Philips Visit to LBNL

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End Use Energy Efficiency Perspectives:

Creating a New Generation of Carbon-Neutral Commercial Buildings

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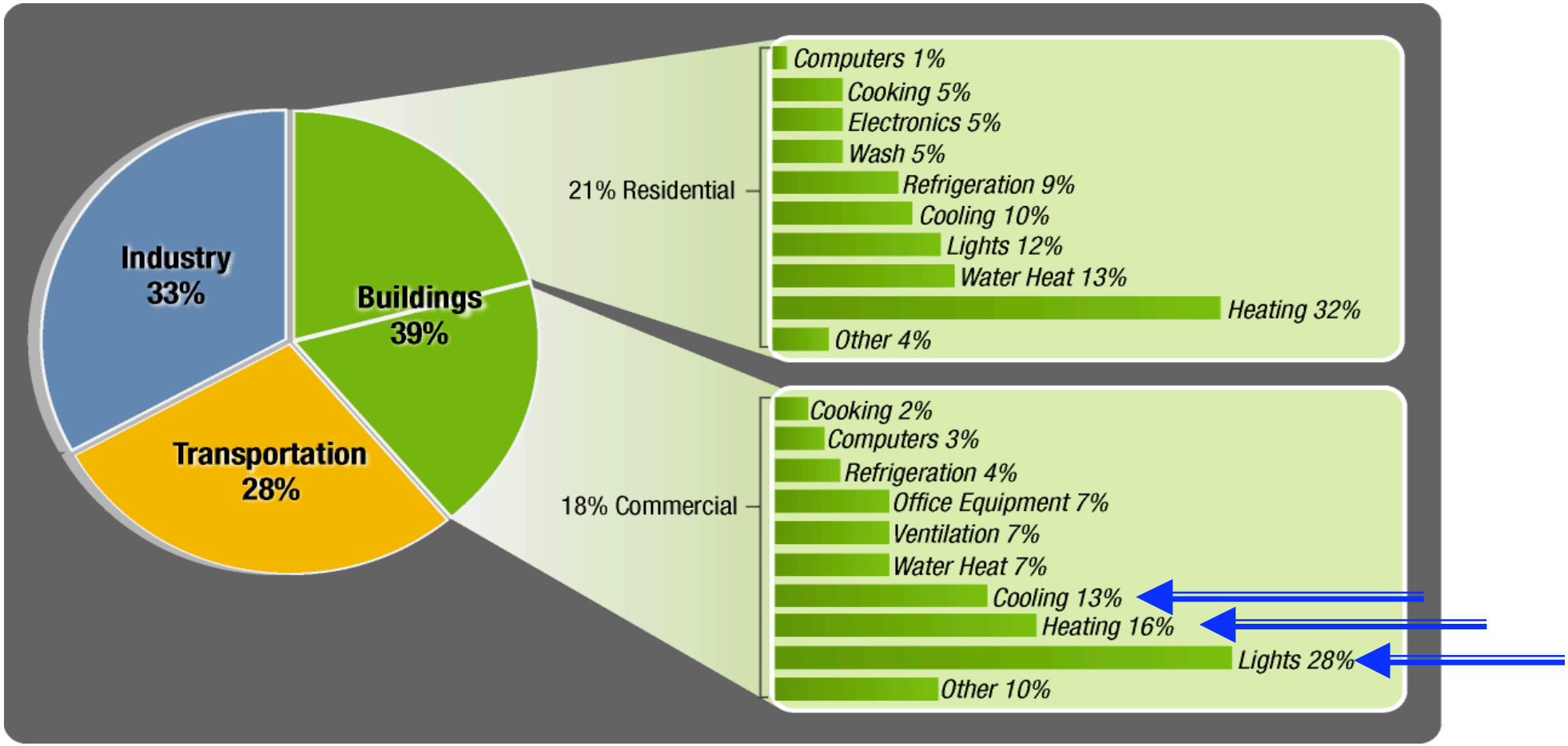
Building Energy Demand Challenge:
End Use Energy Consumption

