

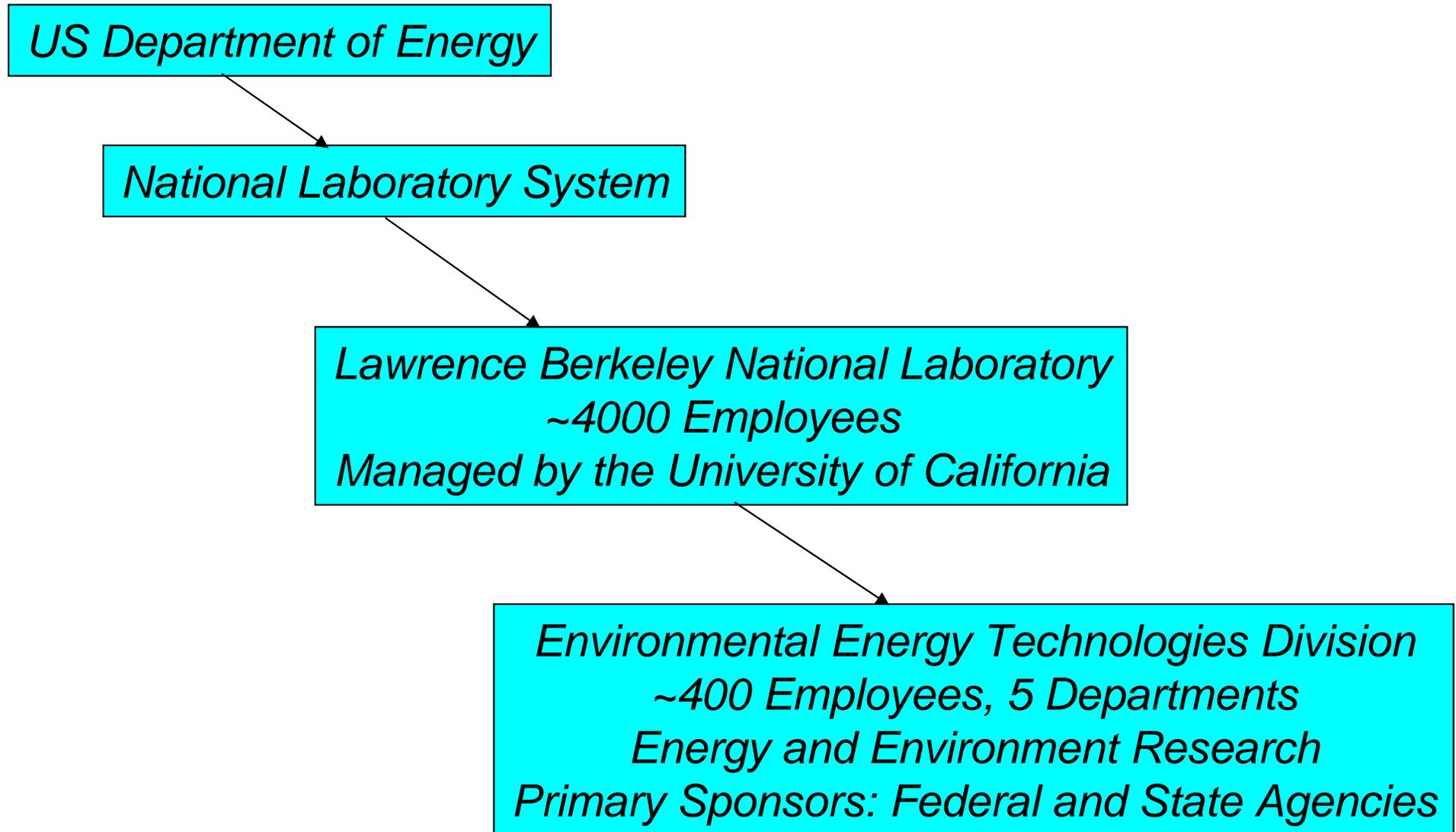


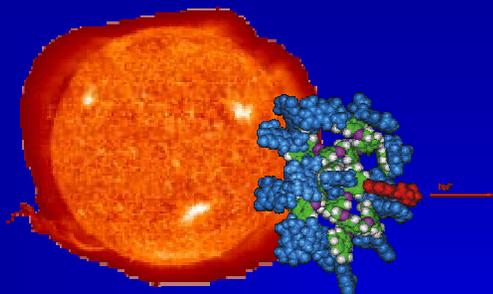
# **Lawrence Berkeley National Laboratory Environmental Energy Technologies Division (EETD)**

## **Saving Energy and Improving Environmental Quality**

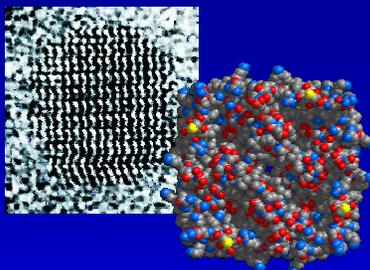
**William J. Fisk  
Acting Division Director**

