Philips Visit to LBNL

December 7, 2007

Energy Efficiency Perspectives:

Business Opportunities in Moving Towards Zero Energy Buildings

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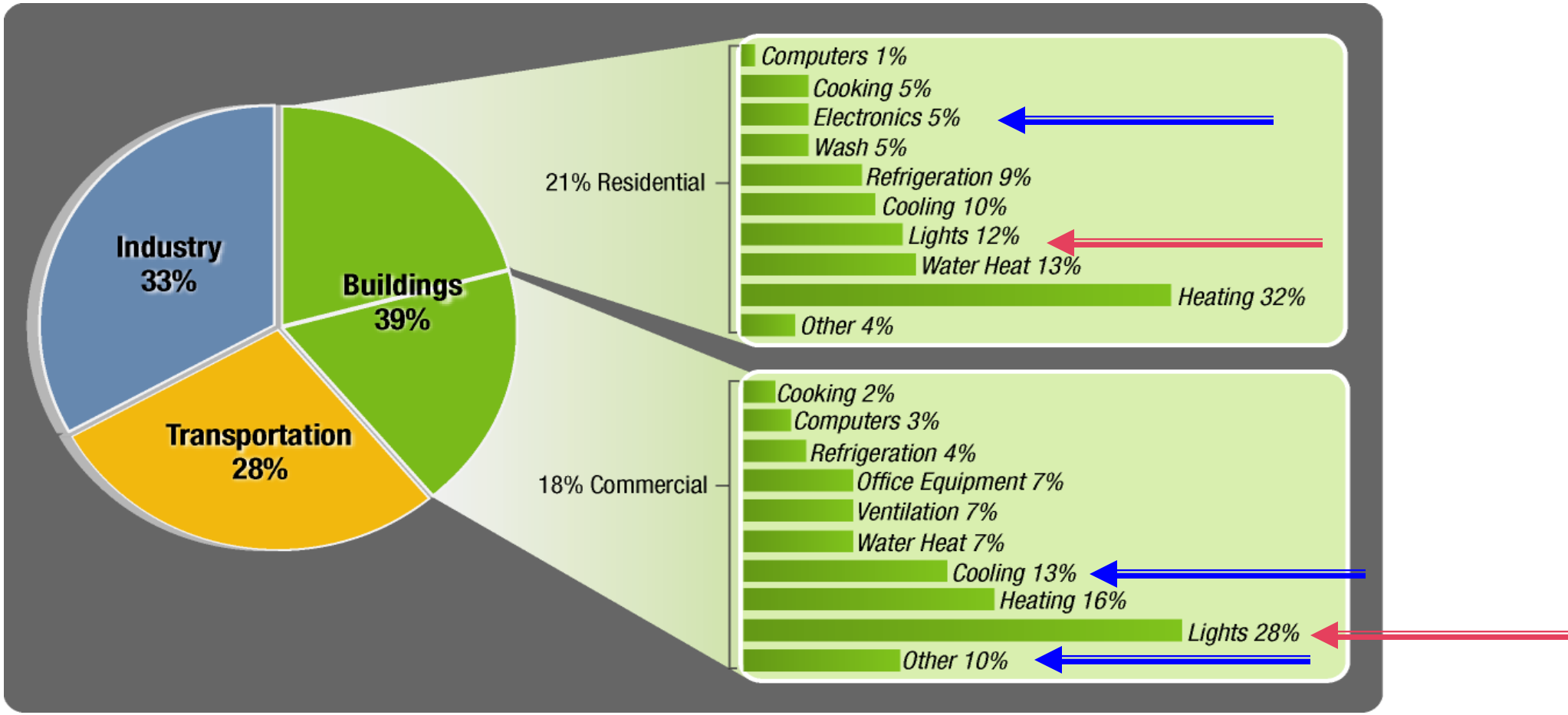
Reducing Energy/Carbon Impacts of Buildings

- **It is critically important to *rapidly and dramatically* reduce energy/carbon and cost impacts of buildings**
  - **Mainstream thinking in Europe**
  - **Accepted by leading global/U.S. corporations: WBCSD**
  - **Building professionals engaged: AIA, ASHRAE, USGBC**
  - **Aggressive action planned by California, other states**
  - **U. S. National activity "in transition"**
- **U.S. Buildings:**
  - **40% of energy use, 40% of carbon emissions**
  - **70% of electricity use;**
    - **Electricity use drives carbon emissions due to utility reliance on coal**
    - **Grid infrastructure, security issues**
  - **Economic impacts**
    - **Construction/renovation: $1050B/yr**
    - **Energy: $340B/yr**
- **Energy Supply, Renewables in the spotlight- new Public Investment and VC interest**
    - **End use energy efficiency is the "stealth" business play**
    - **Opportunity for new initiatives, new markets, new businesses**

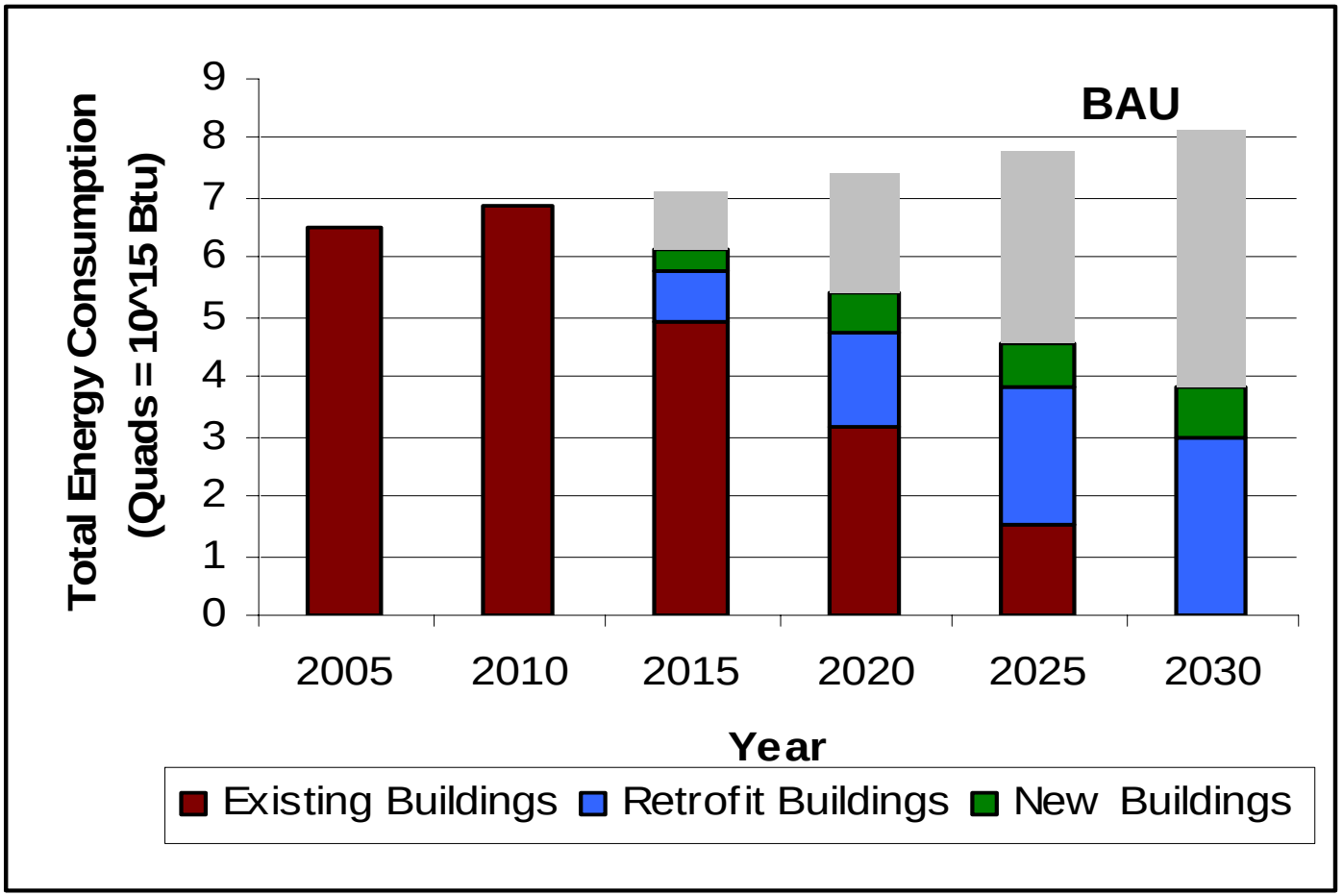
Building End Use Energy Consumption:
("No Silver Bullets")

