BERKELEY LAB
Lawrence Berkeley National Laboratory

Environmental Energy Technologies Division Lawrence Berkeley National Laboratory

FLEXLAB

FACILITY FOR LOW ENERGY EXPERIMENTS IN BUILDINGS

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Building Technologies Program

FLEXLAB Background

- LBNL responded to a 2009 RFP for ARRA funds to develop a facility that:
  - Develops new test methods and solutions for low energy buildings including **low-energy, integrated building systems** under realistic operating conditions
  - Focuses on:
    - Comprehensive whole building **systems integration**
    - **Specific end use integration and component interactions** (e.g., HVAC, lighting, windows, envelope, plug loads control systems)
    - **Controls hardware and sensors**
    - **Simulation and tools** for design through operations

- FLEXLAB developed with input from 35 industry partners
- Commercial buildings focus - retrofit and new construction

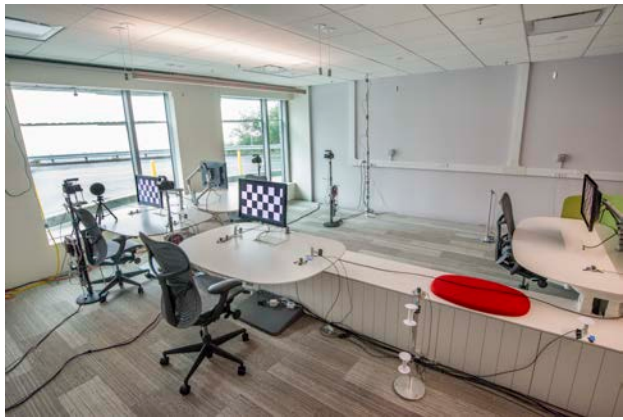
FLEXLAB – Facility for Low Energy eXperiments in Buildings

LBNL developed FLEXLAB, DOE's unique facility dedicated to:

- Developing and applying new test methods and solutions for **low-energy, integrated building systems** under realistic operating conditions
- Research focuses on:
  - Comprehensive whole building **systems integration**
  - **Specific end use integration and component interactions** (e.g., HVAC, lighting, windows, envelope, plug loads control systems)
  - **Controls hardware and sensors**
  - **Simulation and tools** for design through operations

Commercial buildings focus, with applications relevant to office, retail, educational, multi-family

- New construction and retrofit



Energy efficiency studies, including thermal and visual comfort and occupant engagement

FLEXLAB's Unique Value Prop

- Flexlab is the only DOE supported facility providing full-service integrated design research for commercial buildings on an entirely customizable, configurable platform.

- When paired with LBNL's world-renowned building science expertise and private sector market actors and influencers – can move the marketplace.

DOE Goals: 50%+ Savings at Affordable Cost

Current Design and Research Paradigm – Silo Approach

Single component or isolated system EEM → 5-20% Energy Savings for the isolated component or system

Integrated Building Systems Approach

Multi-system integrated EEMs → 30-50%+ Whole Building Energy Savings

CA Goals: **All Buildings Net Zero Energy By 2030**

What is FLEXLAB?

- **Exterior Testbeds**
  - Integrated Systems and Components
- **Lighting & Plug Load Testbed**
  - Controls, Visual Comfort & Behavior
- **Virtual Design/Visualization**
  - Virtual Integrated Design & Visualization of Experiments

"To transform commercial building industry practice from a component-based focus to integrated systems in design and operations, achieving cost-effective, aggressive net-zero energy goals in new and existing buildings."

FLEXLAB Capabilities – Exterior Testbeds

Comparative testing

Controlled environment

- Capabilities to simulate other climates
- Controlled internal loads

Well instrumented and metered facility

- High granularity of power measurement
- High accuracy sensors – temperature, pressure, air and water flow, heat flux, etc.

Highly flexible testbeds – interior and exterior

- HVAC, lighting, glazing, skylights, shading, etc.

