Radiance Workshop Introduction
A Brief Overview of Building Science at LBNL

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U.S. Building End Use Energy Consumption

Building sector has:

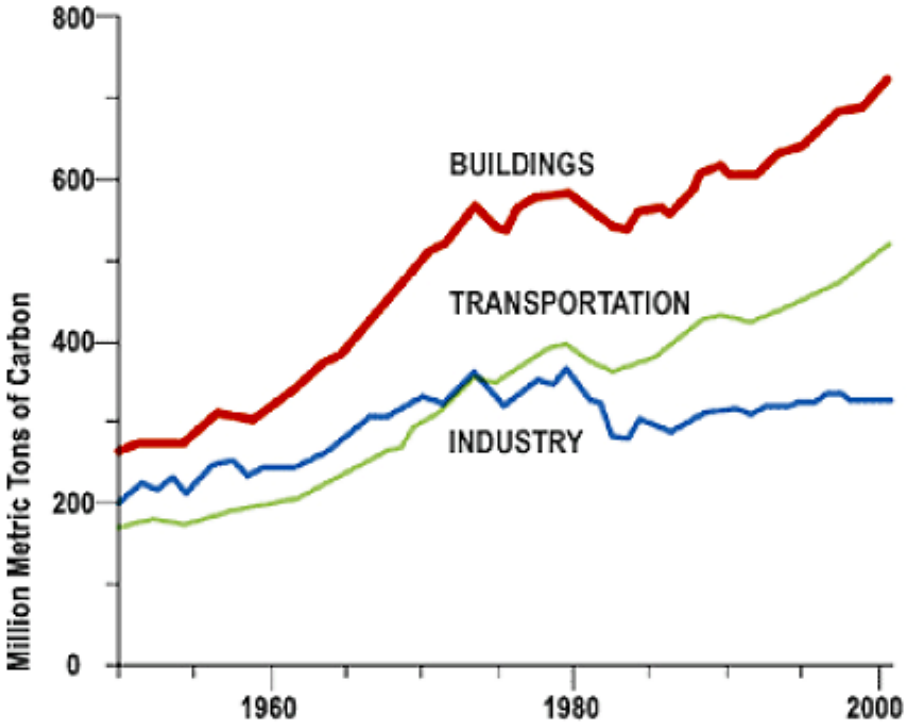
Largest Energy Use!

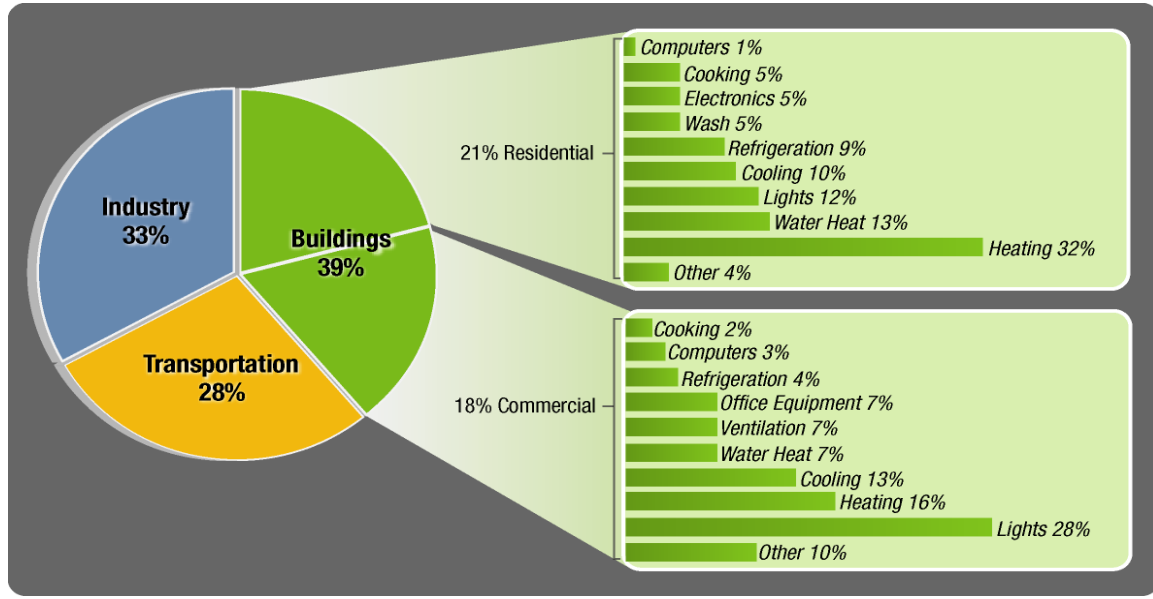
Fastest growth rate!

Buildings consume 40% of total U.S. energy

- 71% of electricity
- 54% of natural gas

No Single End Use Dominates





BERKELEY LAB

LAWRENCE BERKELEY NATIONAL LABORATORY

U.S. DEPARTMENT OF ENERGY

LBNL: Basic sciences—advanced materials, computing, ….
UC Berkeley- Architecture, Engineering, Business,….
UC System- multi-campus collaborations….

4000 Staff; **11 Nobel Prize Winners**
$700M/yr Budget

Energy Efficient Buildings:

Established 1975, ~200+ staff

Materials, Technologies
Building Systems
Facades
Lighting, Daylighting
HVAC
Electrical loads
Indoor Environmental Quality
Hi Tech Buildings
Data Centers, Labs
Field Performance
Distributed Energy Systems
Demand Response
Electric Grid Reliability
Simulation tools
Benchmarking and Rating
Energy standards
Energy policy w/ Renewables
International Studies

Environmental Energy Technologies Division
EETD Vision

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

Mission: *Perform analysis, research and development leading to better energy technologies and reduction of adverse energy-related environmental impacts*

EET Division Profile

- One of the largest research divisions at LBNL
- About 12% of Lab in size of budget; 10% in staffing
- Total staff and visiting researchers
  in 2009: 390; in 2010: 469; in 2011: ~600
- Total funding 2010: $130M
  includes $28M ARRA; 96 research sponsors