Buildings consume 39% of total U.S. energy

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



What Will it Take to Achieve AIA, CPUC Targets?



These levels of efficiency are unlikely to be achieved by market forces alone;

Major new public/private initiatives to drive toward goals

Business opportunities for firms with "solutions"

New Commercial Buildings Save 90% by 2030
plus *50% Retrofit Savings by 2030*

Framing the *Solution*

- **Aggressive Reduction in Energy End Use Demand -**
  - Buys time for other supply options to be developed
  - All sectors, especially buildings
    - 2030 goal: Zero Net Energy Buildings, Carbon neutral buildings
    - Intermediate goals…..
- ***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
- **Corporations are beginning to take aggressive action**
  - Those that can't or don't will be left behind
  - Large Market opportunity for those who can deliver
- **Government beginning to take aggressive action**
  - Seeking industry partners; "doing well by doing good"
  - Business and image opportunity

Business Opportunity

- **Primary industry focus today**
  - Improved components
  - Quick, assured returns, Limited impacts
  - Utilities - “running out of candidates” for energy savings programs
- **New Opportunity: Shift from “components” to optimized “systems integration”**
  - More complex and Difficult- but fewer competitors
  - Systems solutions cannot be easily developed or deployed by small firms without market presence
  - Standards, reputation, national markets, etc - argue for large firms
- **Build upon market presence in Lighting**
  - Philips is already expanding from traditional “lamp and ballast” business

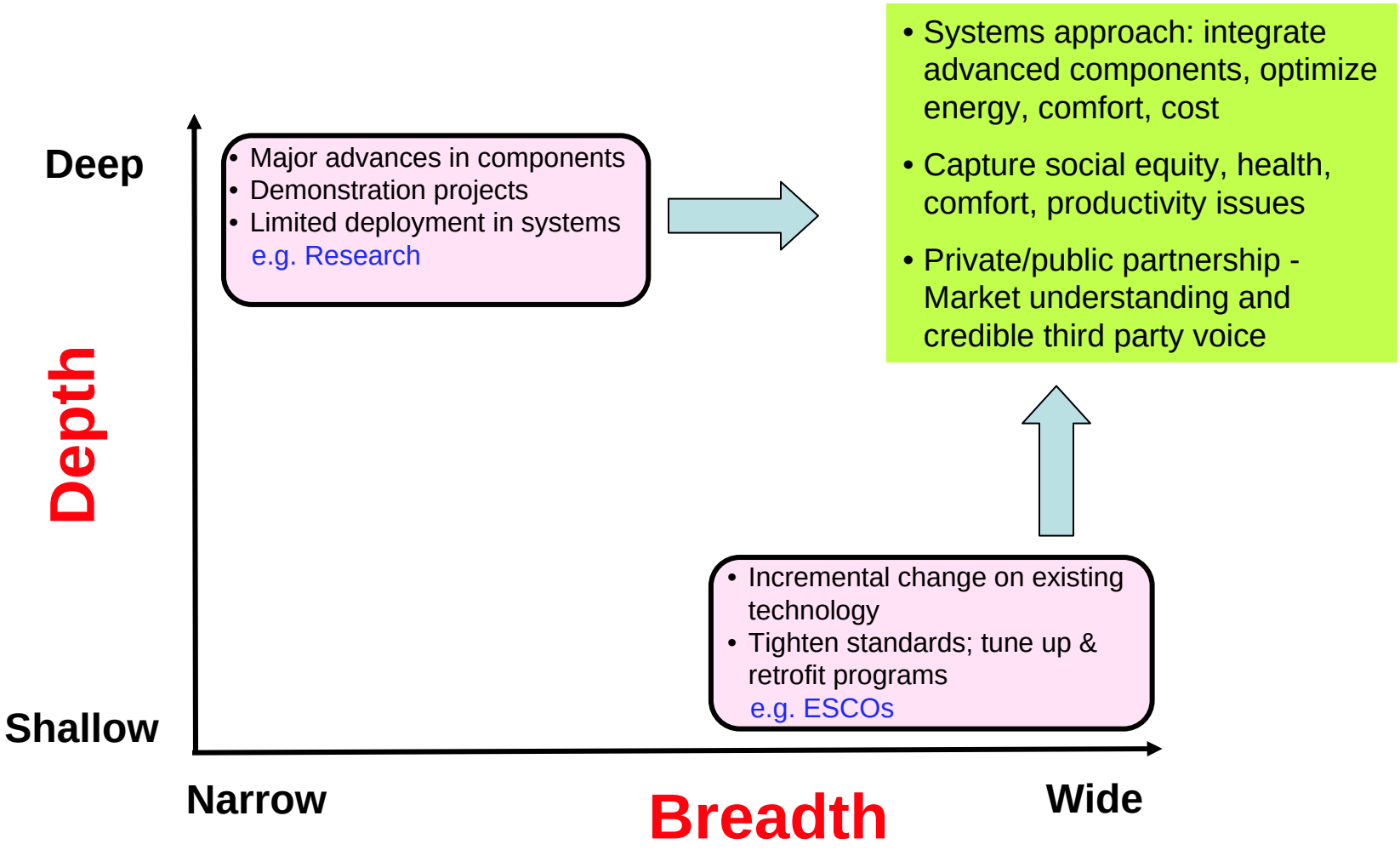
Potential Collaborative Objectives

- **Provide Basis for development and deployment of advanced technology, systems, tools and practices that lead to substantial and sustained reduction in energy use in buildings, with improved health, comfort and productivity.**