Mockup new construction and retrofit conditions

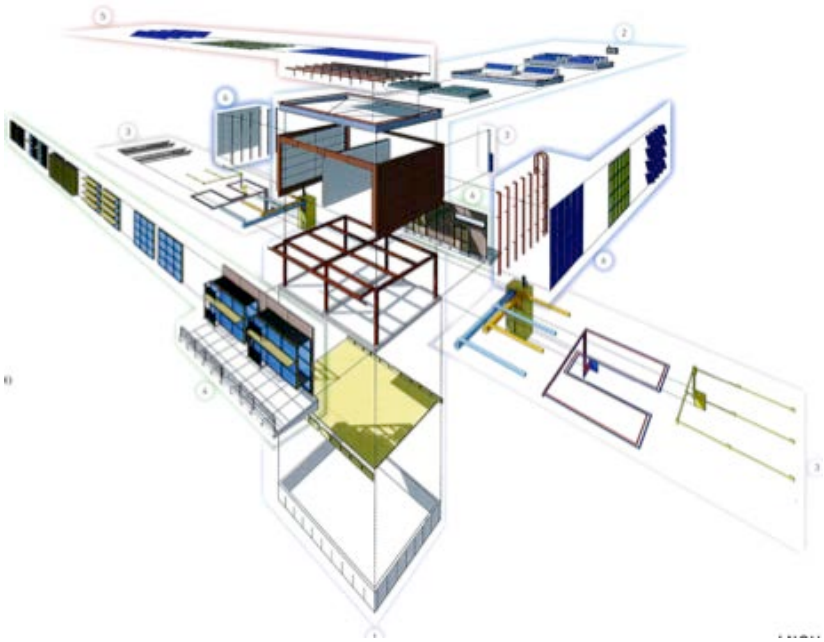
- First fit outs represent 1980s, current code and net zero

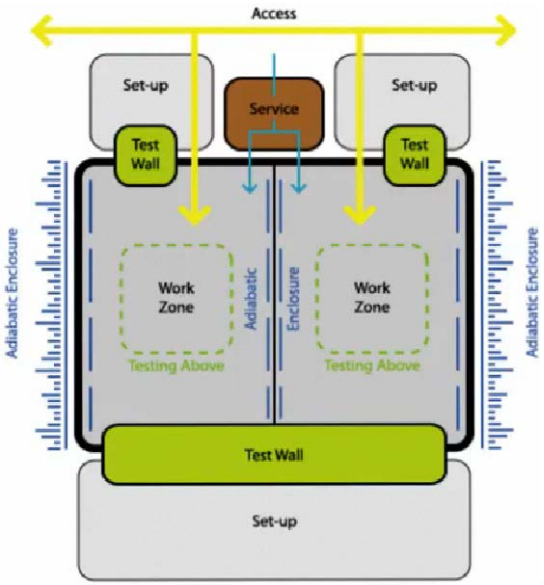
Provides access to multiple flexible systems

- Many manufacturers don't have testing facilities to integrate controls with other systems