Buildings consume 39% of total U.S. energy

- ***71% of electricity and 54% of natural gas***



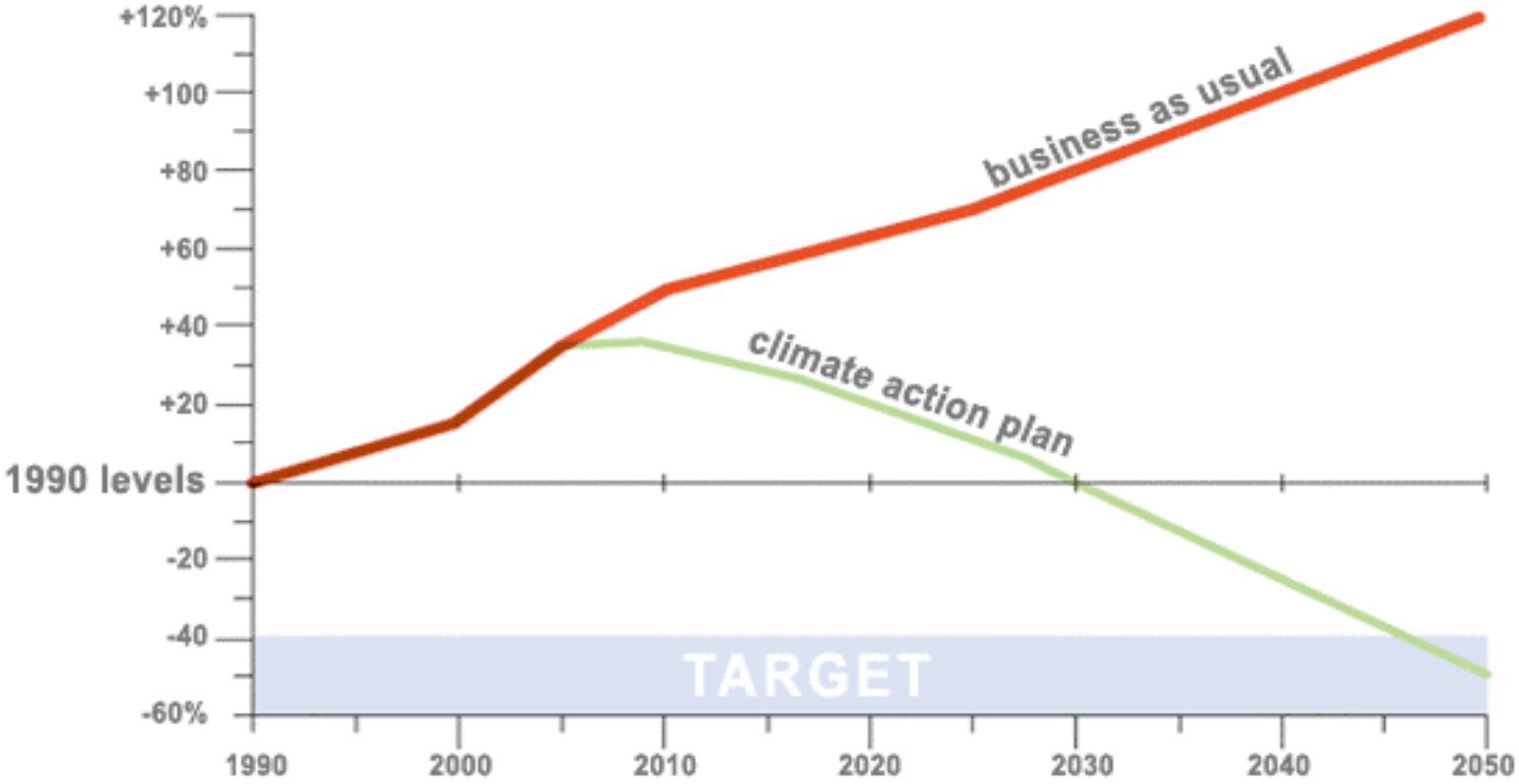
Reducing Energy/Carbon Impacts of Buildings

- **It is critically important to *rapidly and drastically* reduce energy/carbon impacts of buildings**

- **Buildings are**
  - **40% of energy use**
  - **70% of electricity use;**
  - **Today, electricity use drives carbon emissions due to utility shift to coal**

- **Can We Make a Difference?**
- **How Do We Reinvent Our Future?**

Goals of 2030 Challenge:
"carbon neutral by 2030"



“Carbon Neutral Building”

- **Aggressively reduce the demand for energy**
  - Reduce heating and cooling loads
  - Satisfy loads via passive means when possible
  - Design and Select the most efficient equipment and systems
  - Operate and maintain the systems to minimize energy use

  - **Result: 40-90% reduction in net energy use**

- **Generate carbon-free, on-site power = to residual energy demand**

- **Result: “Net” Carbon Neutral Building**

Framing the *Problem*

- **Energy availability, reliability and cost are critical global policy issues**
  - Major driver of carbon emissions and global warming
  - Energy is essential element of our economy and well being
- **Risks are high and increasing:**
  - Potential for serious energy supply disruptions is high
  - Energy disruptions would cause major economic turmoil
  - Energy supplies often international flash points
- **Carbon emissions approaching tipping point; window to take aggressive action to reverse trends is closing, we must act now…**
  - We are not running out of “energy”, rather cheap, accessible, carbon-free energy

Framing the *Solution*

- **Supply - Need non-carbon based sources**
  - Capture and sequester carbon
  - Need massive quantities of liquid fuels
  - Renewable sources: e.g. wind, PV
  - But all require 20 yr + to have significant impact on stabilizing carbon emissions

- **Must Reduce Energy End Use Demand -**
  - Aggressive reductions in end use
  - Buys time for other options to be developed
  - All sectors, especially buildings

- **Good News**
  - Its possible to reduce energy use by 50% or more, now!
  - But not routinely achieved…
- **Bad News**
  - We must do even more- getting to Carbon Neutral buildings
  - Even more challenging…

Our Focus: The Energy Demand Challenge
Our Focus: Building End Use

- Building sector is a key target for action now because:
  - Responsible for 40% of U.S, Energy, $320B/yr
    - Construction - $570B/yr
  - Responsible for 70% of U.S. Electricity

  - *Potential* for savings is very large, but….
    - Market forces won't produce required results, but essential for the overall solution
    - Need public/private partnership at scale suitable to the problem
    - No existing large scale effort today to address the problem

Building Energy End Use Efficiency

- Current programs fall into two categories:
- "Wide and Shallow"
  - **Numerous modest, incremental refinements on existing technology or incremental R&D advances,…**
  - **Improve implementation programs: tighten standards periodically, create "tune-up" and retrofit programs,….**
- "Narrow and Deep"
  - **Major advances, but limited deployment**
  - **"Green buildings" - 30-50% better than code (but only a small fraction achieve these levels today)**
  - **Demonstration projects - "zero net energy buildings" reduce energy use by 70-80%; supply remaining needs with PV**
- Need a New Goal: "Wide and Deep" (and persistent…)
- Focus: Commercial sector

What's Missing?

- None of these programs is likely to "solve" the problem, i.e. produce the changes in energy use needed.
- Lack vision, resources, scope, …

- Can we create a "wide and deep" activity that might succeed in achieving aggressive goals?
  - Technically sound
  - Business sense
  - Marketable ("investment grade") to supporters
- Our Focus: Energy, Carbon and Climate Change
  - but address Social equity, health, comfort, productivity…..