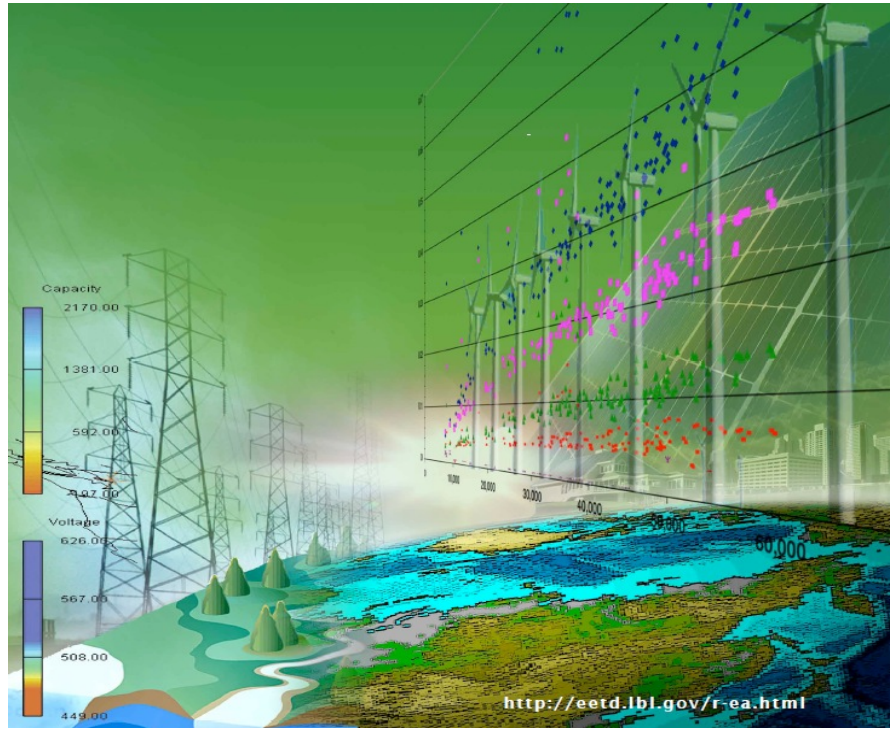
- Multidisciplinary research staff includes 94 principal investigators: architects, mechanical engineers, physicists, chemists, chemical engineers, economists, policy analysts
- Draws on students and recent graduates from UC and other academic institutions for research assistants and postdoctoral appointments
- Some joint appointments at UC Berkeley and UC Davis campuses

Energy Markets, Policy and Analysis

Analyze and design effective energy and environmental approaches

Major Program Areas:

- Appliance Energy Standards
- Demand Response Research
- Energy markets and policy
  - Electricity markets
  - Consortium for Electric Reliability Technology Solutions (CERTS)
  - Renewable energy markets
  - Industrial energy
  - Water and energy
- Next generation analysis tools
  - Web-based tools for consumers
  - Non-technology factors in markets
  - Databases, statistical analysis, agent-based models



Major New Initiatives:

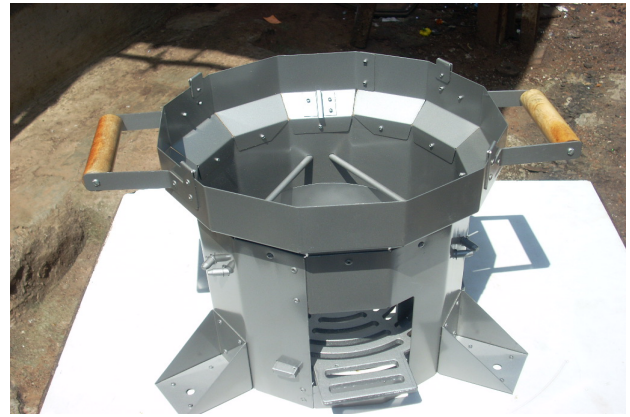
- CC2.0 LDRD strategic proposal
- Utilize exascale computing to build integrated models of energy technologies, markets and climate impacts
- Life cycle assessments for energy and health

International/Developing Countries

Berkeley Lab projects bringing solutions to the developing world

Major Program Areas:

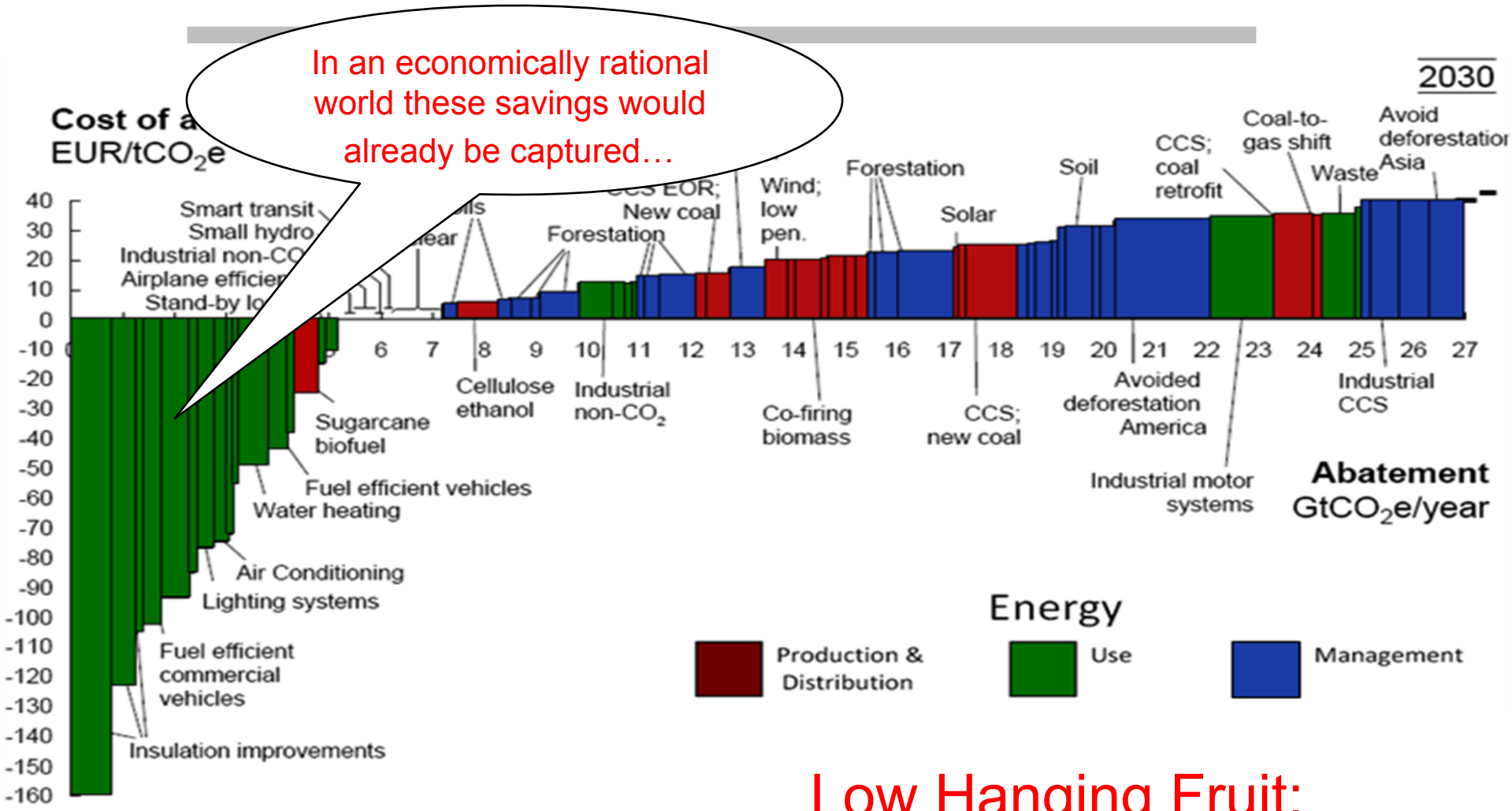
- China Group's work on energy efficiency, industrial best practices, buildings energy standards, technical assistance
- International Energy Group - informs and helps formulate and implement in-country energy and environmental policies
- The Berkeley-Darfur stove, and other stoves projects