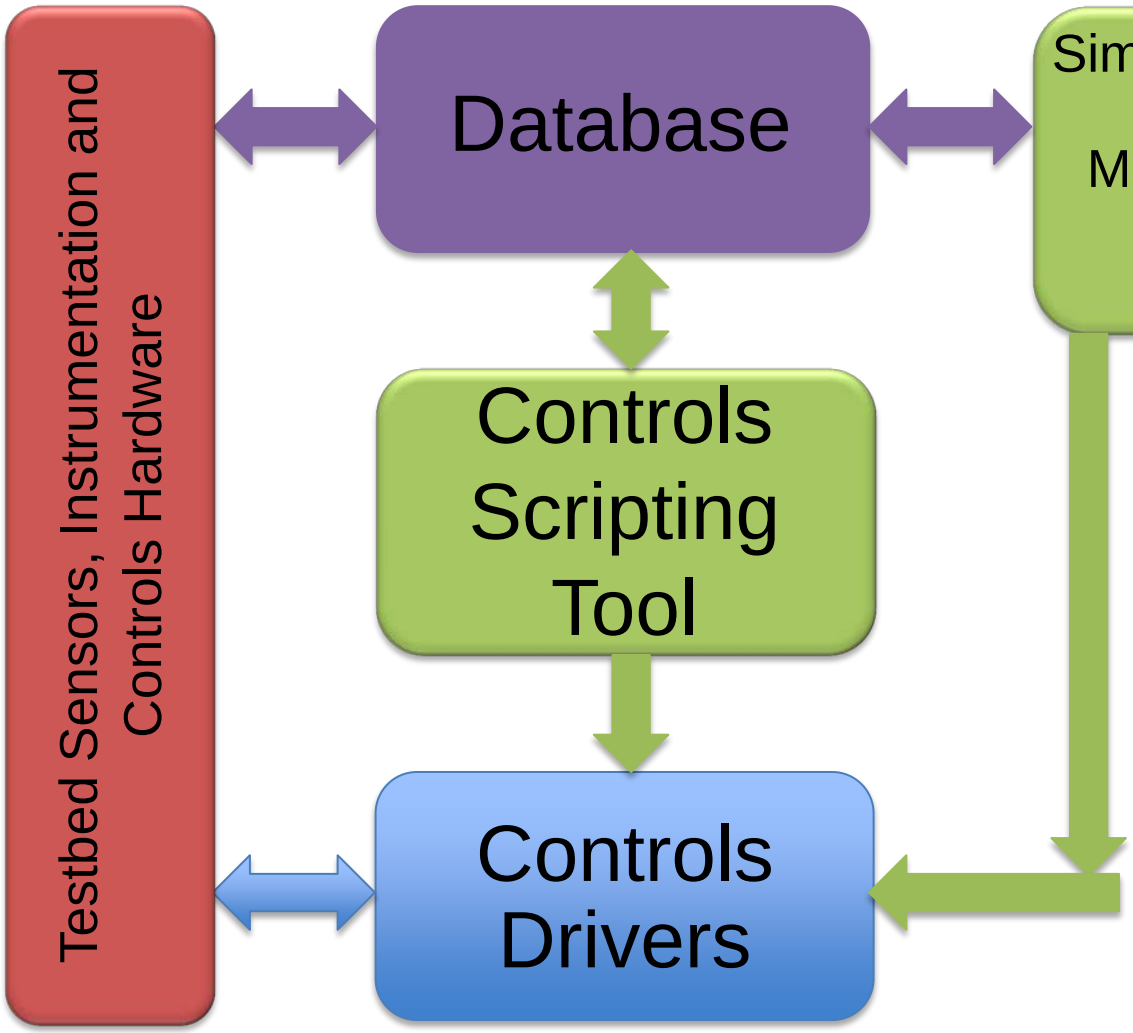
Features - Exterior Testbeds

- **Flexible interior space**, including variable ceiling heights, raised floor at varying heights, and interior partitions may be relocated for zonal studies
  - Two cells, with removable adiabatic wall in between
- **Interchangeable façade elements**, shading, glazing, skylights - permits study of high performance integrated dynamic & façade systems
- **Interchangeable HVAC systems** - permits study of both air-based systems, (VAV, UFAD, DOAS etc) and water-based systems (fan coils, radiant heating and cooling, VAV)
- **Interchangeable lighting** – direct/indirect light fixture studies, and lighting designs that emphasize daylighting controls, and task lighting applications





Data Acquisition and Controls



Infrastructure

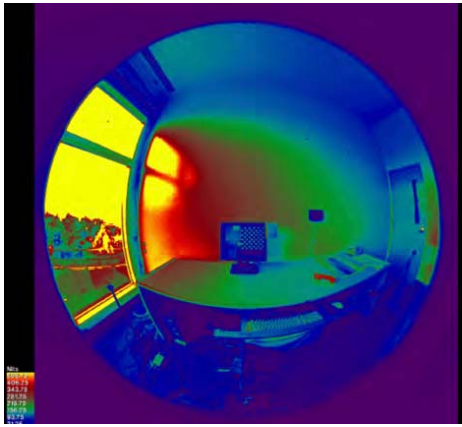
- Central secure database
- Monitoring and Visualization
- Controls Scripting tools
  - HVAC
  - Lighting
  - Shading, etc.
- Onsite or remote access
- Controls interface with different simulation and controls platforms

Features – Lighting and Plug Loads Testbed

- 3000sf occupied workspace
- Occupancy sensors at lighting zone level and workstation/occupant level
- Capable of multiple zones for comparative testing
- Photosensors at individual workstations
- Reprogrammable lighting and plug loads controls
- Individual occupant controls – workstation digital switches reprogrammable to control lights or plugs
- Power measurement at individual outlet level and each light fixture