Next Steps

Next Steps

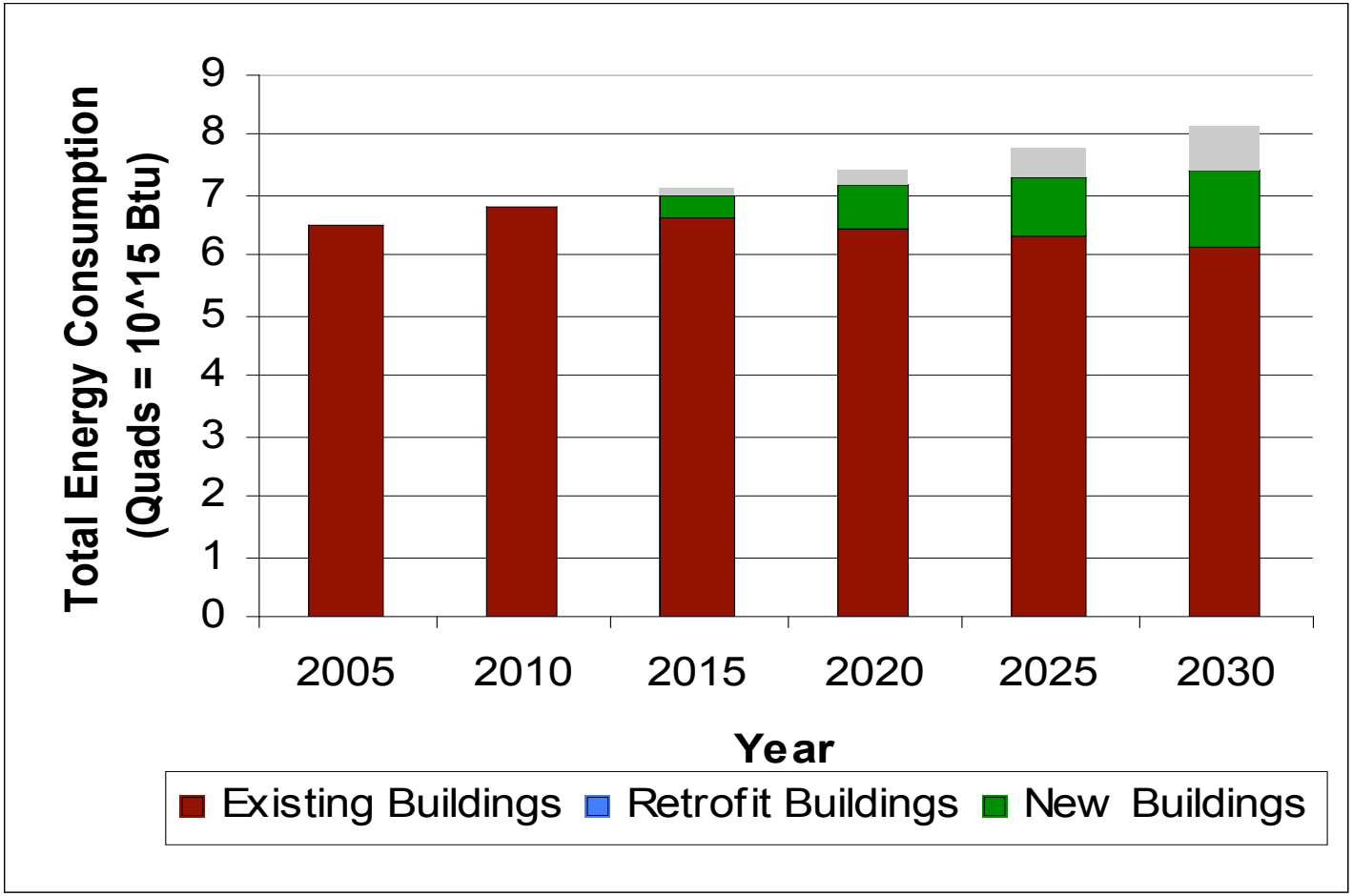
- Layout and fund the “vision/roadmap” action
- 1 year: Generate a comprehensive, marketable vision with clear goals and a roadmap to achieve them
- 10-20 years: Carry out a serious, large, aggressive, well-funded, well managed multi-year effort
  - Integrated *Deployment, Demonstration, Innovation* program
    - Deploy more widely solutions that work well today
    - Demonstrate emerging solutions to feed the deployment pathway
    - Innovate to provide new breakthrough solutions to high-payoff problems

    - Define high-value systems solutions that are needed as part of Zero Energy Performance packages
    - Need decision-support tools, new information technologies
    - Address performance across building life-cycle; design- construct-operate