- **Multiple strategies for different markets and time frames**
  - Reduce energy use by 10-30% in standard practice
  - Reduce energy use by 30-50% in best practice (top 20%)
  - Reduce energy use by 60-90% - State-of-the-art, "Net Zero Energy", "Carbon Neutral"

- **Goals of R&D:**
  - Create enabling knowledge bases, technologies, systems, tools
    - Key Incremental advances that move toward systems
    - "Leapfrog", "disruptive" technologies and systems
  - Demonstrate and quantify impacts
    - Verify/optimize savings
    - Reduce costs and risk
    - Accurate Information to guide investment decisions
  - Facilitates change in building design and operations
  - Actionable business strategies by Philips

Conceptual Approach for Identifying High Level Business Goals



LBNL-Industry Partnership Approaches:

Leveraging LBNL strengths
Value for Industry Partners
Research with Market Impacts

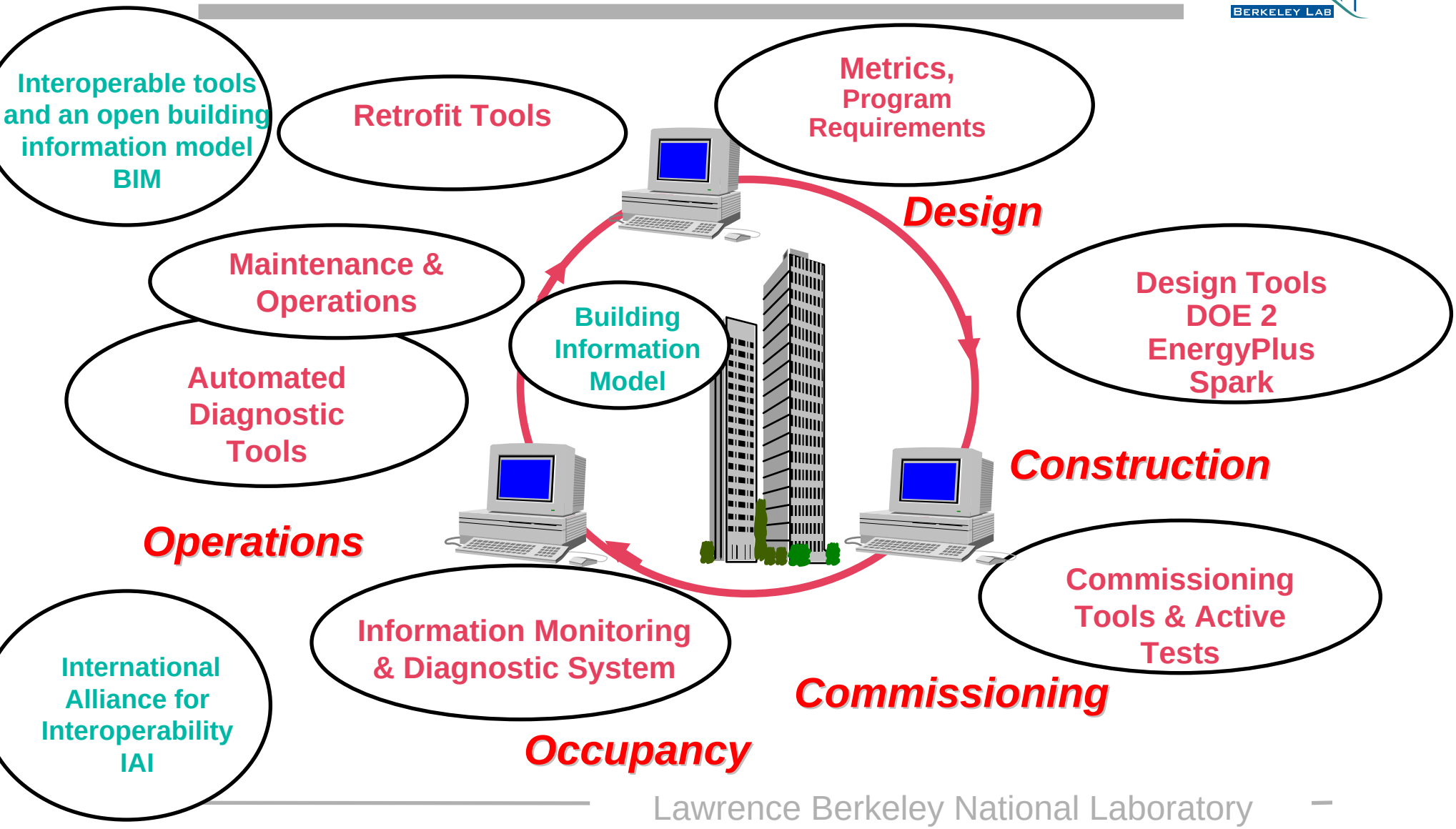
LBNL Capabilities

- Scale: Nanotechnology < --> Building Technology
- Time frame: Days <--> Decades
- Domain: Basic Science <--> Engineering <--> Markets
- Technology Expertise: coatings, sensors,….
- Systems Expertise: Lighting/HVAC/Envelope; simulation
- Building Focus: Commercial, Residential
  - High tech buildings, e.g. data centers, hospitals
- Team: ~ 200 Building Scientists
  - Link to global building science R&D
  - Links to designers, owners, operators
- R&D Perspective

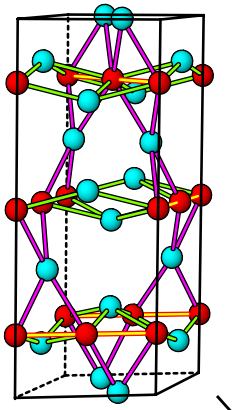
  1) Building life cycle: Design ---> Operations

  2) Comprehensive, integrated, performance perspective

Information Technology-based Building Life-Cycle Performance View

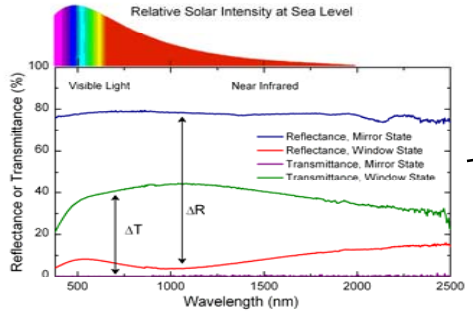


Electrochromic "Smart Glazing" Program:
Coatings/Optics Laboratory <--> Systems Testbed