Guaranteeing Building Energy Performance

- Technology development and optimization, demonstration and validation of integrated systems and controls
  - Comparison of technologies to code minimum or retrofit scenarios
  - Occupied or unoccupied testing, comfort and behavior studies
  - Emerging technology testing and verification
- Grid integration technology development
  - Demand response testing and validation
  - Building controls development to integrate with electric vehicle charging and onsite battery storage
- Validation of Design and Operational Tools
  - Improve performance and prediction capabilities
  - Increase industry confidence
- Virtual models extend facility testing results
  - Custom models of FLEXLAB modules, highly calibrated
  - Provides results for whole building scale, other climates and building cases – enables a ‘standardized’ demonstration test result to be extended to national impacts, other building types



Initial Target Markets

- **Investor Owned Utilities (IOUs)**
- **Design/Build/Operate Community (aka AECO)**
- **Manufacturers of Building Industry Products**

FLEXLAB's key offerings:

- **Real, built environment, testing conditions:** FLEXLAB is unique in the US in its ability to provide side-by-side testing of fully integrated building systems (envelope, lighting, HVAC) in a fully reconfigurable space
- **Unparalleled data collection, interpretation and analysis capability:** The only highly customizable 'built-up' research environment for technology development & validation through real-time, objective, high quality, high accuracy data.
- **Risk reduction in early testing and demonstration:** Unique ability to test strategies or systems, set up and evaluate controlled or user interactions.
- **Insightful Testing Opportunities:** Accelerated testing under different climatic, solar and use case scenarios, reducing risk, speeding "time to market".

Market Challenges

Key challenges for 3 target users:

	Challenges
Utilities	**Component** level ET reaching cost-effective max. **System** level ET opportunities need comparison studies to determine savings. **Field demo variable conditions** unsuited for systems assessment.
	Design assistance programs need **validated strategies**
	Modeling tools need to include ET, and predict with confidence
Manufacturers	**Manufacturers lack facilities** and expertise to develop & test integrated solutions across building systems
	Products and solutions need **validated performance** against baselines for integration into codes and standards
	Design tools need to accurately represent new ET for adoption
AECO (Architects, Engineers, Contractors, Owners))	**Technology** performance data needed to design with **confidence**
	Performance based mockups optimize and quantify performance to allow **design** to be predicted with **confidence**. Opportunities for better construction, Cx **lowering change orders and total costs**.
	Buildings tend to use more energy than design predictions. **Simulation tool algorithms need validation**.

FLEXLAB Delivers

High accuracy comparative tests

Develop/test integrated system solutions

Validated tools close gap- predicted to actual performance

First FLEXLAB Project – Genentech & Webcor

Testing and Mockup Objectives:

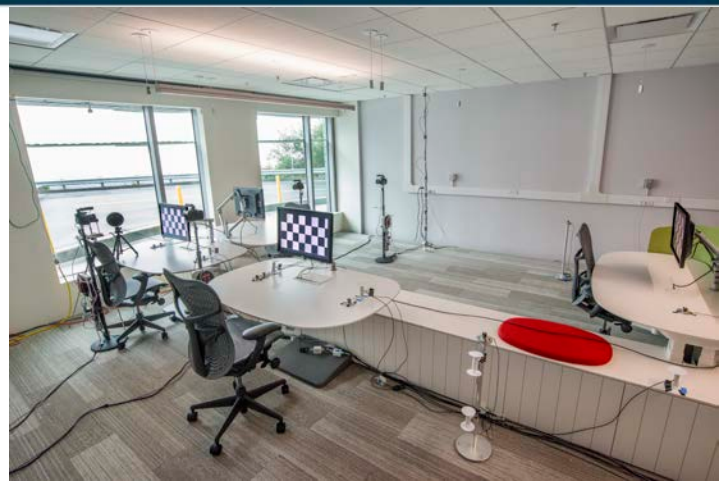
- Performance based mockup of 250k sf building
- *Optimization* of shading, lighting, controls systems, interiors design for *energy use, visual and thermal comfort*
- Pre-vetting of O&M needs of systems, opportunities for improvement
- Pre-Cx system review – accelerate the commissioning process in construction
- Constructability experience with systems