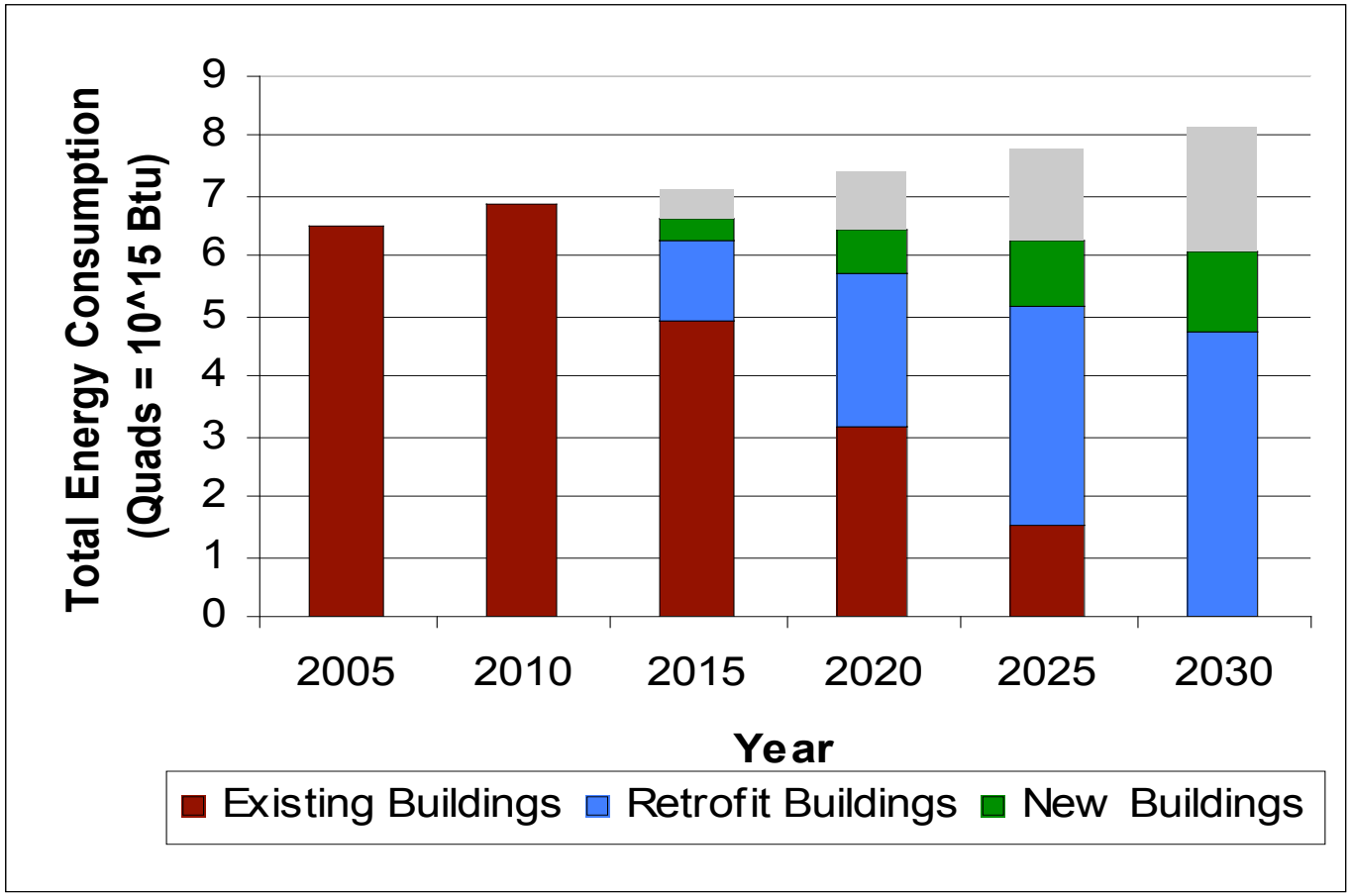
Key Program Elements

- Deployment - facilitates widespread implementation of known, proven and deployable practices, technologies and building systems
- Demonstration - feed the deployment pipelines, providing reliable performance data for new systems and solutions that exist but are not yet widely known or utilized.
- Innovation - achieving the very aggressive goals of carbon neutral buildings will require research- based innovation to solve known and emerging problems with technology, systems integration, performance prediction, etc
- Investment/Decision support - tools and information management at all levels to drive optimal investment of resources and effort

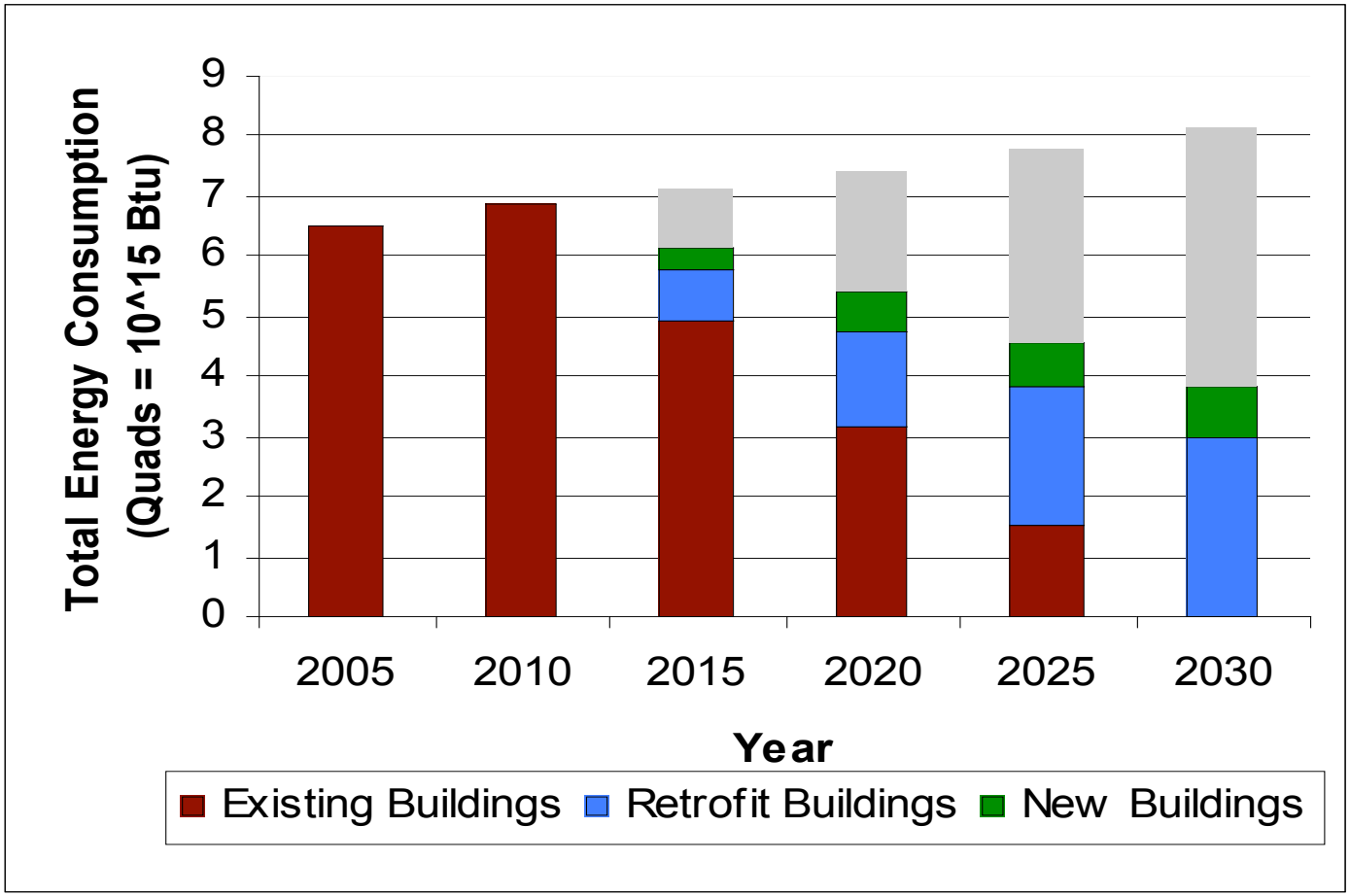
Scenario 1:
New Buildings Save 50% by 2030