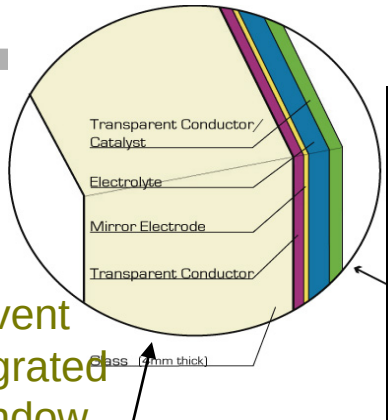


Mg_2Ni

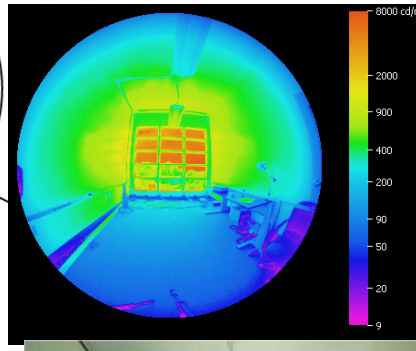
Invent New Materials



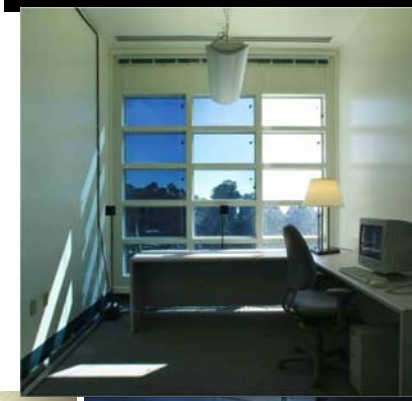
Characterize Coating Performance

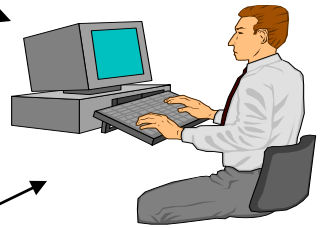


Invent Integrated Window

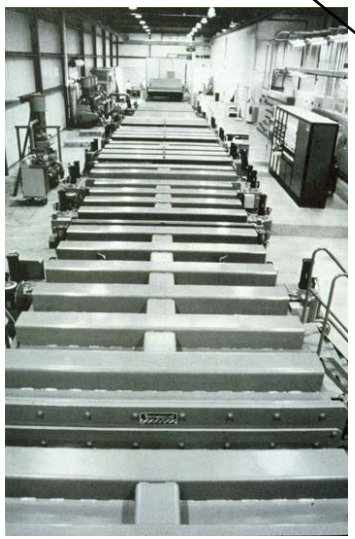


Assess Human Factors



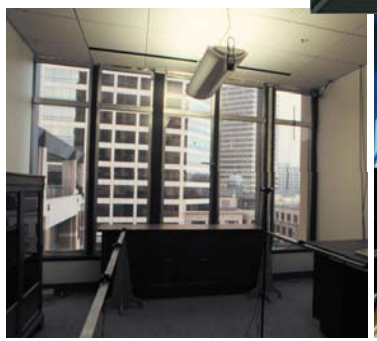


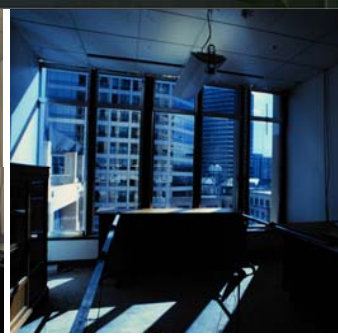
Assess Savings



Invent Innovative Manufacturing Process

Invent/Test Integrated Systems





Philips Building Systems Integration Testbed
Framework to Stimulate Discussion

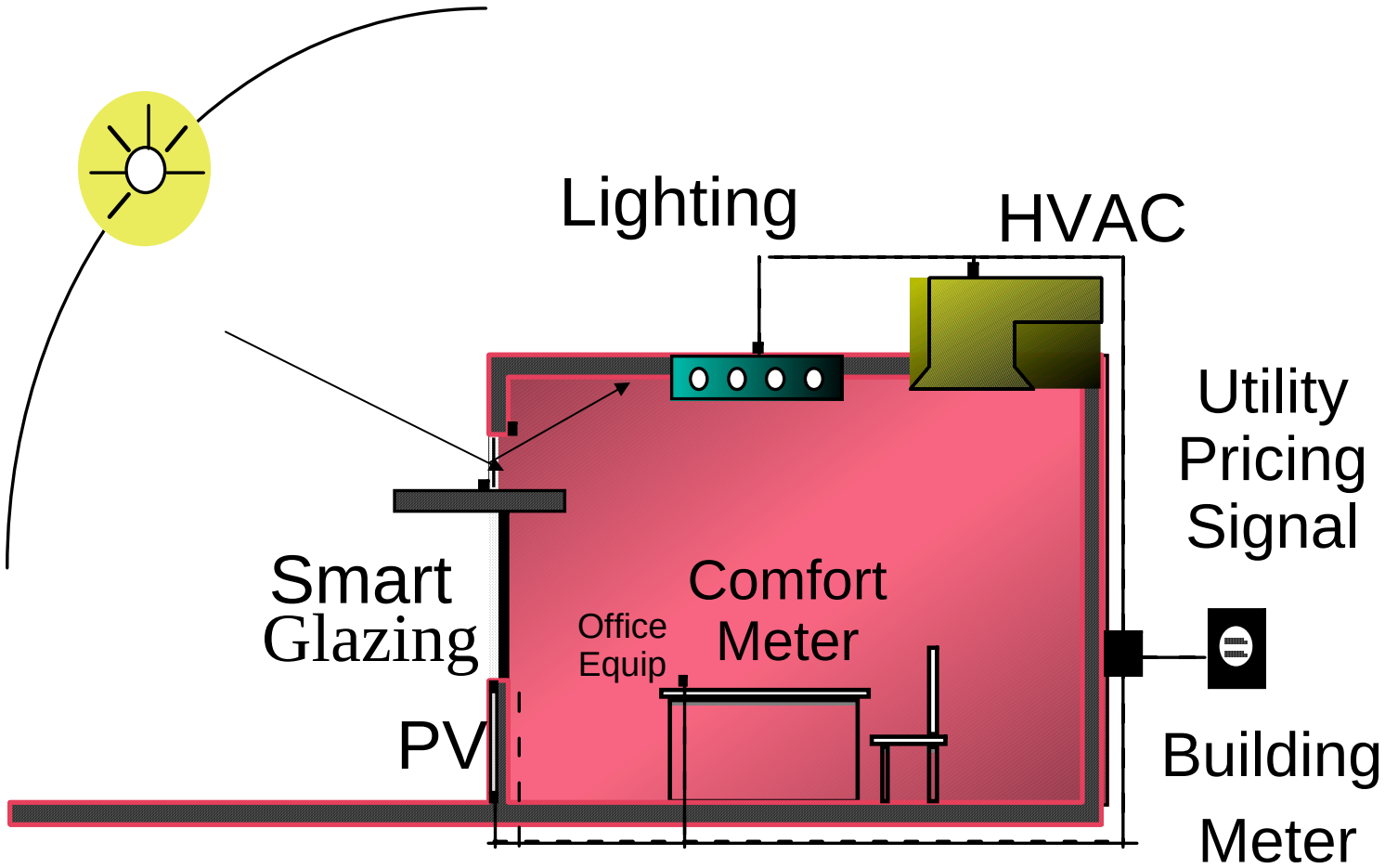
- Proposal: partnership to develop a building systems testbed
  - "How to do" collaborative research vs "what to do"
- Why this approach?
  - Focuses on field test of system integration of building energy management and control systems
  - Addresses key technical and market issues
  - Leverages collaborative, interactive R&D
  - Involves customers, users as partners