## *What is the Environmental Energy Technologies Division?*

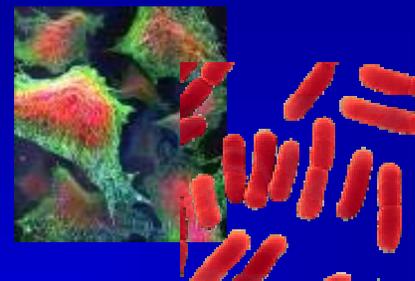




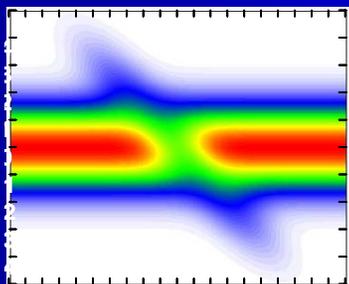
**Solar to Chemical  
Energy**  
Basic Energy Sciences



**Nano-Bio Frontier**  
Basic Energy Sciences

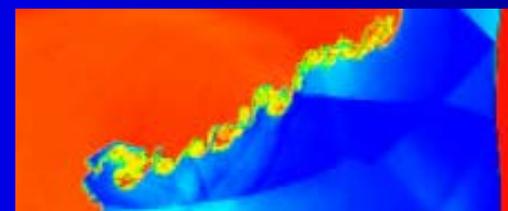


**Quantitative Biology**  
Biological and  
Environmental Research



**Ultrafast Science**  
Basic Energy  
Sciences

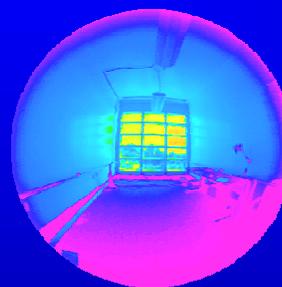
## **Berkeley Lab's New Scientific Directions**



**Scientific Computing**  
Advanced Scientific  
Computing Research



**Matter and Energy  
in the Universe**  
High Energy Physics



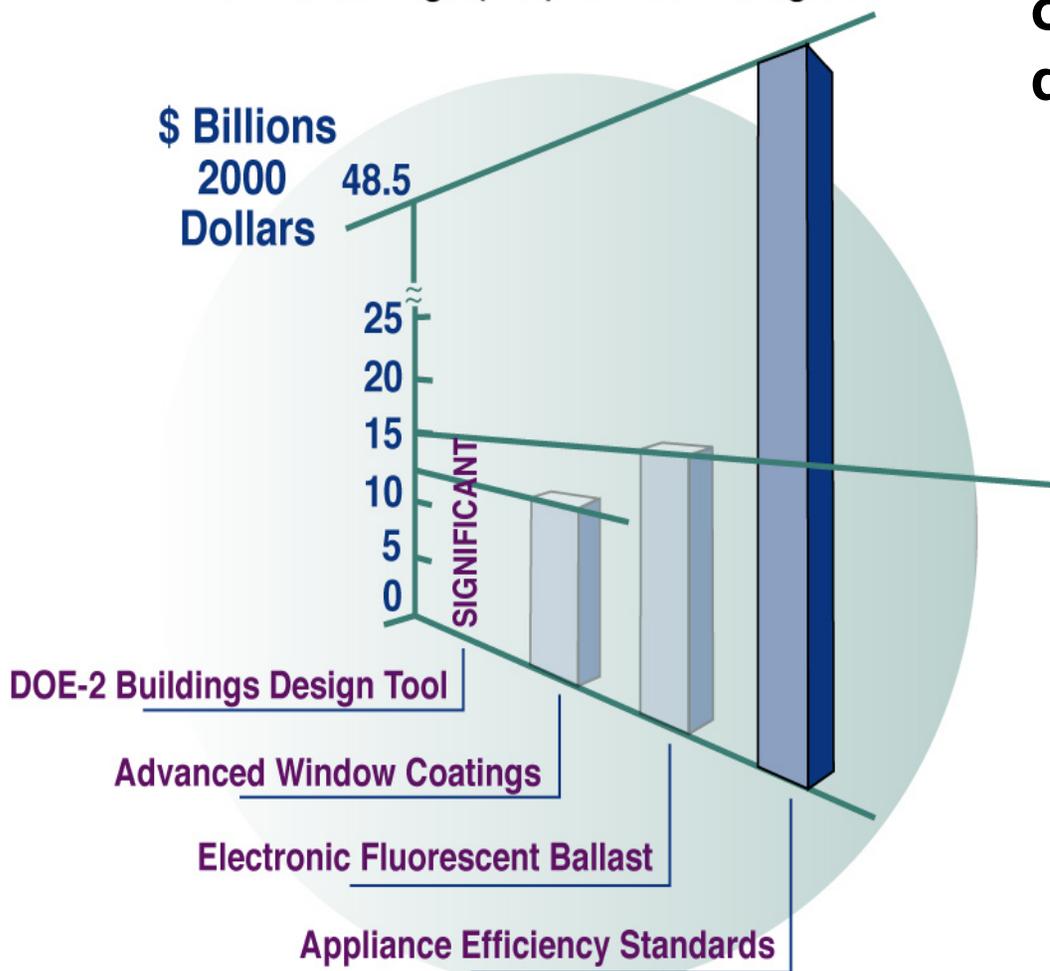
**New Energy Systems and  
Environmental Solutions**  
Energy Efficiency and  
Environmental Research