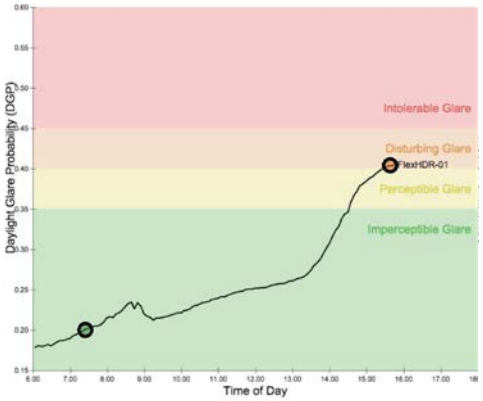
"Getting Comfortable with Energy Efficiency" video
See https://www.youtube.com/watch?v=hZ_5sJswyz4

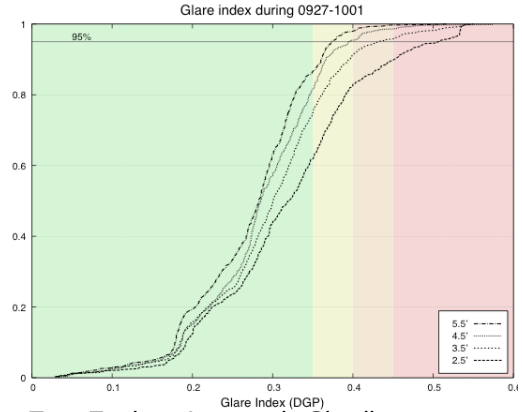
First FLEXLAB Project – Genentech & Webcor

Results:

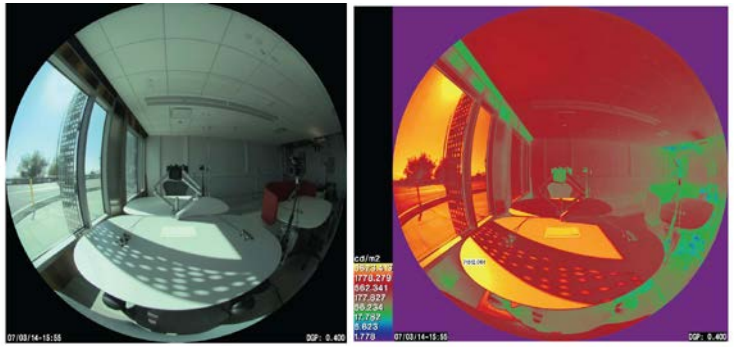
- Lower energy building design, validated comfort, lowered construction and operating costs
- Thermal comfort improvements – related to shading, interior layout, occupancy
- Light quality and visual comfort

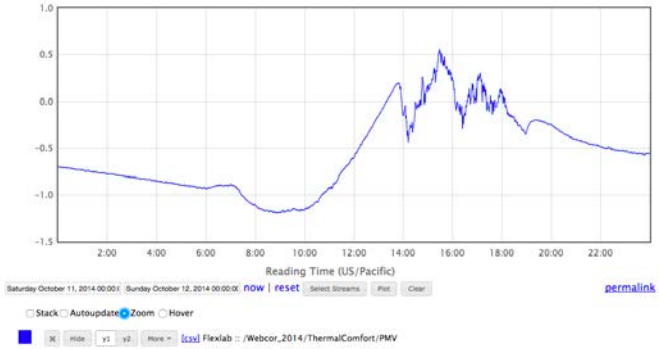






East Facing, Automatic Shading





PG&E FLEXLAB Projects

High Performance Envelope with Optimized Lighting, Daylighting, and Office Equipment Loads