- *Building Systems Integration Testbed*
  - Design, build and operate at LBNL
  - Extend results with extensive modeling
  - Philips staff co-locate in Berkeley
  - Web accessible to remote staff-
    - On-line, real time data
    - "Remote Collaboration tools"- data, voice, image, manipulation

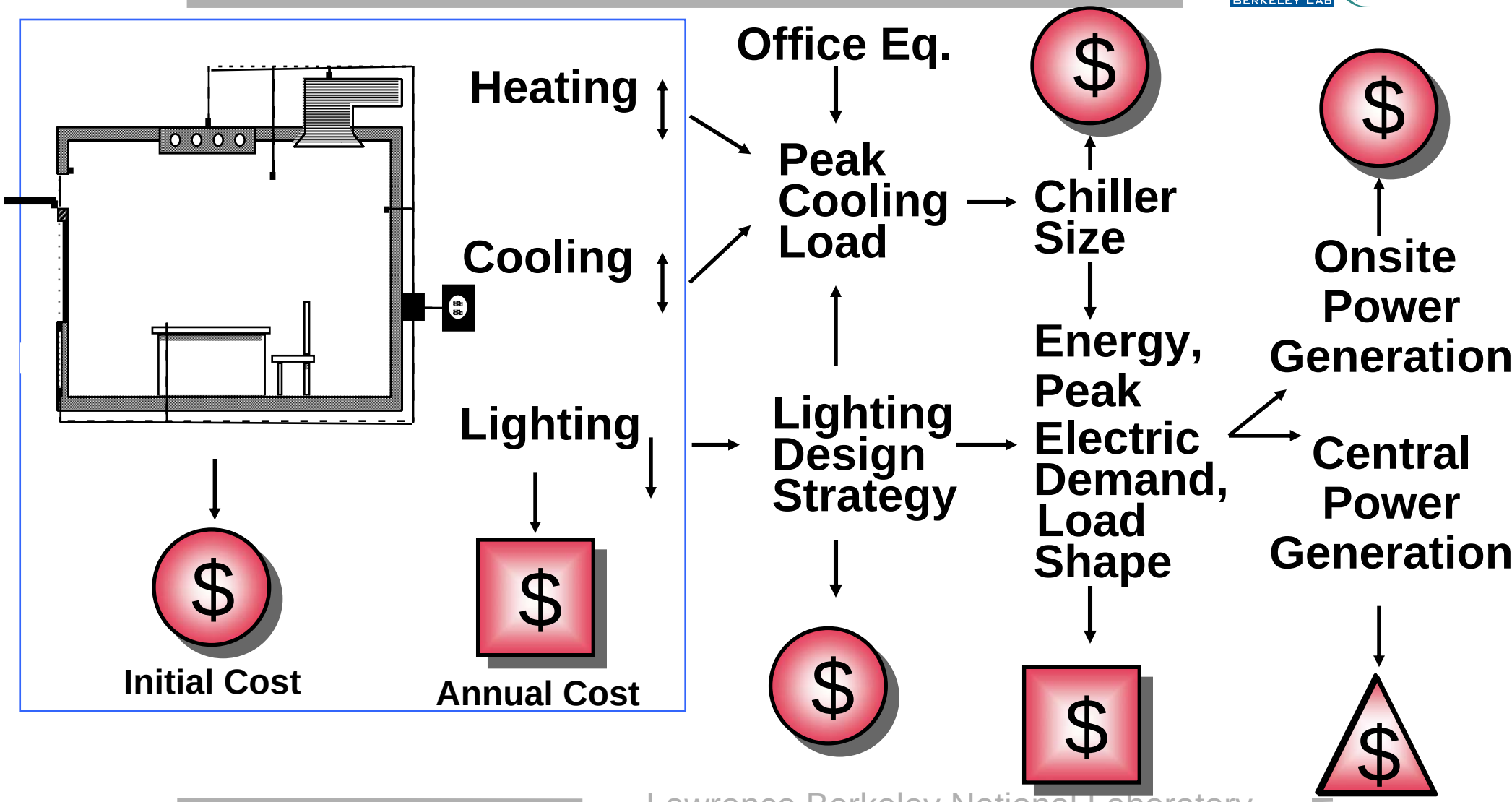
Philips Building Systems Integration Testbed - 2

- Focuses on optimized design and control of key building systems
  - Start with lighting, expand to other systems
    - **Daylight, glare control**
    - **Other Building systems**
    - **Power systems, utility interaction**
  - Energy, power, load shape, carbon
  - Occupant response- satisfaction, comfort, performance
- Explore new systems integration concepts
  - Develop and optimize design and performance
    - **Could involve component R&D**
  - Owner, designer, customer involvement, assessment
- Build and validate virtual models and tools
  - Extend performance to other spaces, buildings, climates
  - Basis for sales, marketing, customer support