# Prior Impacts of EETD's Efficiency R&D

## From National Academy of Sciences Report

### 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

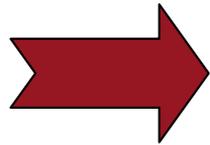
- *Primary energy savings*  
= **9%** of 2025 residential energy use
- *Carbon reductions in 2025*  
= **132 million metric tons CO<sub>2</sub>/year**

# Improved Energy Technologies

An energy- efficient and safe torchière lighting fixture



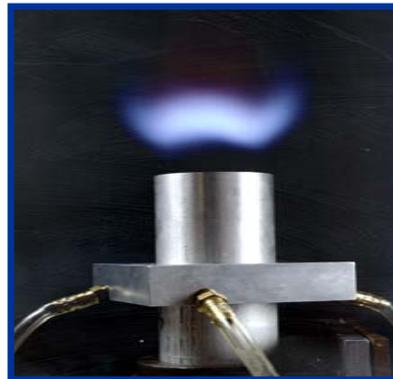
Berkeley Lamp



Aerosol duct sealer



Low- emission burner for heating and power



Low energy fume hood



# Energy Impacts (cont.)



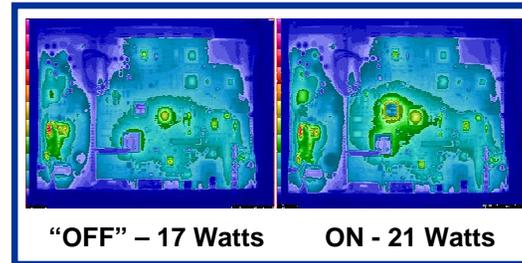
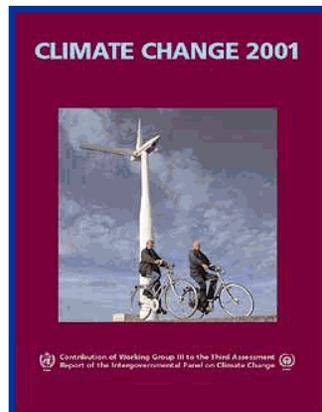
## China energy efficiency policies

### Assisted China in:

- Transformation of refrigeration and lighting industries
- Appliance standards
- Building energy standards
- Iron & steel industry efficiency
- Motor systems

## Intergovernmental Panel on Climate Change

- Significant contributions to reports

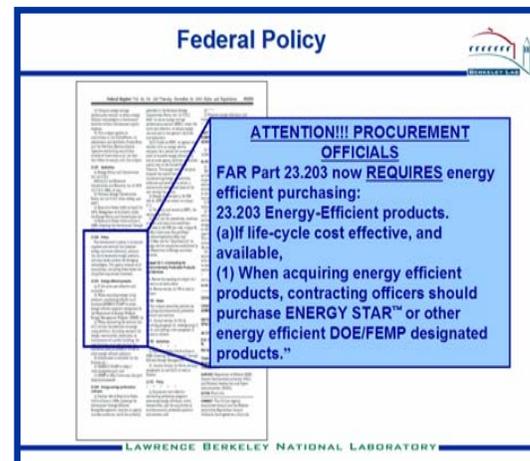
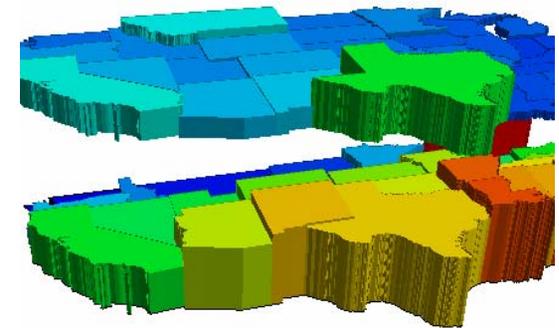