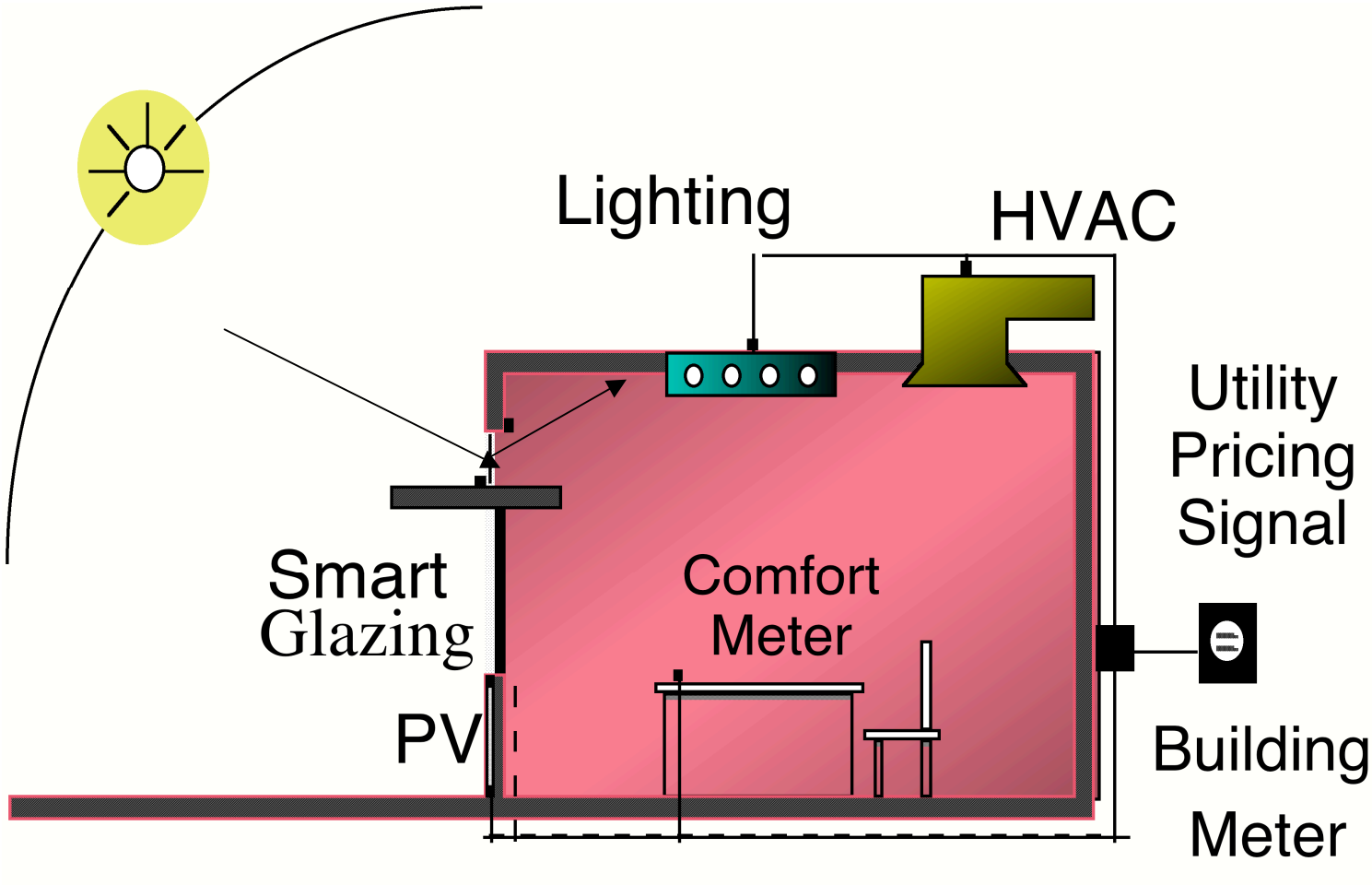
Scenario 2: New Buildings Save 50% plus 20% Retrofit Savings by 2030