Major New Initiatives:

- Energy efficient stoves for Haiti earthquake survivors
- Mongolia air quality and appliance standards
- China/US Energy Center - Buildings
- Projects in India on electricity market regulation and energy efficiency policy
- Projects in Ethiopia, Kazakhstan, Singapore, ASEAN
- Super-efficient Appliance Development – global project
- CLASP – global project

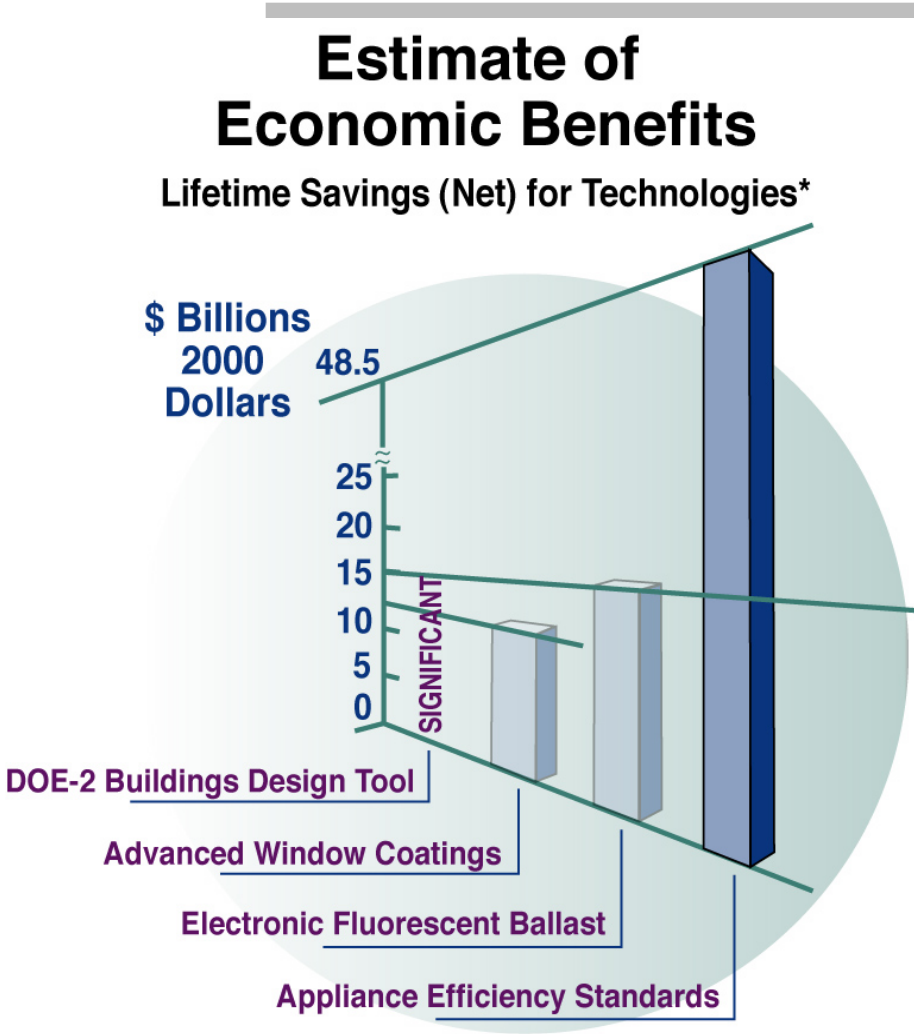
Saving Carbon vs. Energy Sectors
Production, Distribution, Use



Source: McKinsey Global Institute, 2007
Replotted: John Zysman, UCB

Low Hanging Fruit:
Energy Efficiency Pays for Itself

Prior Impacts of Efficiency R&D
From National Academy of Sciences Report (2001)

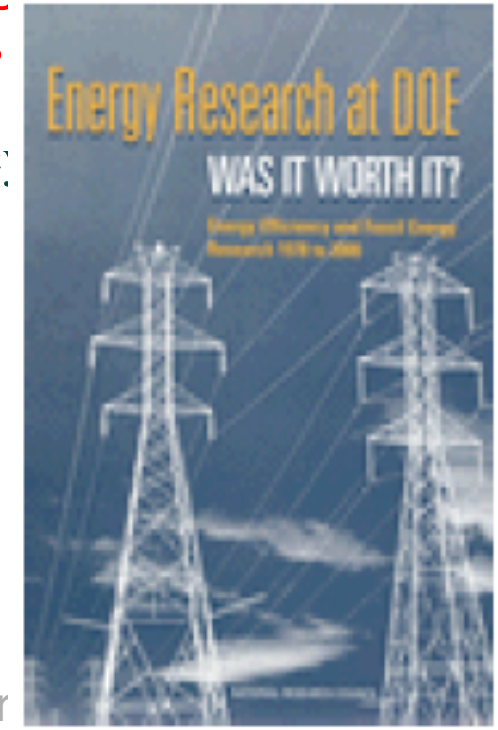


NAS estimate of economic benefits of EE R&D assigns $23 of $30 billion in savings to building technologies.