## Reducing standby power losses

- U.S. executive order
- International 1-watt guideline

## Electricity reliability

- Real time monitoring tools

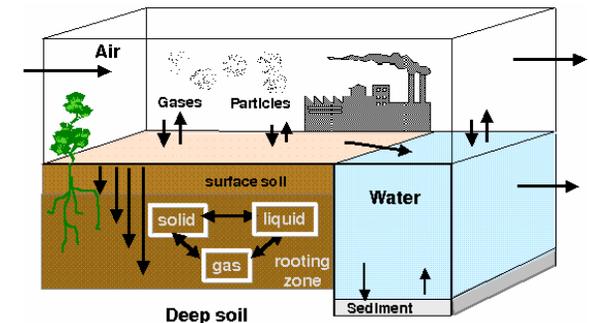


## Federal procurement

- Energy Efficiency in Federal Acquisition Regulations
- Federal Energy Management guidelines

# Widely Used EETD-Developed Simulation Tools

- **DOE-2**
  - Building energy simulation program widely used for building design and energy performance compliance with standards
- **EnergyPlus**
  - Next generation of building energy simulation program with expanded capabilities and flexibility
- **Radiance**
  - Program for predicting and rendering lighting environments, used for lighting system design
- **Window**
  - WINDOW 5.2 is a publicly available computer program for calculating total window thermal performance indices
- **Home Energy Saver**
  - Web-based tool to guide selection of energy efficiency technologies by homeowners
- **CalTOX**
  - a risk assessment model that calculates chemical emissions and concentrations and the risk of an adverse health effects



# Understanding and Improving Indoor Air Quality (IAQ)

## LBNL's leadership role in IAQ Research

- **Characterizing indoor pollutant sources**
- **Identifying risk factors and health effects**
- **Evaluating and demonstrating energy efficient technologies and practices for improving IAQ**

## *Potential Health Improvements from Better IAQ*

Reduced	Annual U.S. Health Benefits	Impacts (1996 \$U.S.)
Respiratory disease	16-37M avoided illnesses	\$6 - \$14 billion
Allergies and asthma	8 - 25% decrease in symptoms in asthmatics and allergy sufferers	\$1 - \$4 billion
Sick building syndrome	20 - 50% reduction in symptoms	\$10 - \$30 billion

Source: Fisk Annual Rev. E&E 2000

# Affordable Energy-Efficient Provision of Clean Water for The Developing World

- 25% of the world's population lacks access to safe water
- 60 million children suffer from stunted growth or development due to water borne disease
- 4 million deaths/year in developing world from polluted drinking water

## UV Waterworks

- Appropriate low-cost technology provides water for less than \$2 per person per year
- Now serving populations in Mexico, India, Philippines, Ghana, South Africa and elsewhere



# Examples of EETD's Ongoing Energy Research



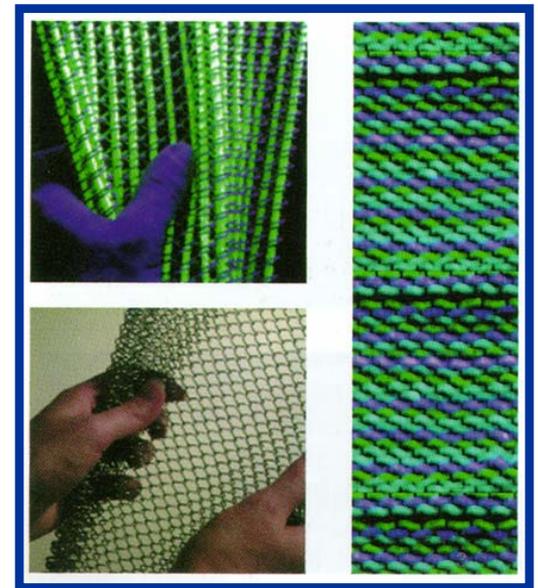
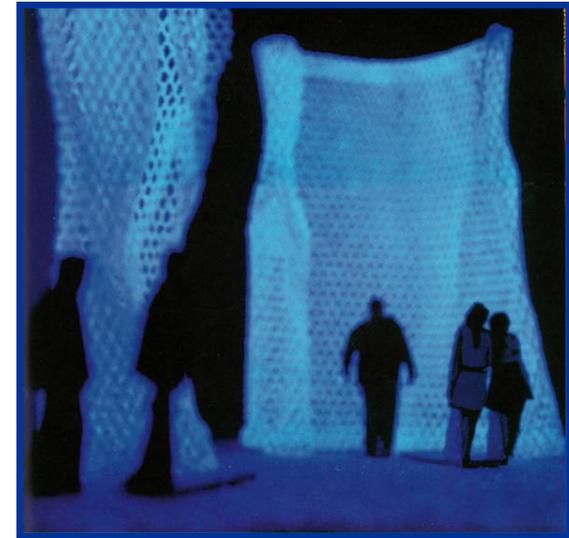
# Switchable Electrochromic Windows



- **LBNL full-scale windows field test facility**

# Solid State Lighting: The Next Generation of Energy Efficient Lighting Products

- **Goal:**
  - Contribute unique expertise to development of solid state lighting technology
- **Significance:**
  - Lighting represents 30% of the total electric energy used within residential and commercial buildings.
  - **Solid state lighting could cut lighting energy use in half**