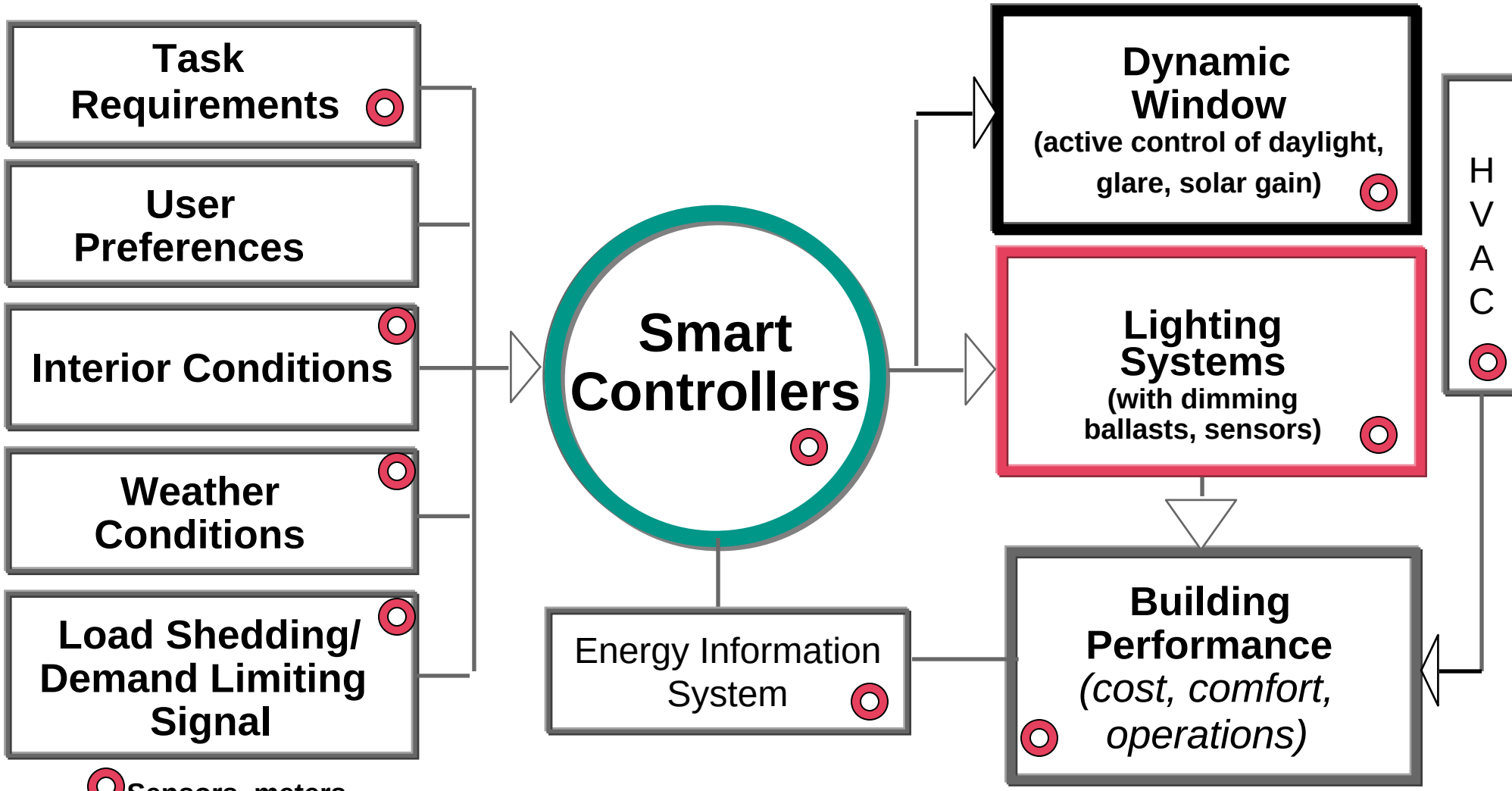
Platform for Design of Carbon-Neutral Buildings using Integrated Building Systems



System integration: Cost tradeoffs



Exploring Intelligent Control Systems



Opportunities to Explore Building Systems Integration Issues

- **Test room level - research lab context**
  - Extensive instrumentation
  - Side by side comparisons
  - Controlled conditions but realistic weather
    - Perimeter rooms/ core space options
  - Occupancy impacts
- **Full size mockup of portion of building;**
  - Section of floor plate; Realistic construction details,
  - Full building systems interactions
  - Occupancy impacts
  - Ex: New York Times HQ project includes specifications, commissioning, etc
- **Occupied, monitored building**
  - One of a kind but full systems integration issues
  - Limited flexibility to do controlled experiments (evenings, weekends)
- **Virtual Building testbed**
  - Virtual controls testbed to optimize control strategies before occupancy
  - Model based simulation tools link to design phase

Example:
Fenestration Systems Testbed

Advanced Glazing/Shading Controls Testbed

<-- Flexible testbed; any glass, shading and daylighting control system can be tested

Extensive instrumentation

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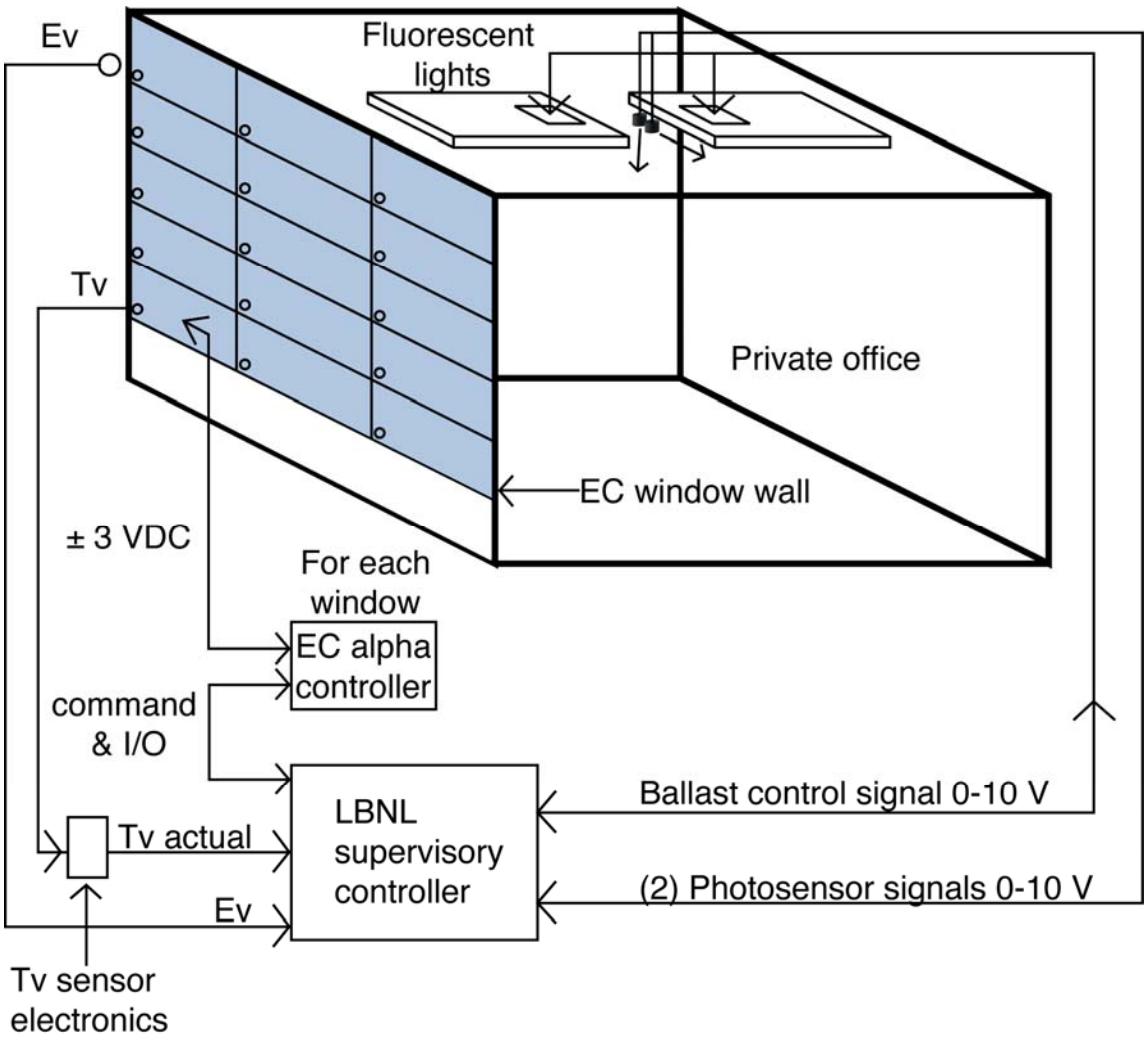
Interiors are highly instrumented, but can be fitted as office space for use by workers to test reaction to the new technology.