ROI => 1000/1 for successful investments;

Overall Portfolio shows net g
small number of big winners

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



U.S. Building Construction: ~ $1T/yr

Building Energy Consumption: ~$425B/yr

(The total cost of all higher education was $289B/yr in 2002: Wikipedia)

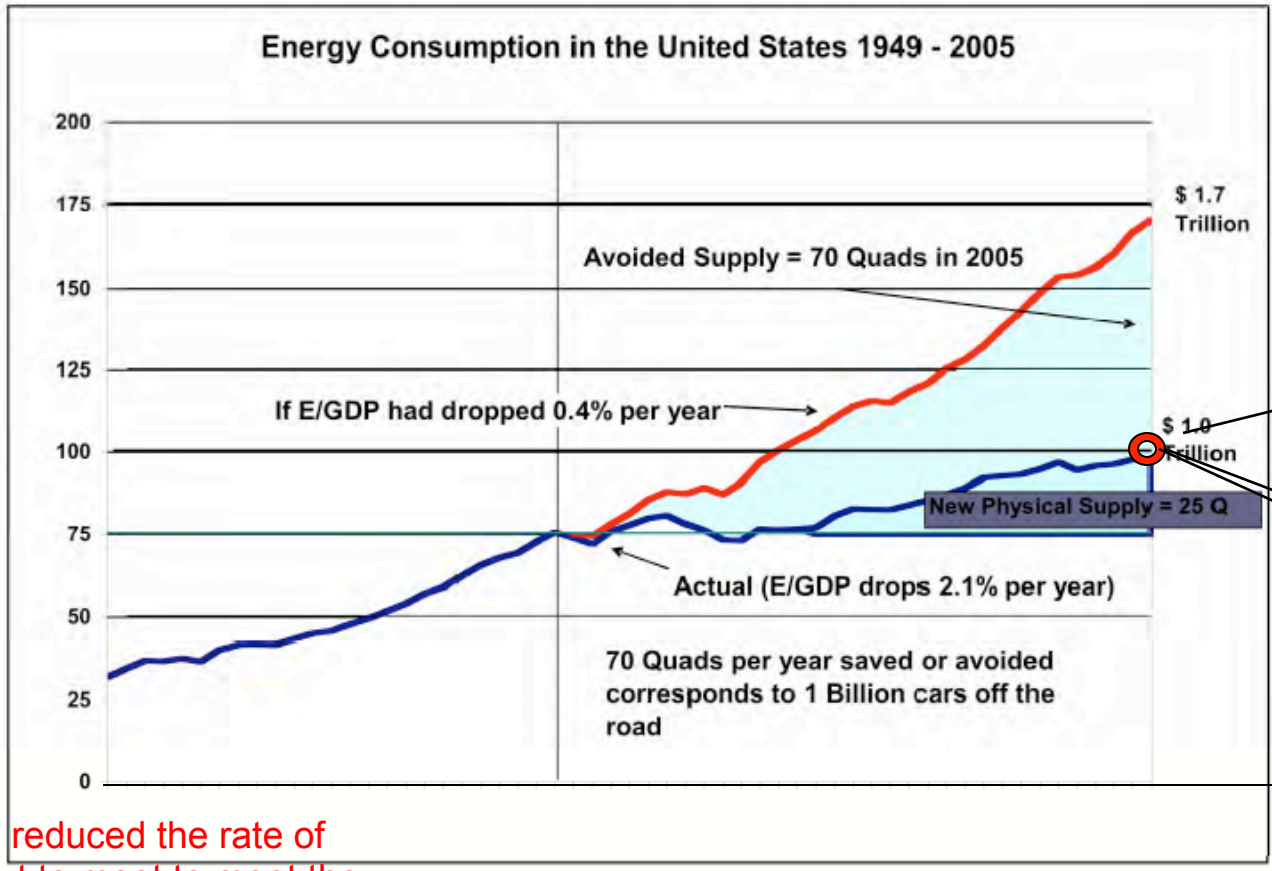
US. Department of Energy Buildings R&D Budget: ~ $100M/yr over the last decade -> 4000:1

“Gentlemen, we have run out of money.

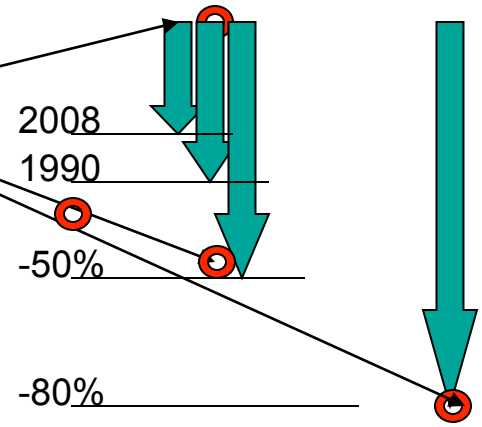
It is time to start thinking.”

Sir Ernest Rutherford, Nobel Laureate (Physics)