Luminous woven materials

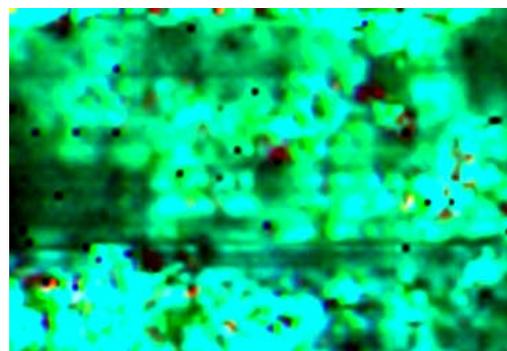
# High Power Lithium-Ion Batteries

## Discovering causes of battery power loss in hybrid electric vehicles

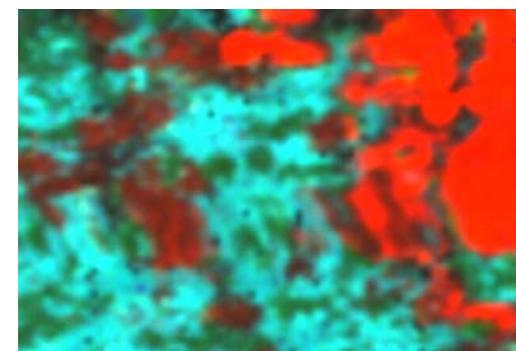
- Hybrid EVs are entering the market, and lithium-ion is poised to become the preferred battery technology
  - Higher power & energy, longer life, and similar cost, compared to Ni/MH
- EETD researchers are addressing key issues to advance lithium-ion technology

### Microscopic images of electrodes

Fresh cathode



Failed cathode



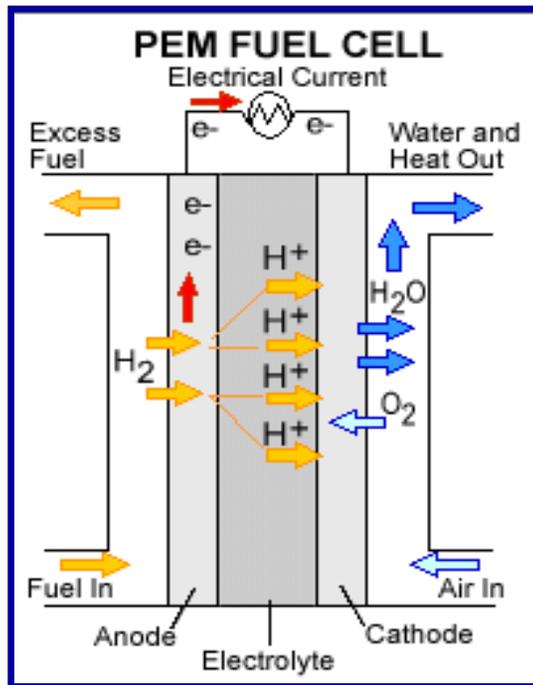
10  $\mu\text{m}$

- ◆ LiNi<sub>0.8</sub>Co<sub>0.15</sub>Al<sub>0.05</sub>O<sub>2</sub>
- ◆ graphite
- ◆ acetylene black

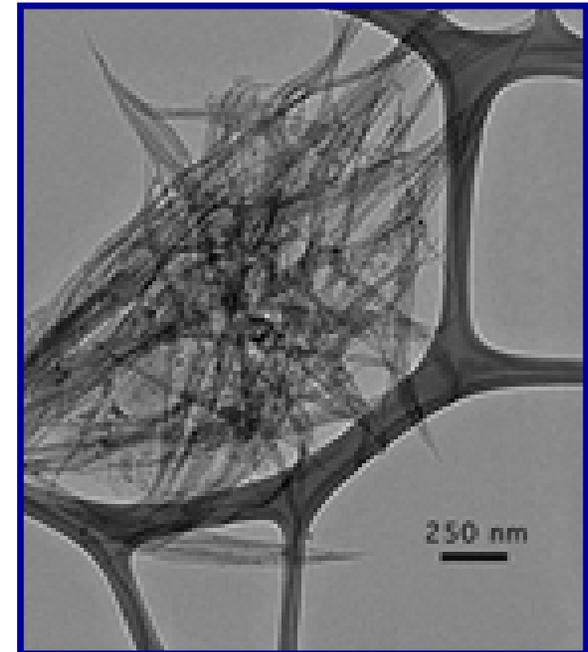
- Color-coded images reveal how electrode surface chemistry changes during battery tests
  - Loss of conductive carbon contributes to unwanted battery power loss

# Fuel Cells for Transportation Applications

- **Proton-exchange membrane fuel cells** are favored for future transportation
  - Benign emissions, non-petroleum fuel, good performance, rapid refueling
  - Require lower cost, greater durability, hydrogen storage, infrastructure, and production