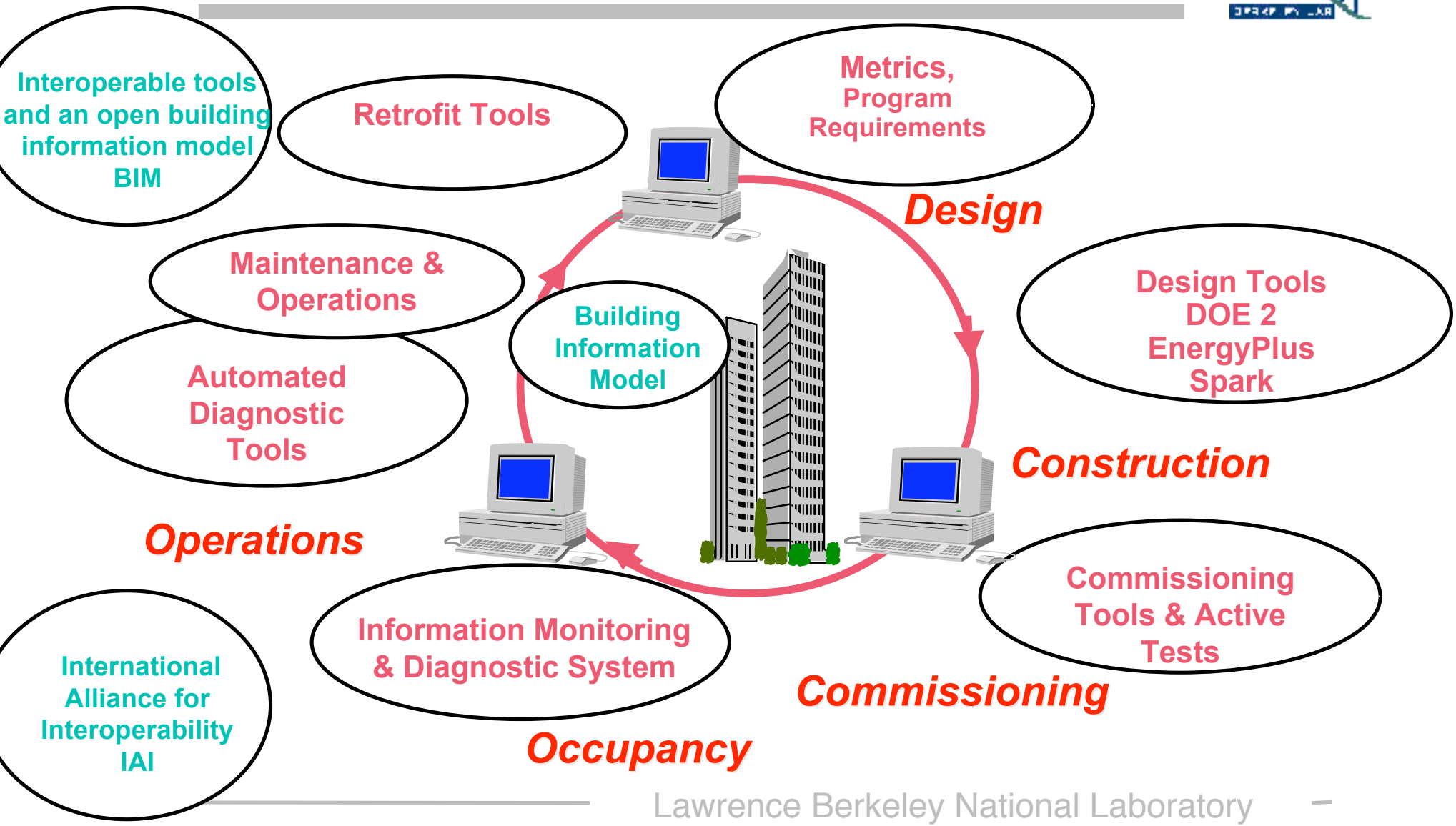
Scenario 3: New Buildings Save 90% by 2030 plus 50% Retrofit Savings by 2030



Conceptual Design for a Carbon-Neutral Office using an Integrated Building Facade Systems