Systems Engineering for EC and Lighting Control



Pilot study on manual control of individual EC panes

- Informal test with team members
- Control of panes based on:
  - View
  - Privacy
  - Daylight
  - Glare

Example:
Owner Driven Testbed

The New York Times HQ Building

Owners program:

- Highly glazed façade gives workers views and allows the city to see “news” at work
- But glare, cooling, visibility etc

Need/Goal:

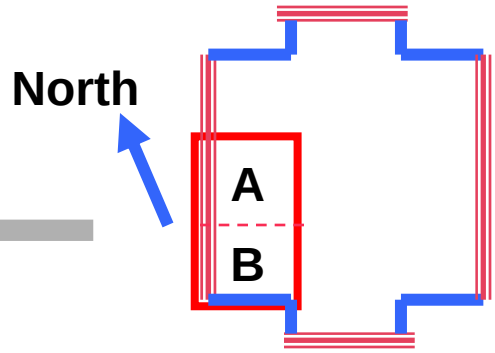
- Develop integrated , automated shading and dimmable lighting system
  - Affordable, reliable and robust
- Transform the market- push these solutions toward widespread use

Challenge:

- How to develop a workable integrated hardware/software solution
- How to “guarantee” that such a solution will work in practice

- 160,000 sq.M
- Full glass facade
- Occupancy in 2007

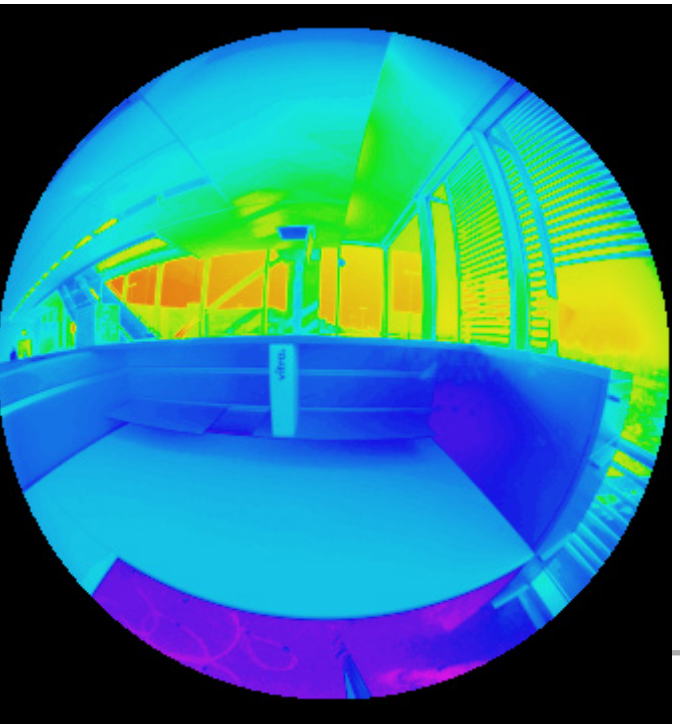
Approach: Test Performance in a Full-Scale Mockup



- **Shading, daylighting, employee feedback and constructability: ~4500 sf mockup**

- Concerns with glass facade:
  - Window glare (Tv=0.75)
  - Control of solar gain/cooling
  - Daylight harvesting potential
- Lighting Systems
  - Daylight dimming
  - Addressable systems
  - Task tuning
  - Load Shed/DR

- Real sun and sky conditions, 12-month monitored period



Discomfort glare

<u>Computed from monitored data at the mockup</u>

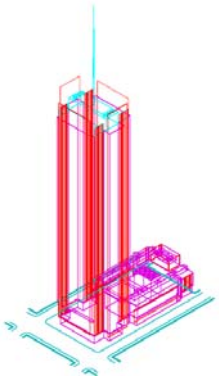
For tasks facing the south-facing window with side view of west-facing window, discomfort glare index (DGI) was between "just uncomfortable" and "just intolerable" for:

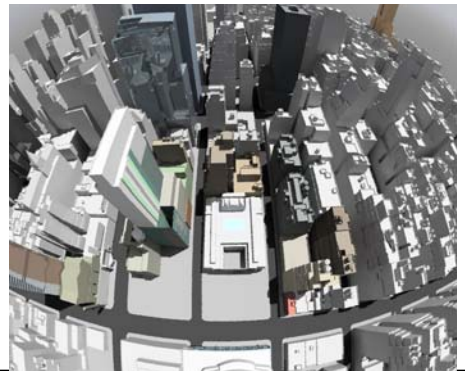
- **6 min on average per day and**
- **no more than 30 min max per day**
- **Why? Eye is adapted to the bright environment near the windows**

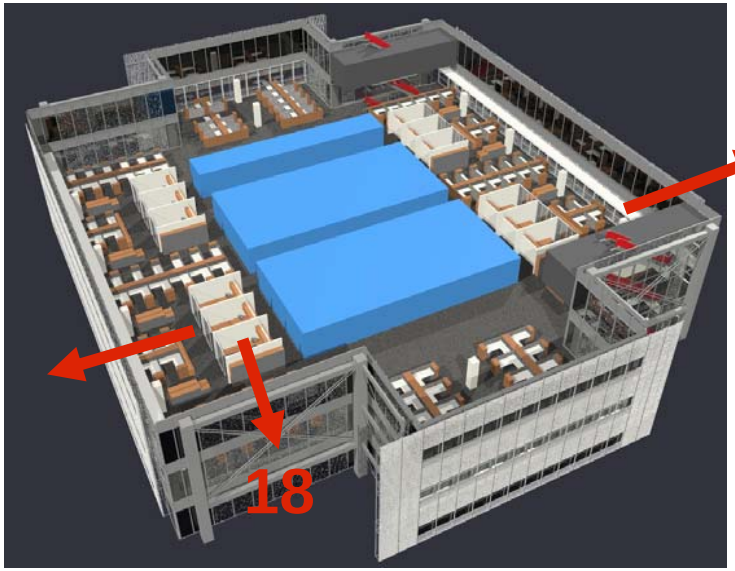
- Shade controlled for direct sun. Fabric had a 3% openness factor and a light gray interior surface.
- Data for December 21 through June 21