- **Research Areas:**
  - **Novel catalyst layer: microstructures to reduce Pt loading (cost issue)**
  - **Nanostructured membranes**
  - **New diagnostic methods to help develop advanced hydride materials**
  - **Modeling of fuel cell components**



# Zero-Energy Commercial Buildings

## Background

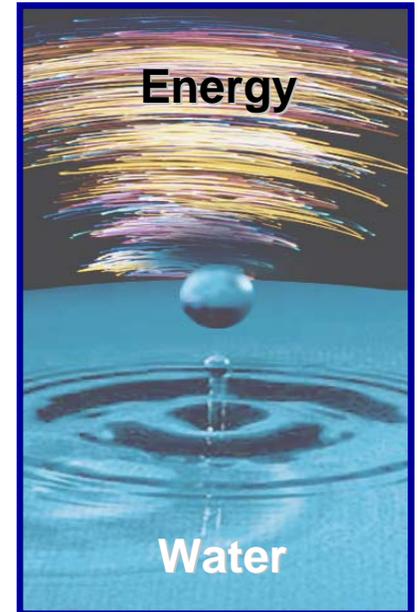
- The buildings sector accounts for about 40% of total U.S. energy consumption
- Approximately half of that is from commercial buildings.
- The commercial sector is the fastest growing energy end-use sector

## Goals

- EETD is partnering with Alliance to Save Energy, AIA, ASHRAE, World Business Council for Sustainable Development to define and propose a major initiative to:
  - ✓ *Stimulate measurement and disclosure of the energy performance of buildings*
  - ✓ *Develop and demonstrate scaleable and replicable building energy system solution packages*
  - ✓ *Develop a strategy for sector-wide building transformation*

# Water and Energy

- **Goals:** identify cost-effective ways to:
  - Increase energy efficiency of water delivery
  - Reduce waste of water
- **Significance:**
  - 7% of world energy is for delivering water
    - 50-60% of some municipal electricity bills is for water
  - U.S. freshwater withdrawals:
    - 38% thermoelectric power (recycled and reused)
    - 39% irrigation
    - 19% commercial, industrial, residential
  - **Serious and growing water availability problems** – in U.S. and worldwide
    - As in energy efficiency, technology can play a major role in reducing water use; behavior may be more important for water



# Reducing Data Center Energy Consumption

## Energy Demands at Data Centers and Super Computer Centers are Growing Rapidly

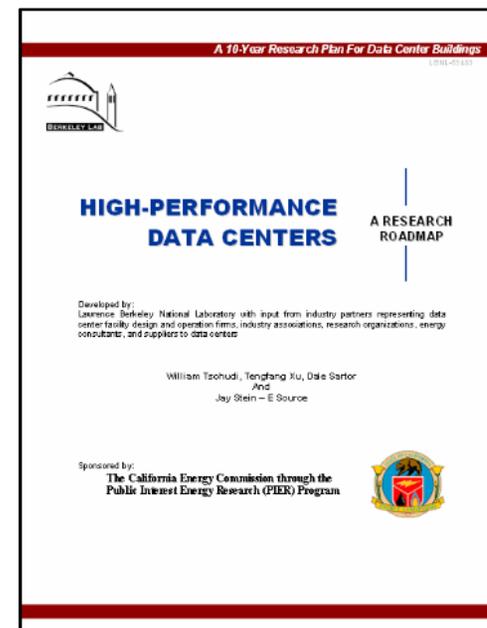
- Google warns “Power could cost more than servers”
- LBNL’s supercomputer center expects 7 fold increase in electricity demand over 10 years



NERSC IBM Bassi SuperComputers  
XBD200510-00348-13

## Research areas

- Understanding how energy is used in data centers
- Efficient power supplies
- Efficient computer cooling strategies
- Real time monitoring and control
- Use of outdoor air for free cooling
- Power efficient algorithms