Information Technology-based Building Life-Cycle Performance View

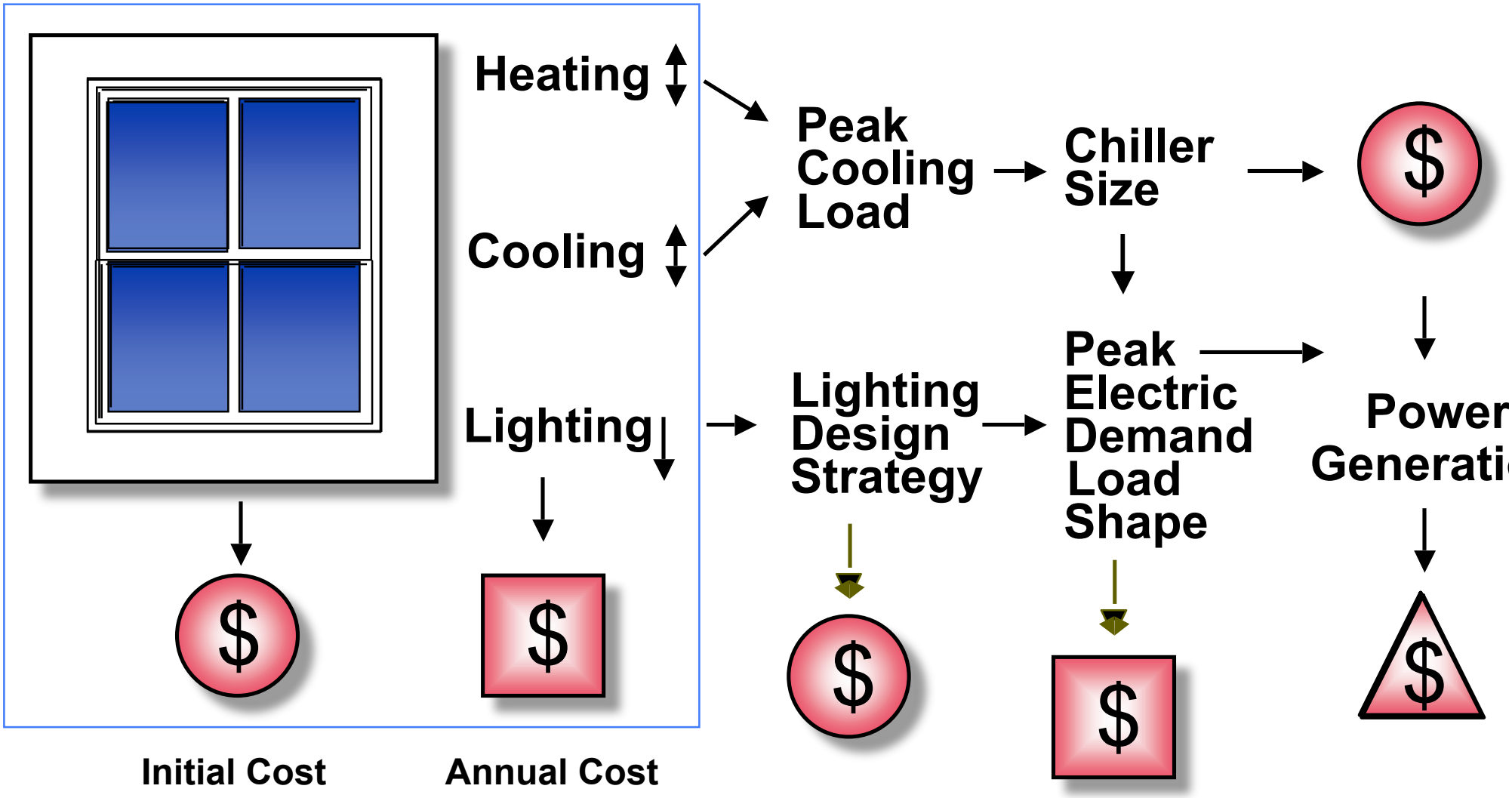


Energy Costs in Perspective

Cost / Sq. Ft. Floor -Year

- Energy Cost: $2.00
- Maintenance: $3.00
- Taxes: $3.00
- Rent: $30.00
- "Productivity" $300.00

System integration Cost tradeoffs



Diagnostics and Controls for Commercial Buildings

- Goal:
  - Transform ability to aggressively control energy use in commercial buildings through information technology (monitoring, diagnostics, and new tools)
- Significance:
  - 10- 20% savings achievable through low-cost operational modifications (e.g., simple fixes) of existing buildings
  - "Optimal" control likely to yield >30% savings
  - Even greater savings needed for zero energy buildings; ultimate goal is 60-70% reductions
  - Automated controls infrastructure can support demand response during electricity supply shortages
    - Note: commercial buildings consume >35% of total electricity

- LBNL Role:
  - Leadership, in partnership with major private firms and public organizations
  - Develop and test new integrated systems, automated controls and novel operating strategies for both efficiency and demand response

Diagnostics and Controls for Commercial Buildings

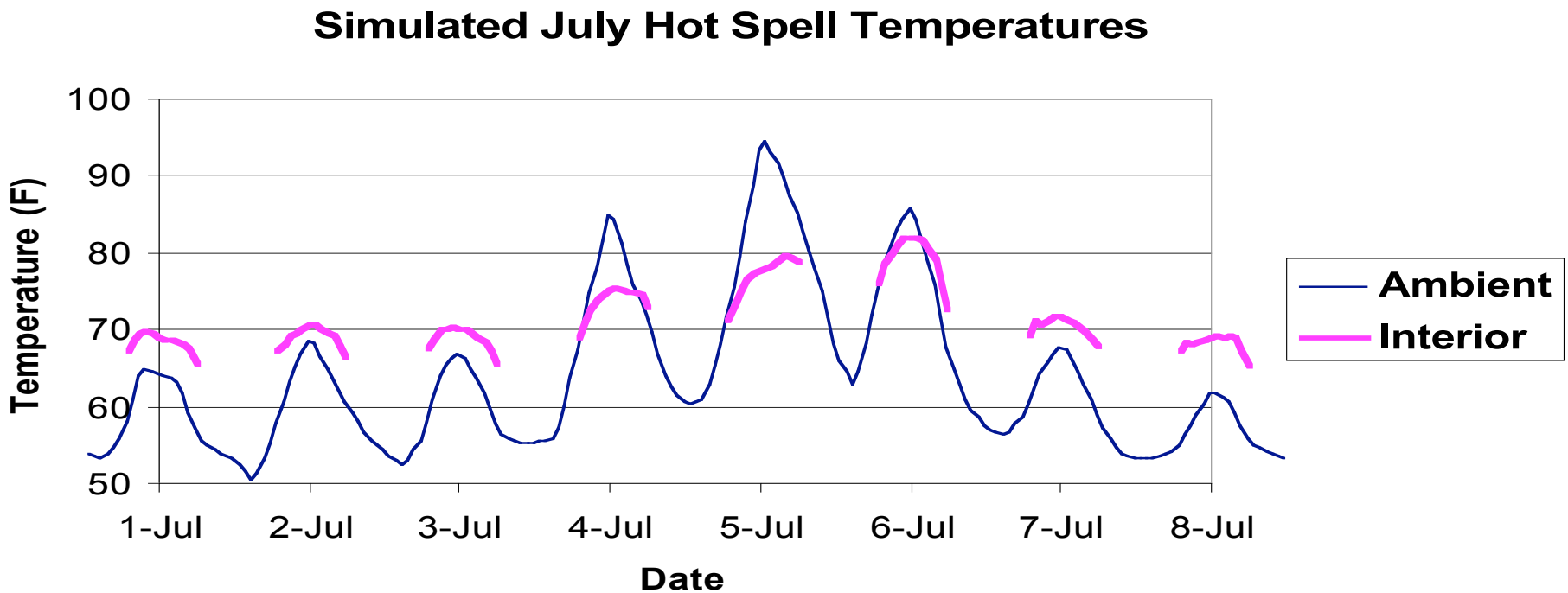
- **Current commercial buildings R&D program - a large collection of small, short term projects from multiple sponsors**
- **New effort to define a National R&D Agenda and Roadmap for Commercial Buildings and generate funding support to launch a multi-year, integrated R&D program.**
  - Supports aggressive ZEB goals but address shorter term industry interests as well
  - Combine national program with state and regional efforts
  - Link to growing interest in sustainable design that addresses need for building stock with "carbon-neutral" impacts.