History and Future Needs
Good News/Bad News



Annual Energy Outlook Forecast ~ +30%

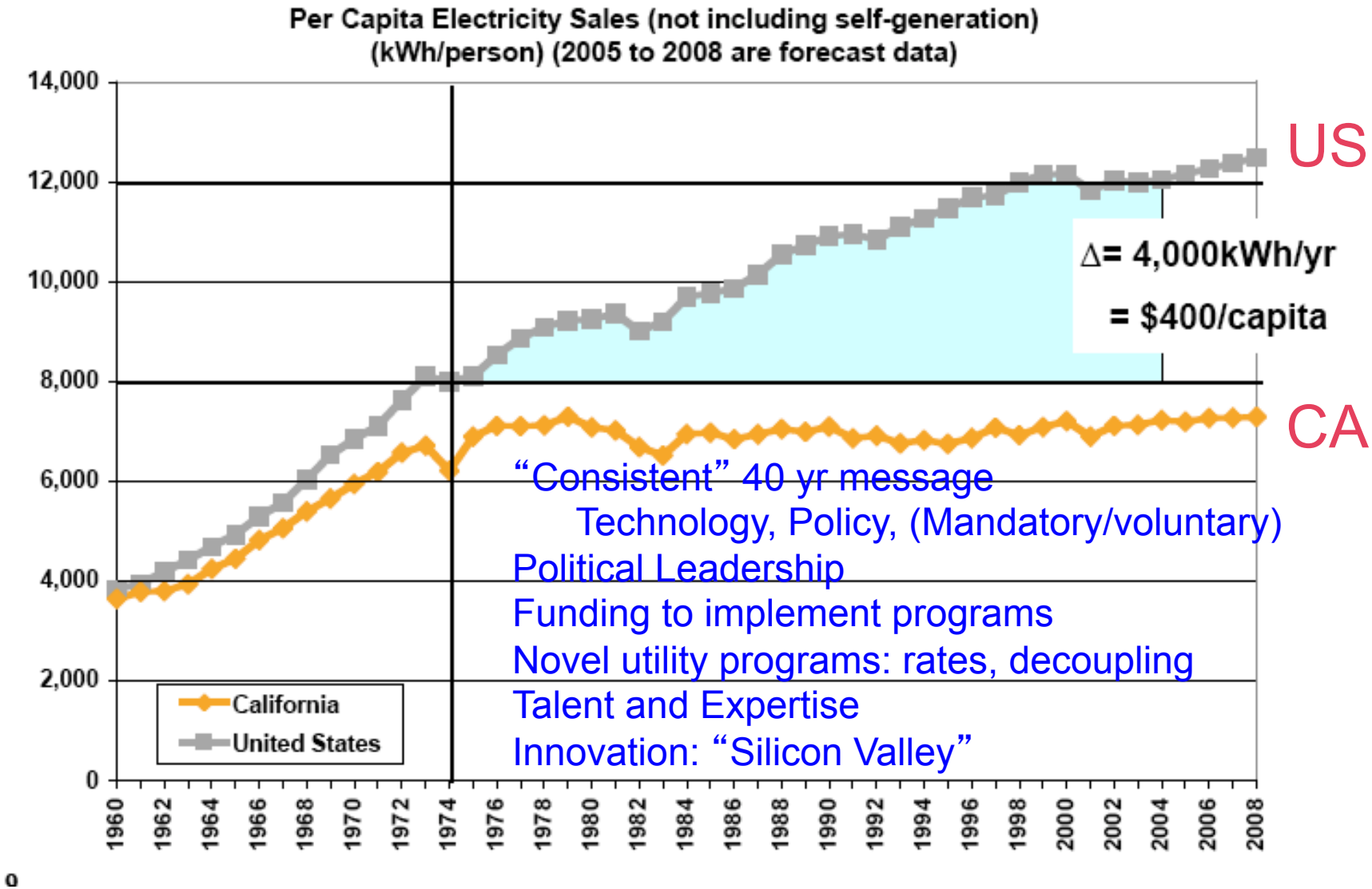


We've reduced the rate of growth but to meet to meet the various 2030- 2050 Energy and Carbon goals we need dramatic reductions, never before achieved

1973 2005 2020 2030 2050

Caution: Energy vs GHG goals

California Success to Date: Per Capita Electricity Sales



Note: per capita is flat is but Total still increases with Population

"BIG BOLD" ENERGY EFFICIENCY STRATEGIES




In order to guide market transformation in a number of key sectors, this Plan embraces four specific programmatic goals, known as the "Big Bold Energy Efficiency Strategies," established by the CPUC in D.07-10-032 and D.07-12-051.These goals were selected not only for their potential impact, but also for their easy comprehension and their ability to galvanize market players.

1. All new residential construction in California will be zero net energy by 2020;
2. All new commercial construction in California will be zero net energy by 2030;
3. Heating, Ventilation and Air Conditioning (HVAC) will be transformed to ensure that its energy performance is optimal for California's climate; and
4. All eligible low-income customers will be given the opportunity to participate in the low income energy efficiency program by 2020.

California:

All new residential construction will be zero net energy by 2025

All new commercial construction will be zero net energy by 2030

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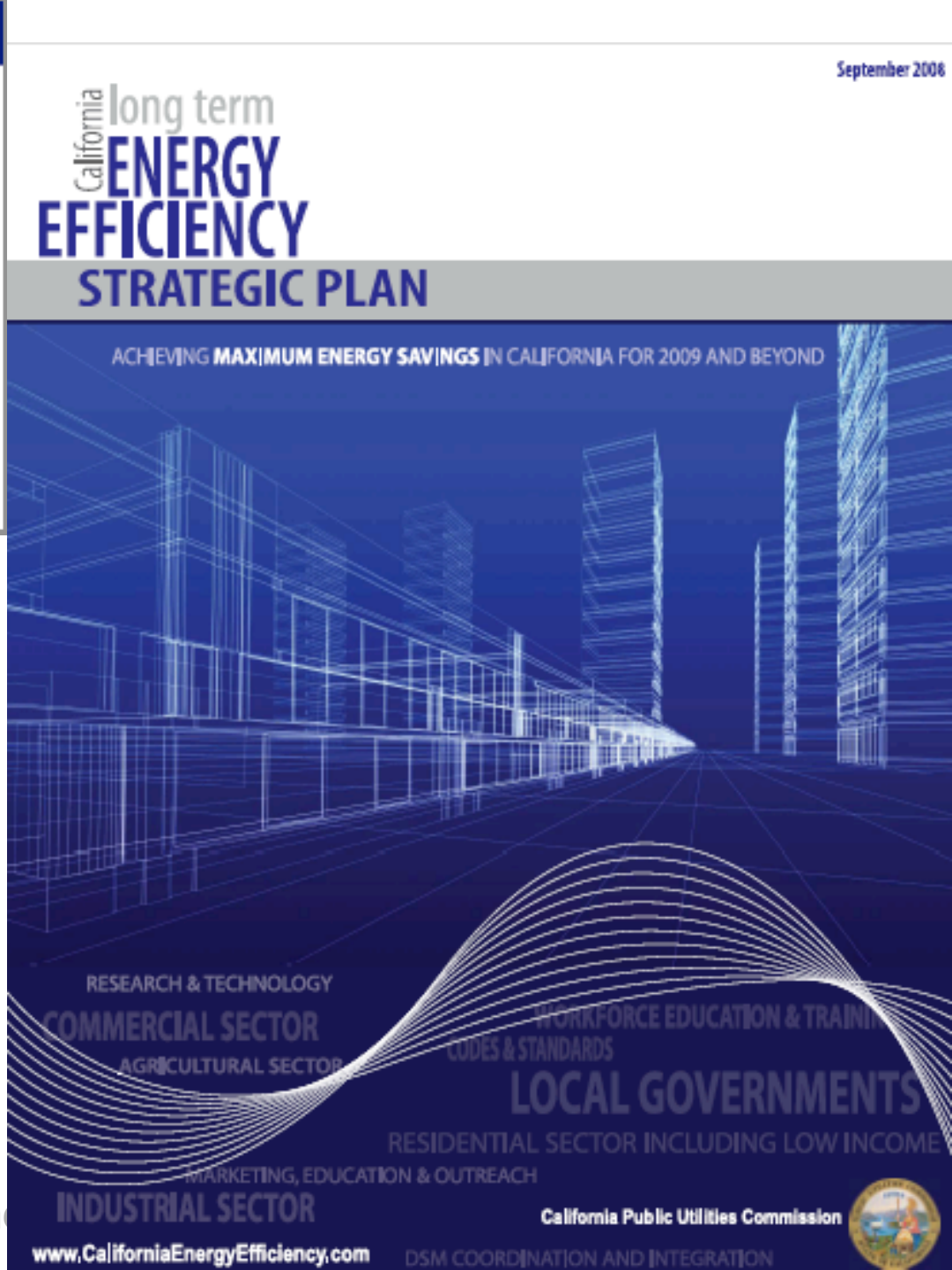
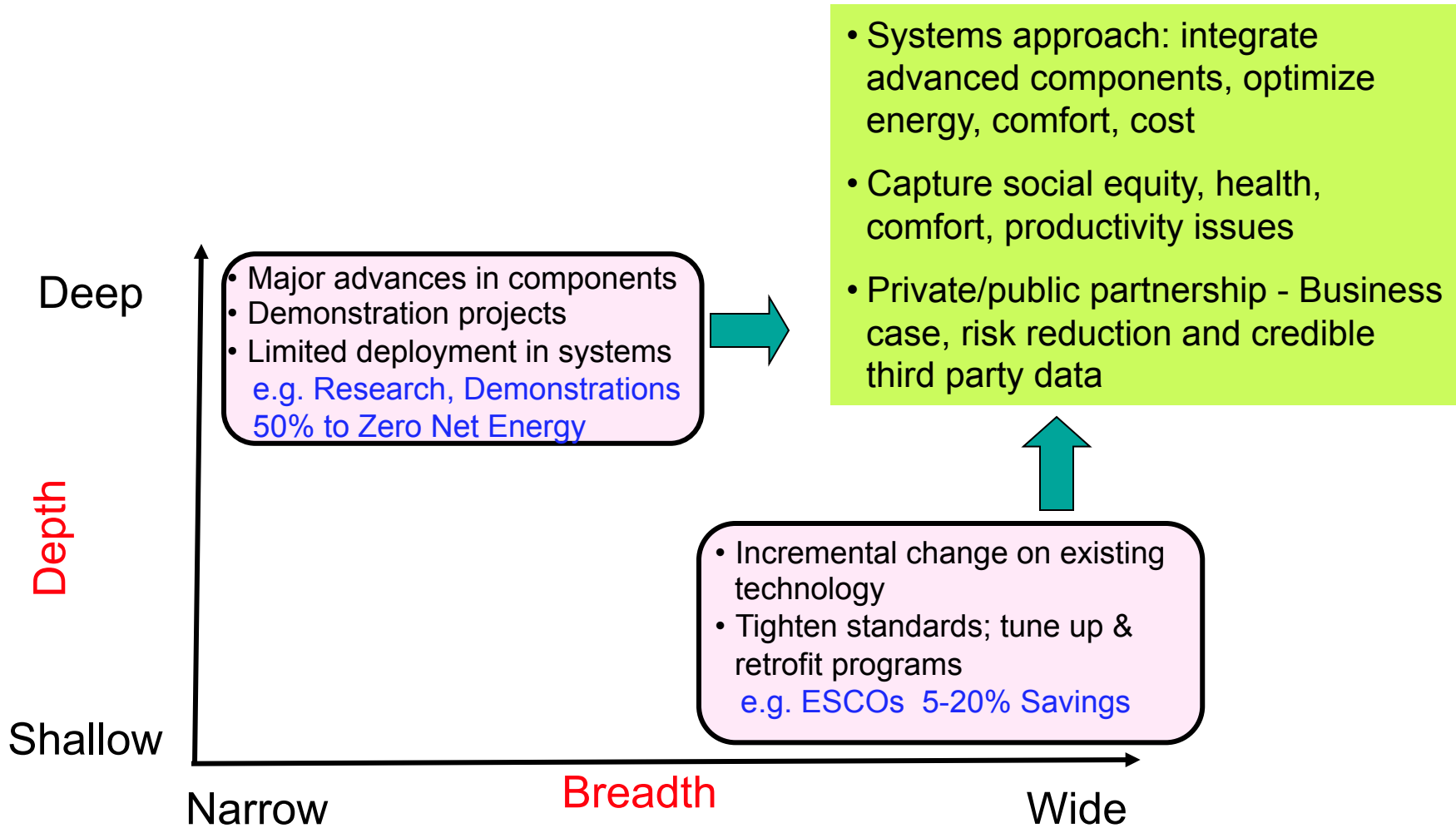


Scale and Impact:
Approaches to Achieve Sector-wide Efficiency Goals?



Buildings "Grand Challenge"

- Focus on Life Cycle of the Building
  - Design → Construction → Operations → Renovation→ Decommissioning
- Focus on Measurable, Documented Energy Impacts
  - Make performance visible, understandable, actionable
- Focus on Integrated Smart Building Systems
  - Materials → Devices → Integrated Systems → Buildings
- Focus on Buildings and the Grid
  - Renewables, Storage, Microgrids, Neighborhoods, "Smart Grid"
- Focus on People and Behavior
  - Policy makers, Designers, Investors, Contractors, Occupants,..
  - Occupant behavior, life style, satisfaction, comfort,….
- Focus on "Intersection" of Technology and Policy
  - Incremental + Innovative, Disruptive technologies
  - Investment and Decision making

Building Innovation "Game Changers"

MATERIALS AND SYSTEMS

- Smart Glass/Dynamic solar control
- High R Windows, Insulation
- Thermal Storage- Envelope, structural

- 200 lumen/watt lighting
- Daylight integration
- Dimmable, Addressable Lighting Controls

- Task Conditioning HVAC
- Climate Integrated HVAC
- HVAC vs comfort and IEQ

- Miscellaneous Electrical Loads

- Demand Response
- Controls infrastructure- sensors, networks
- Building- and Grid- Smart electronics
- Electrical Storage