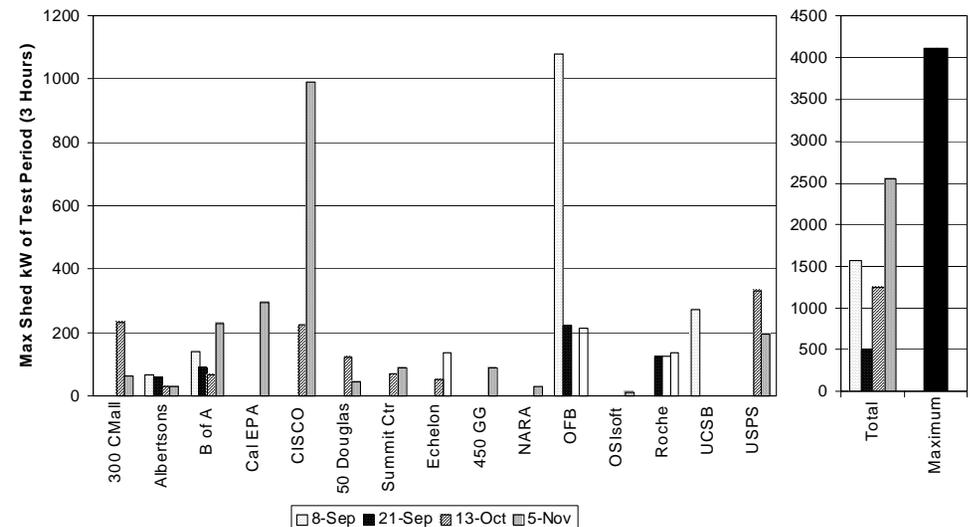
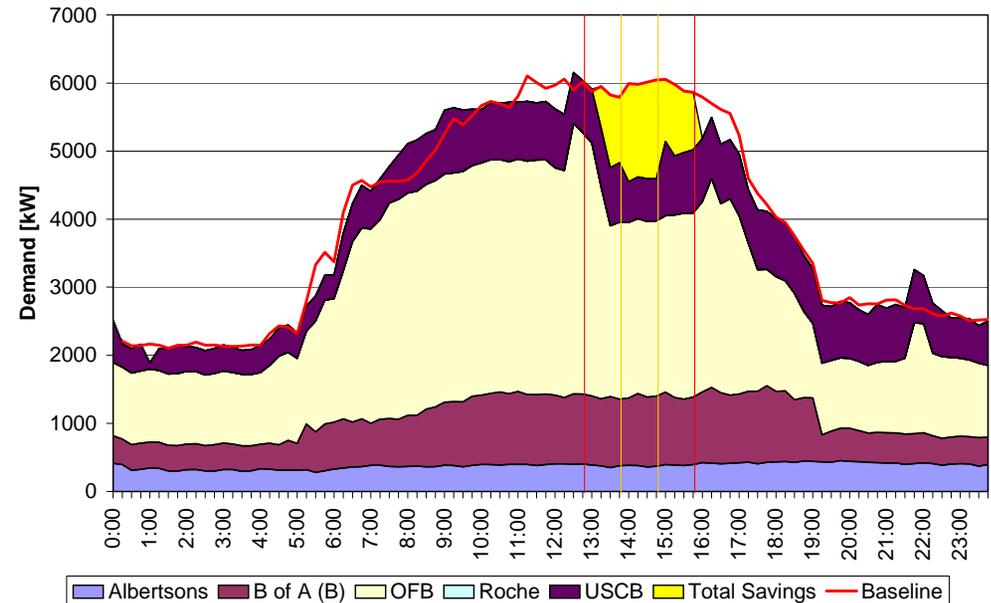


# Fully Automated Electricity Demand Response

## *LBNL's Demand Response Center*

- Demonstrates large electricity sheds can take place without complaints
- Demonstrates range of strategies to produce electricity sheds and capabilities needed
- Provides knowledge and experience needed for related policies and building codes

Aggregated Demand Saving, Sept 8th



# Monitoring the Electricity Grid to Reduce Failures

- **Background:**

- Massive amounts of real time data collected about electricity flows on U.S. transmission grids

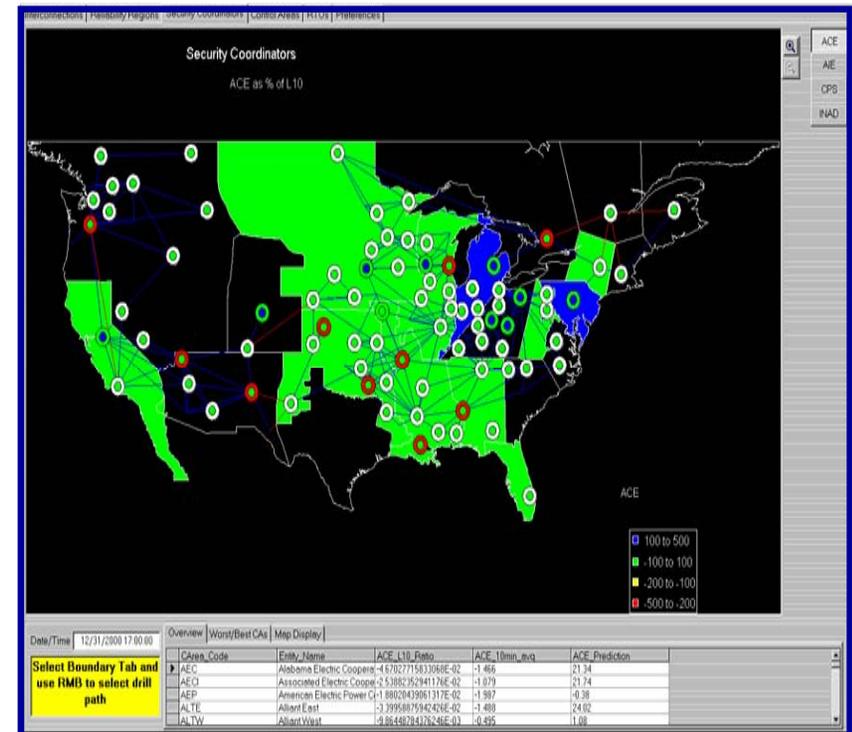
- **Problem:**

- Operators of electricity grid were unable to analyze the data in close to real time

