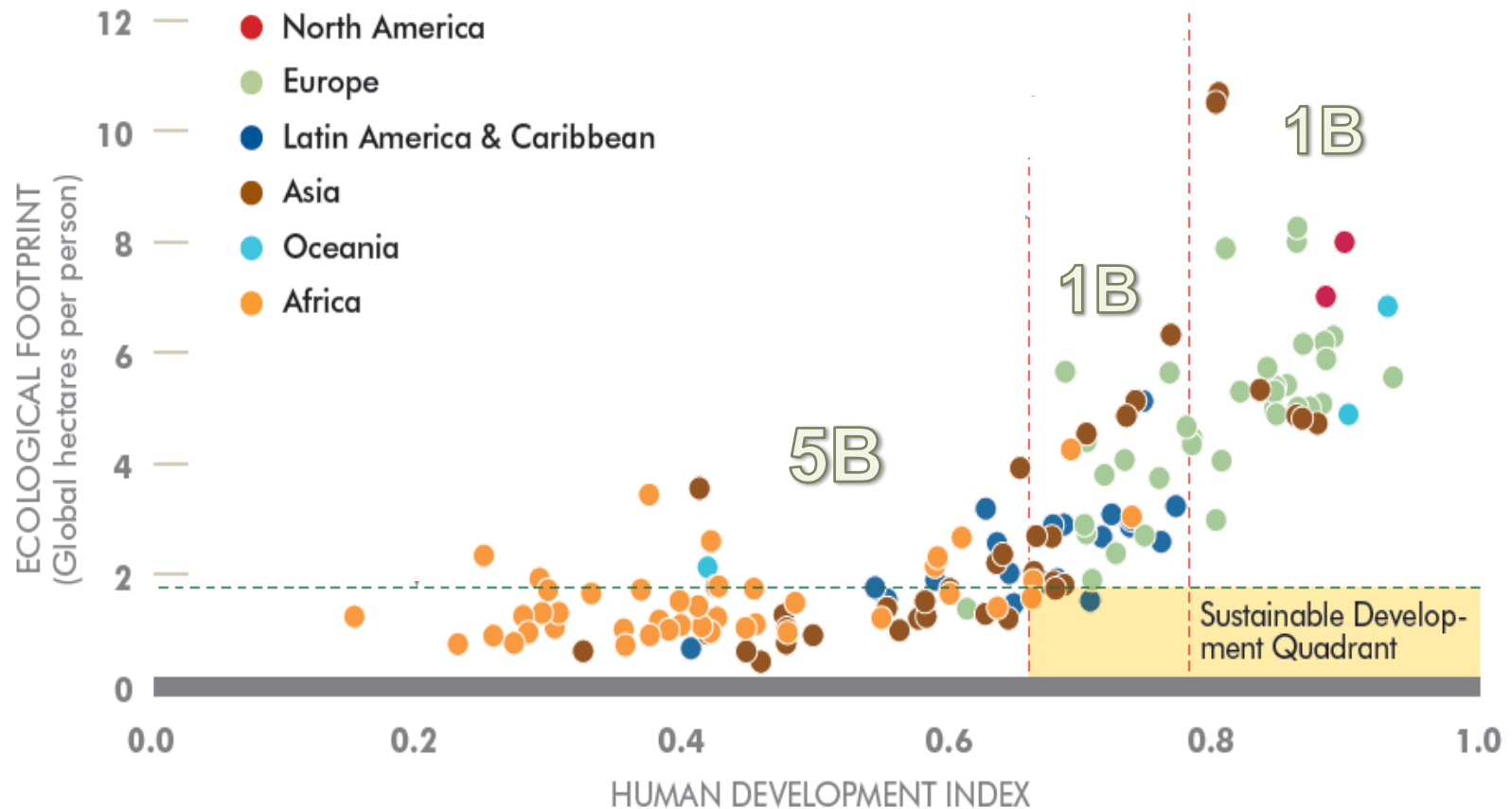
- ❖ Energy efficient stoves for Haiti earthquake survivors
- ❖ Mongolia air quality and appliance standards
- ❖ China/US Energy Center - Buildings
- ❖ Substantial engagement with India on electricity market regulation and energy efficiency policy
- ❖ LIGTT – Institute for Developing Country Technologies

# CC2.0 Initiative



# Inexorable pressure in Emerging Countries for Development pushing boundaries of what is sustainable for the planet

## Human Development Index and Ecological Footprint of Nations



# Motivation:

1. Anthropogenic Climate Change and its consequences constitute the single biggest threat to modern society
2. Even the best actions, if limited to the first world, will be overwhelmed by the rapidly rising emissions from the high-carbon path to development from the rest of humankind (6B people)

**A low-carbon development path is needed for the developing world**



**BERKELEY LAB**

LAWRENCE BERKELEY NATIONAL LABORATORY



# LIGTT

LBNL Institute for Globally Transformative Technologies  
An Institute to deploy Transformative Technologies for Global Human Development

[www.LIGTT.org](http://www.LIGTT.org)



# End of Slides

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Questions?

New field being launched:  
Development Engineering at Berkeley

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[DIL.berkeley.edu](http://DIL.berkeley.edu)