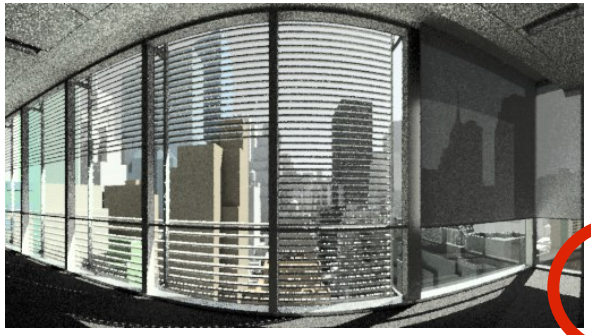
Developing Shade Control Algorithms for Motorized Shades using Simulation

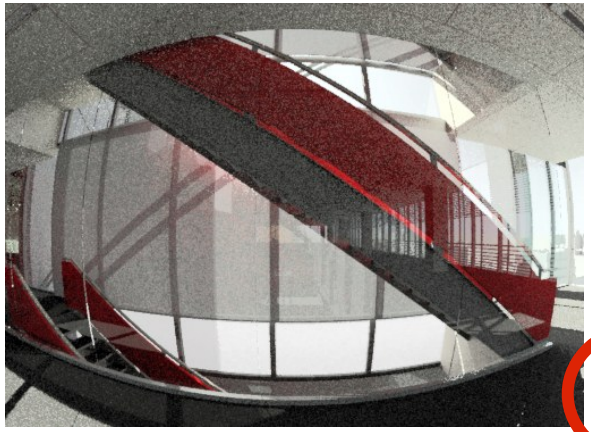
- Each shade system has its own sensor and motors
- Performance will vary with orientation, floor elevation, view out, and neighboring buildings.
- How to address performance with this variance?
- **Build a virtual model of the building in its urban context using hourly weather data simulate performance**





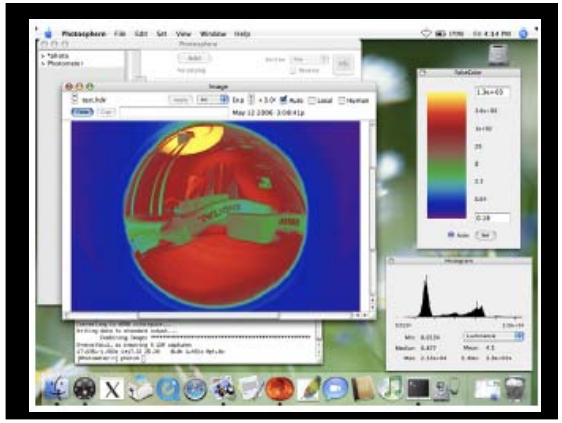




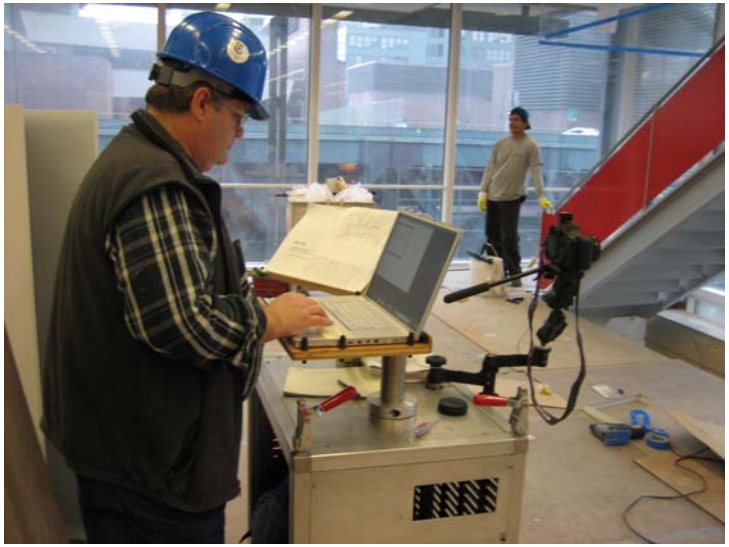


Simulated Views from 3 of 22 view positions

Challenge: Rapid Characterization of Luminous Environment



- High-dynamic range (HDR) digital images
- Captured automatically, processed within 1 minute, then produces continuous luminance maps of the scene.
  - Accuracy to +/- 10% within 0-5000 cd/m^2 range
- R&D tool in testbed
- Used by owner to check calibration of installed systems



NY Times; Occupied June 2007

Example:
Virtual Controls Testbed

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, dimmable lighting
- Designed with state-of-the-art simulation tools, EnergyPlus* and CFD
- Control system tested with EnergyPlus prior to installation

- Virtual Controls Testbed

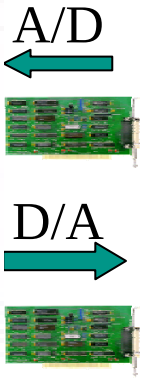
Control System Testing Using EnergyPlus

Control system tested using design simulation:

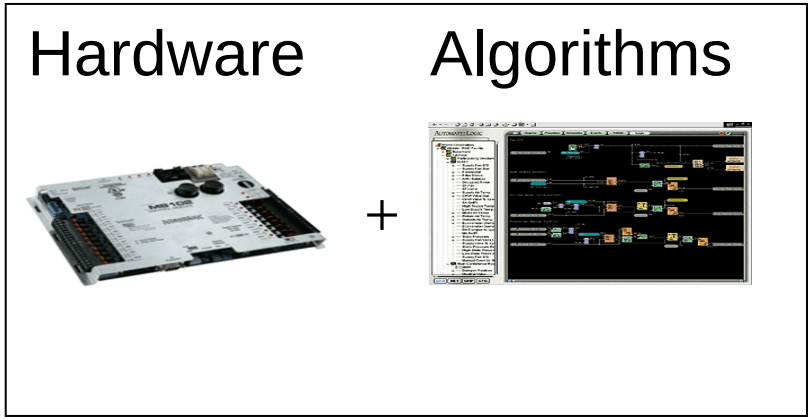
- Real-time EnergyPlus with hardware interface
- Control hardware from the building
- Control program as implemented by controls contractor

Virtual Building

EnergyPlus & SPARK



Real Control System



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

Testbed as vehicle to Explore Building Systems Modeling and Integration Issues

- **Testbeds and modeling tools can play a unique role in developing, marketing and deploying new technologies and systems**
  - Combination is more powerful than each by itself
  - Technology performance, integration, optimization
  - Owner and occupant feedback
  - Some Cost issues can be addressed
- **Starting point: Full size mockup of portion of building at LBNL**
  - Philips staff located here
  - "Collaboratory" model - share experiments remotely
  - Could evolve in several different directions
- **LBNL Partnership**
  - Extensive expertise, experience across the spectrum of solutions
  - Existing partner network: owners, designers, other manufacturers
  - Ability to move forward quickly
  - Collaboration issues - partnership relationships, publications, IP, support levels
  - Activity level: scalable beyond initial critical mass
  - Potential for other partners

Discussion