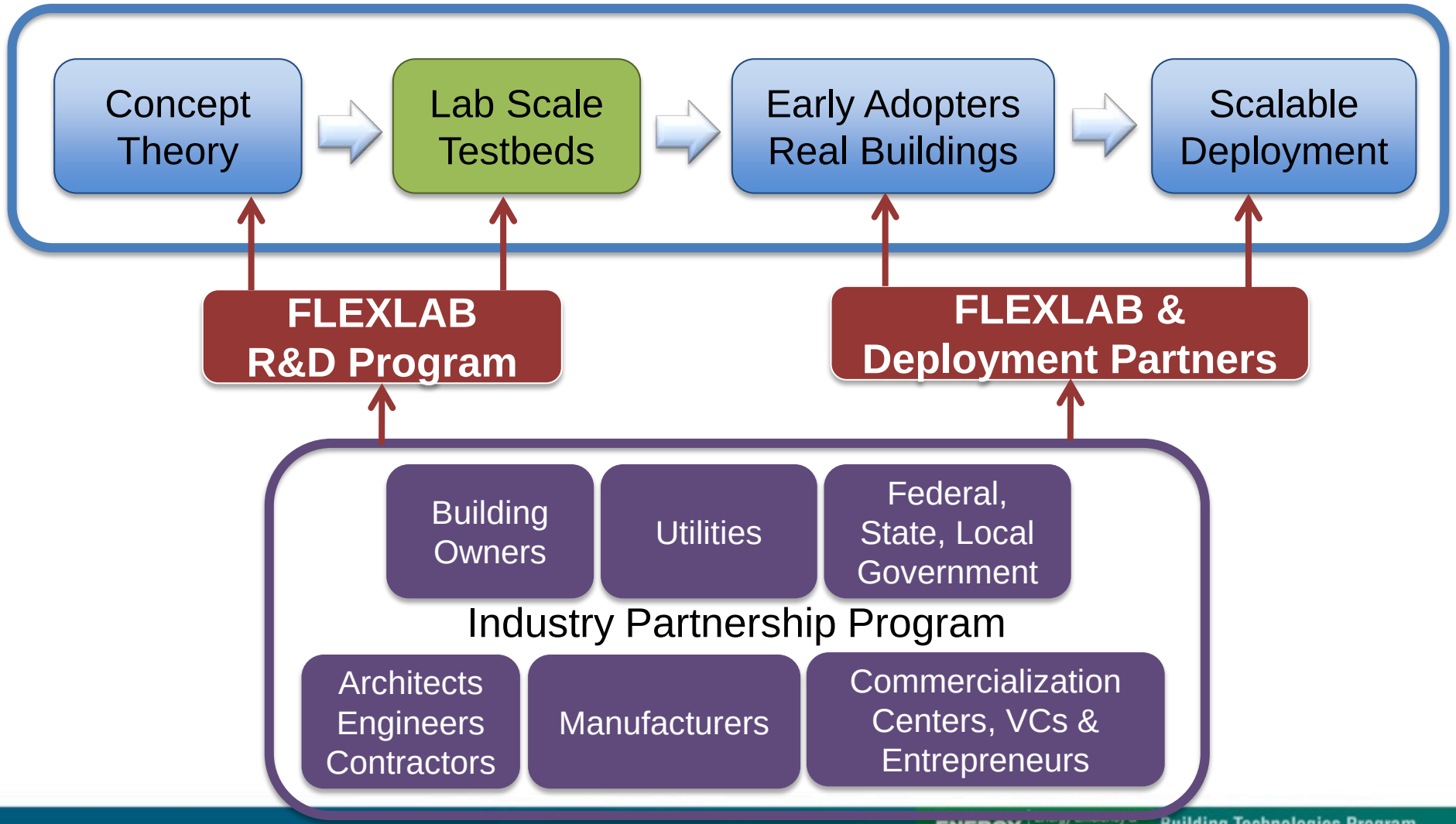
- Test and demonstrate systems that provide 20-40% energy savings over T24
- Focus on 50-65% WWR glazing assemblies, and deep daylighting strategies

High Performance Building HVAC and Controls

- Summer, winter and swing season testing of a suite of low energy HVAC strategies
- Comparison study of systems
- Focus on load shape reductions, peak reduction, overall energy savings