- **Achievements**

- Created **visualization tool** to analyze and **display** data in real time

- **Tool being adopted** by all 23 National Electricity Reliability Council Coordinators (covering nation) and by several Independent System Operators

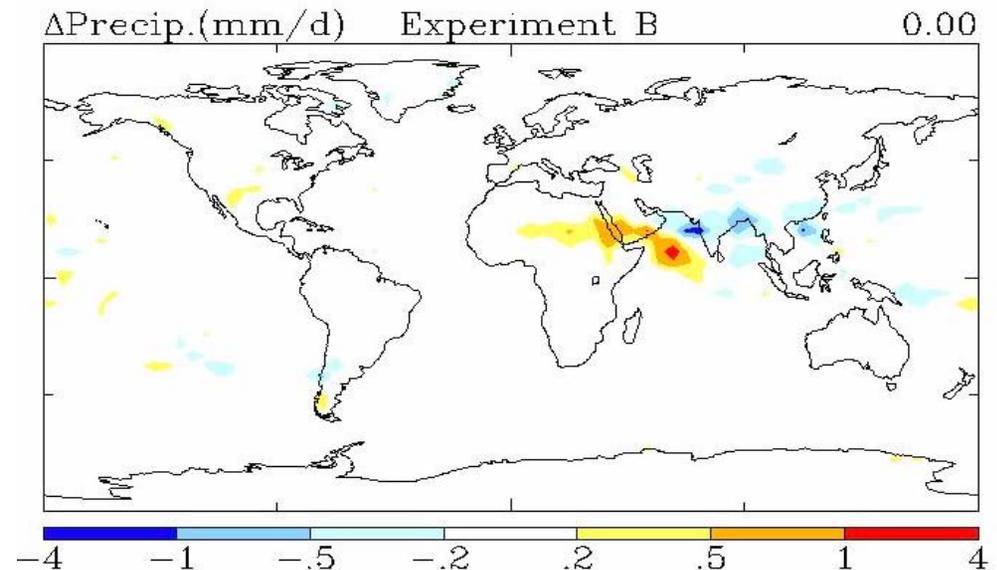
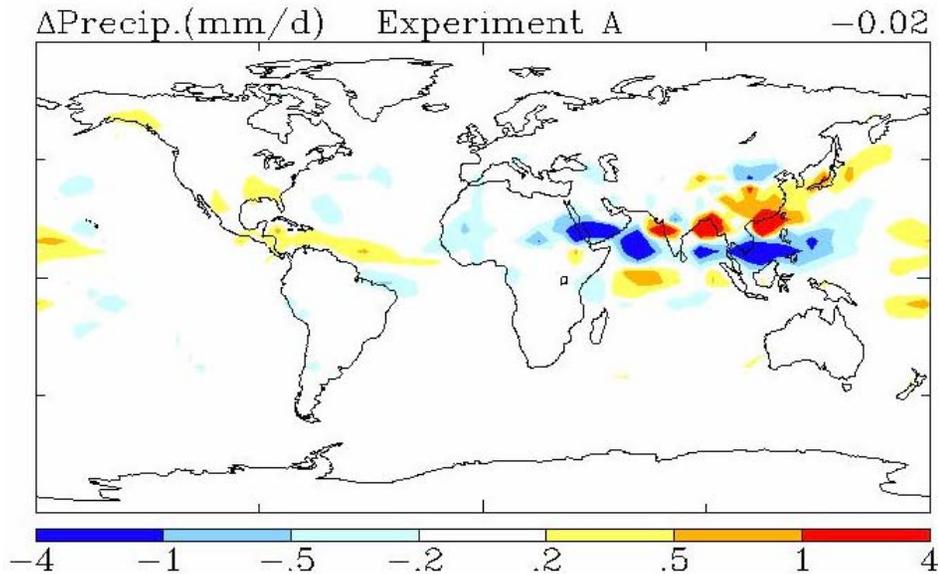


# Climate Effects of Aerosols

- Using the Goddard Institute for Space Studies climate model
- Simulations revealed that the **heating effects of black carbon result in lower level heating**, changes in vertical motions, circulation, and thus **cloud cover and rainfall**. (Menon et al. Science, 2002)
- Results show that the regional climate effects of BC particles can be quite significant.

With black carbon  
 $\Delta$  Precipitation mm/d

Without black carbon  
 $\Delta$  Precipitation mm/d



# For More Information

A decorative graphic consisting of a green curved line with an orange circle at its peak, resembling a stylized sun or a wave.

<http://eetd.lbl.gov/>