Controls for Natural Ventilation: the New San Francisco Federal Building

- Natural ventilation in tower – no mechanical cooling or ventilation in open-plan perimeter office space
- Mechanically operated and manually operated windows
- Extensive daylighting
- Designed with state-of-the-art simulation tools, EnergyPlus* and CFD
- Control system tested with EnergyPlus prior to installation

Design Support for SFFB

- Can the building ride through the occasional hot spells without mechanical cooling - *Ye*
- Is a double façade required – *No (savings: $1.5M)*



Role of simulation:

- ***select system***
- ***give designers and client confidence that natural ventilation will work***

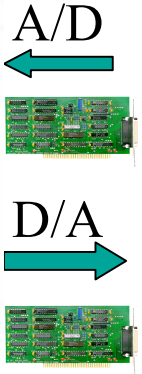
Control System Testing Using EnergyPlus

Control system tested using design simulation:

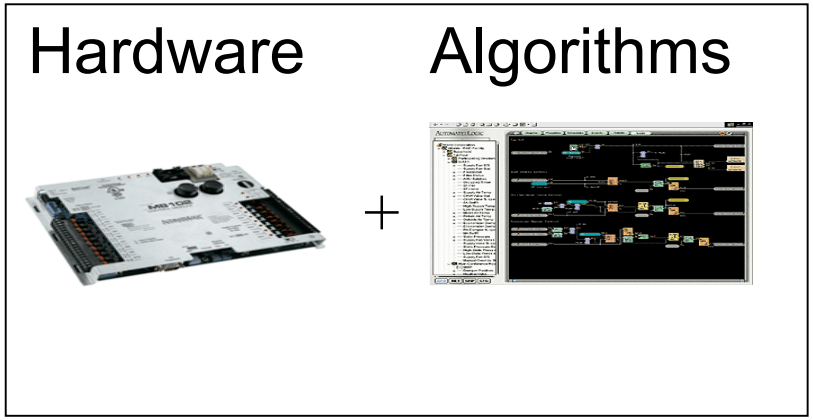
- Real-time EnergyPlus with hardware interface
- Control hardware from the building
- Control program as implemented by controls contractor

Virtual Building

EnergyPlus & SPARK



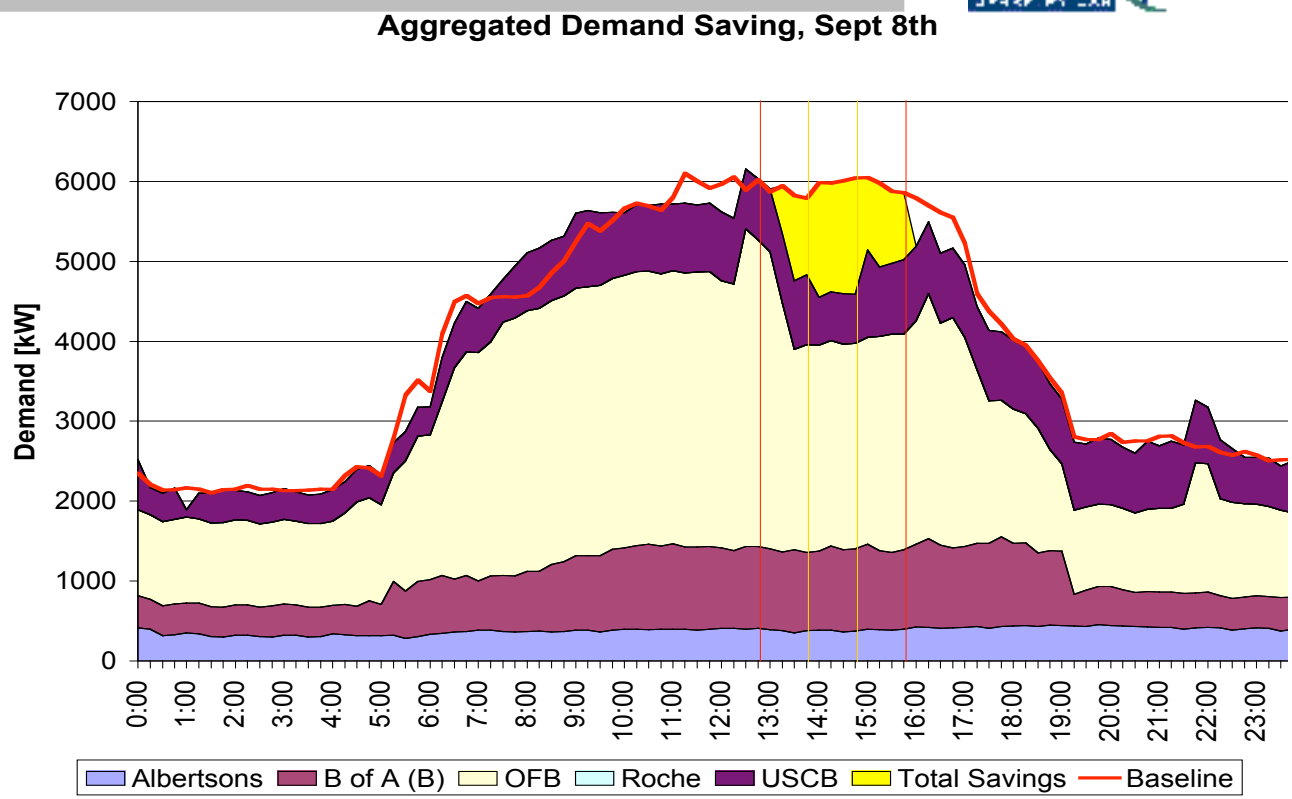
Real Control System



- Pre-commissioning of the controls before installation allowed programming problems to be identified and fixed well be occupancy
- Simulation can provide a quantitative link between design and operations

Fully Automated Demand Response: DR Research Center Project

- Demand Response is a strategy for shifting and shedding load to reduce peak electric demand
- Demand response can obviate the need for new fossil fuel plants
- Requires control systems to be operating correctly



- LBNL demonstrated fully automated demand response using an Internet price signal – large sheds with no complaints
- First steps toward enabling policy and adoption of technology in code