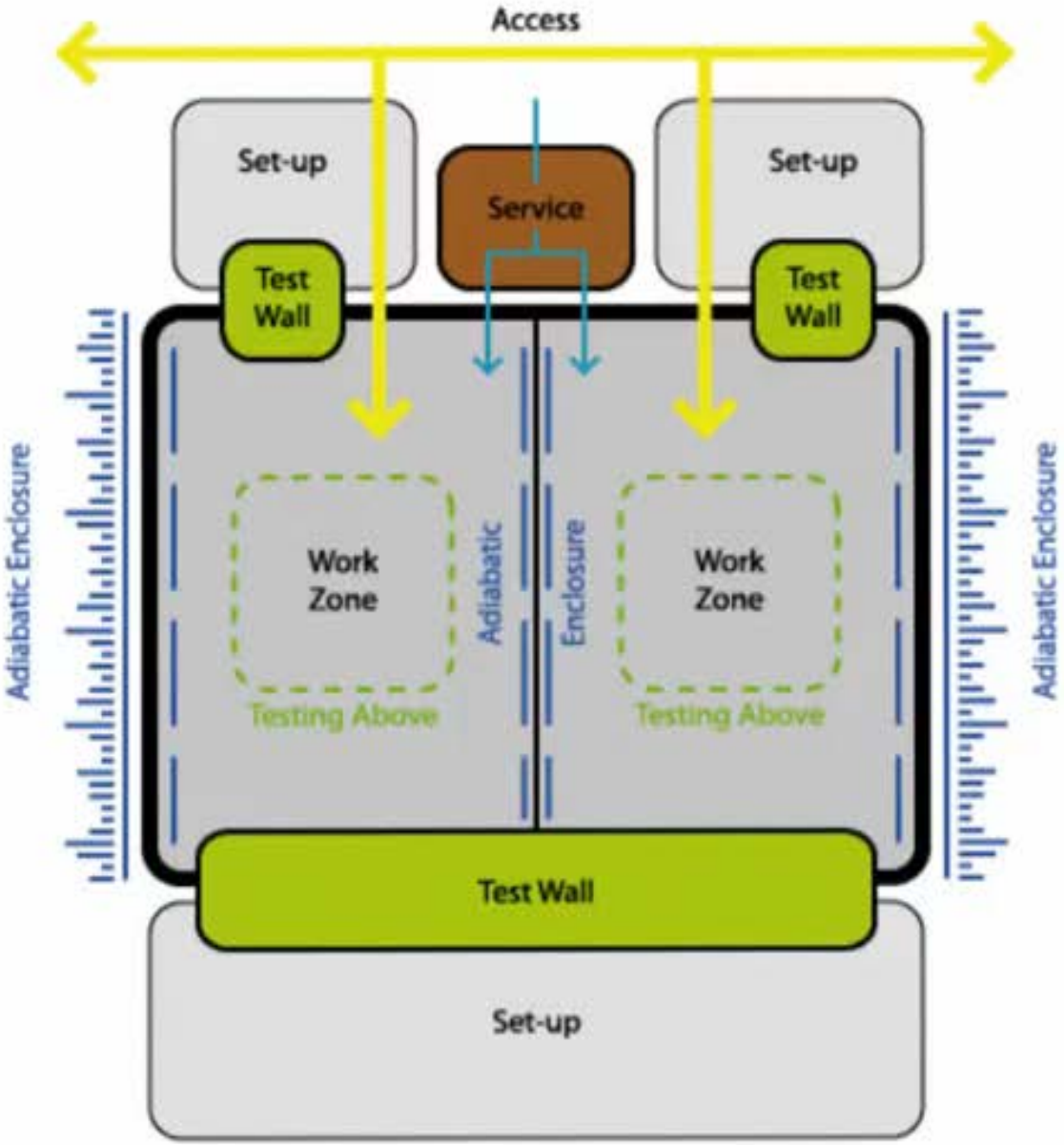
FLEXLAB RDD&D Chain

- FLEXLAB provides proof of concept, reduces risk for early adopters
- With partners lined up and technologies demonstrated, FLEXLAB accelerates the deployment curve



Press

- September 2013 Cover Story in Engineering News Record
- San Francisco Chronicle
- San Jose Mercury News
- Guardian UK
- NPR
- Associated Press
- Architectural Record
- Building Design and Construction
- Politico
- Yahoo News
- KQED radio
- ABC, Fox News, NBC affiliates
- And more….



Test Bed Diagam

FLEXLAB™: THE WORLD'S MOST ADVANCED BUILDING EFFICIENCY TEST BED

FLEXLAB CLOSES THE ENERGY-EFFICIENCY ACHIEVEMENT GAP FOR BUILDINGS

> *This facility could be the most important building in the country.*
>
> JES PEDERSEN
> CEO, WEBCOR BUILDERS

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