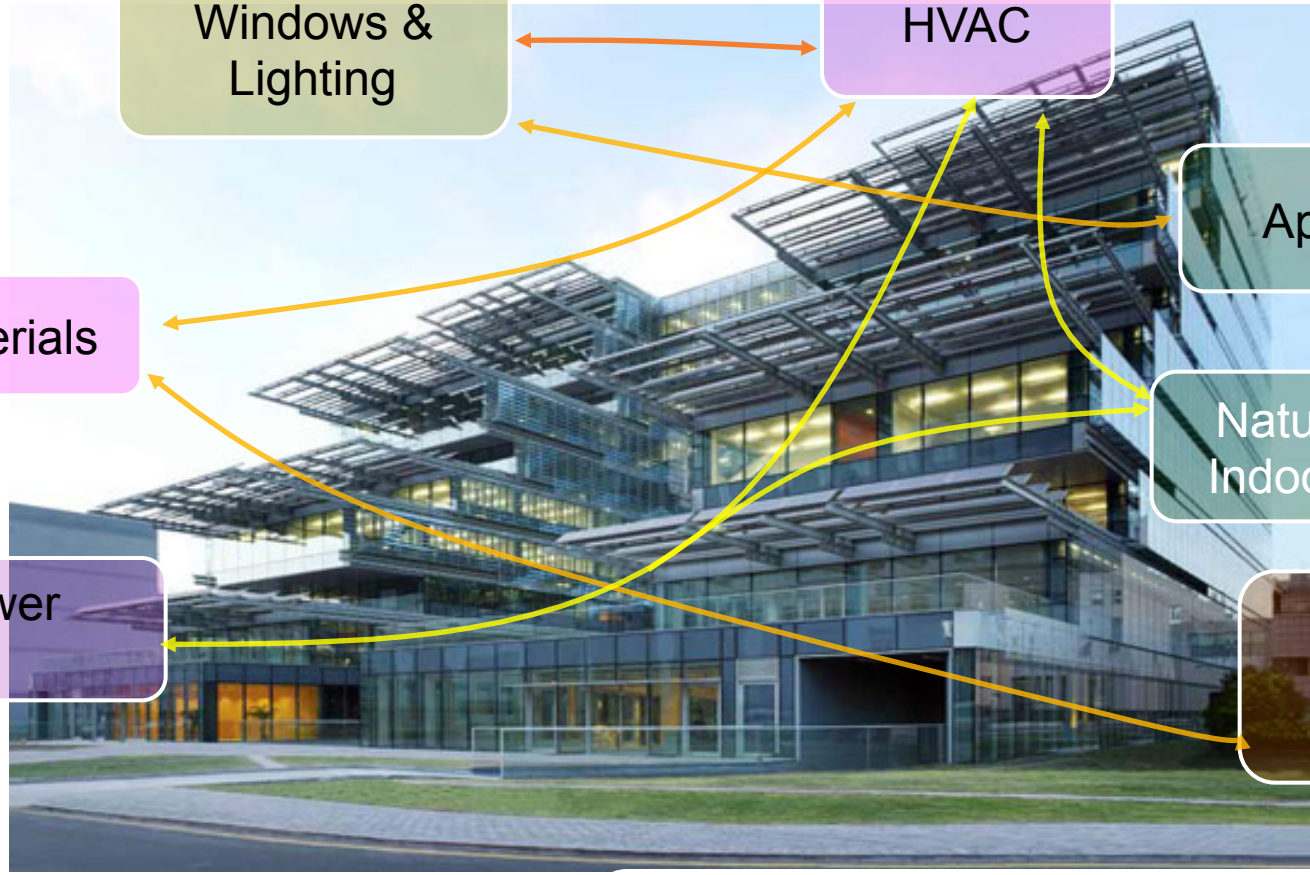
LIFE-CYCLE OPERATIONS

- Building Life Cycle Perspective
- Benchmarks and Metrics
- Building Information Models (BIM)
- Integrated Design Process and Tools
- Building Operating Controls/Platform
- Building Performance Dashboards

- Understanding Occupants/Behavior
- Facility Operations

System of Systems

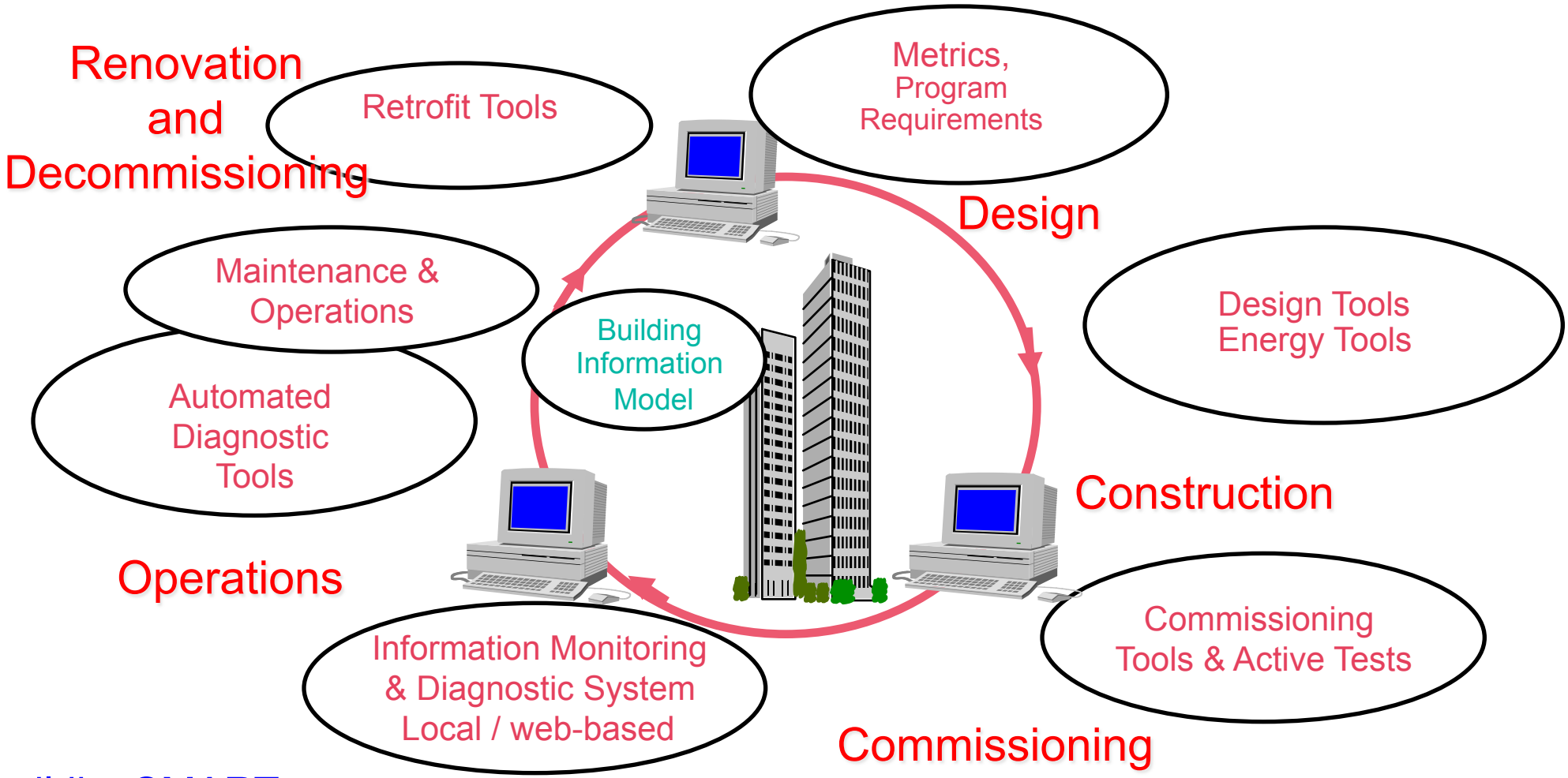
Integrated Whole Building Approach



Building Design Platform:
Tool for Architects to Design New Buildings With Embedded Energy Analysis

Building Operating Platform
Sensors, Communication, Controls,
Real-Time Optimization for Cost, Energy Use, CO_2 Footprint

Information-Technology based Building Life-Cycle Integration View



buildingSMART
Data model

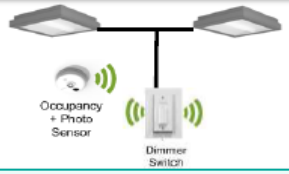
BERKELEY LAB

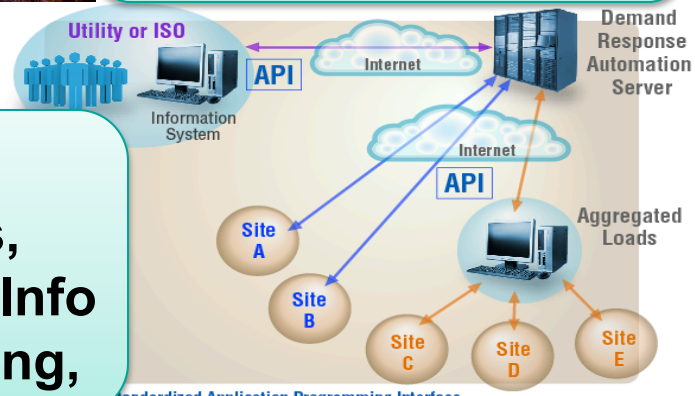
Commercial Buildings Research

Windows, Daylighting & Lighting Controls

Ventilation, Indoor Environmental Quality

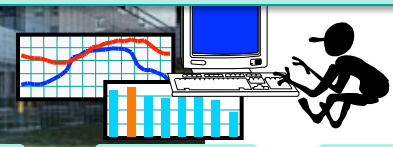
Grid Responsive Integration, On-Site Generation





Computational Tools, Interoperability, Design, Retrofit, O&M

Actionable Information Systems, Benchmarking, Energy Info Systems, Commissioning,

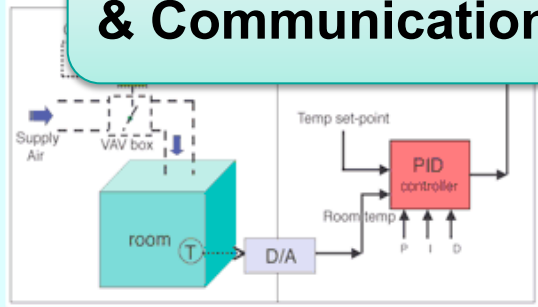


Data → Information → Action

Deployment, DSM Policies & Programs, Market Assessment and EM&V

Hi-Tech Buildings. Labs, Data Centers

Sensors, Controls & Communications



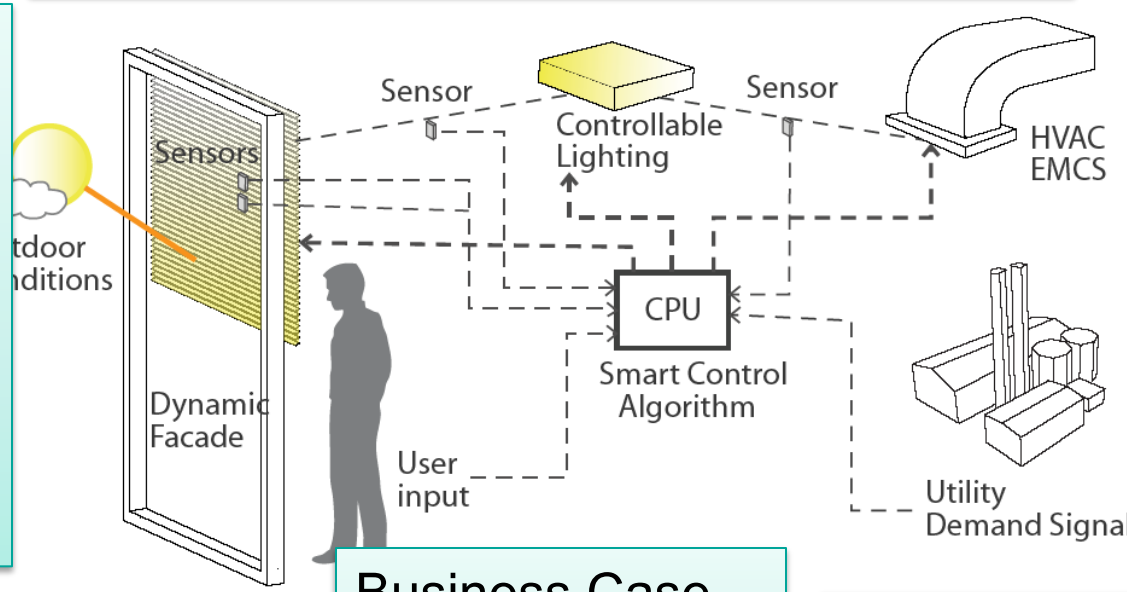
Advanced Facades and Daylighting

Program Goals:
Net Zero Energy Balance for New and Retrofit
Enhanced View and Thermal Comfort
Reliable, cost effective operations
Tools to design, optimize, specify, control
Adoption/diffusion throughout industry

Application:
All climates
All Building types
New-Replacement-Retrofit

Program Activities:
Simulation
Optimization
Lab test
Field Test
Demonstrations
Standards

Advanced Technologies:
Sensors;
Controls;
Hi R windows,
Cool coatings;
Switchable coatings;
Automated Shading;
Daylight-redirecting
Operable windows,



Human Factors:
Thermal comfort
Visual comfort
Satisfaction
Performance

Business Case
Manufacturing
Installation
Commissioning
Reliability
Cost

Decision Tools
Books, Guides
Websites
Simulation Tools
Testbeds

Partners
Manufacturers
Owners
Architects
Engineers
Specifiers
Code officials
Contractors
Utilities

Benefits of High Performance Building Systems

Improve Occupant Comfort, Satisfaction and Performance

Occupant

Add Value, Reduce Operating Costs

Building Owner

Reduce Energy, Greenhouse Gas Emissions

Planet