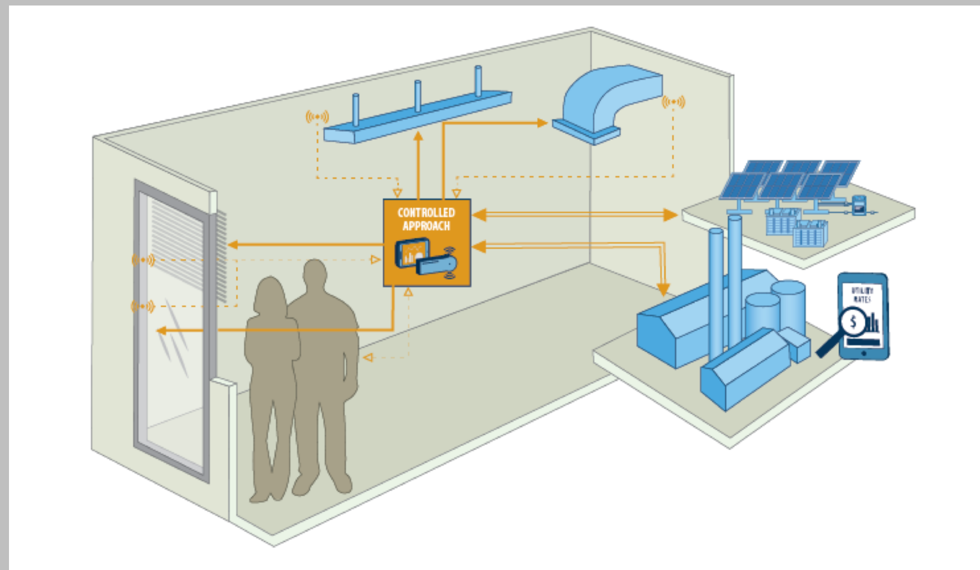
Beyond Widgets:



Building Systems for Utility Incentive Programs

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

Building Technologies Program

BERKELEY LAB

ENERGY TECHNOLOGIES AREA

Outline

1. Challenges and Opportunities
2. Project Phases, Partners and Deliverables
3. Definitions and State of System Retrofits
4. Enabling System Retrofits - First & Second Utility Cohorts
5. Impacts
6. Next Steps

Challenge

System retrofits can provide 50%+ additional whole building energy savings in existing buildings over ‘widget’ retrofits.

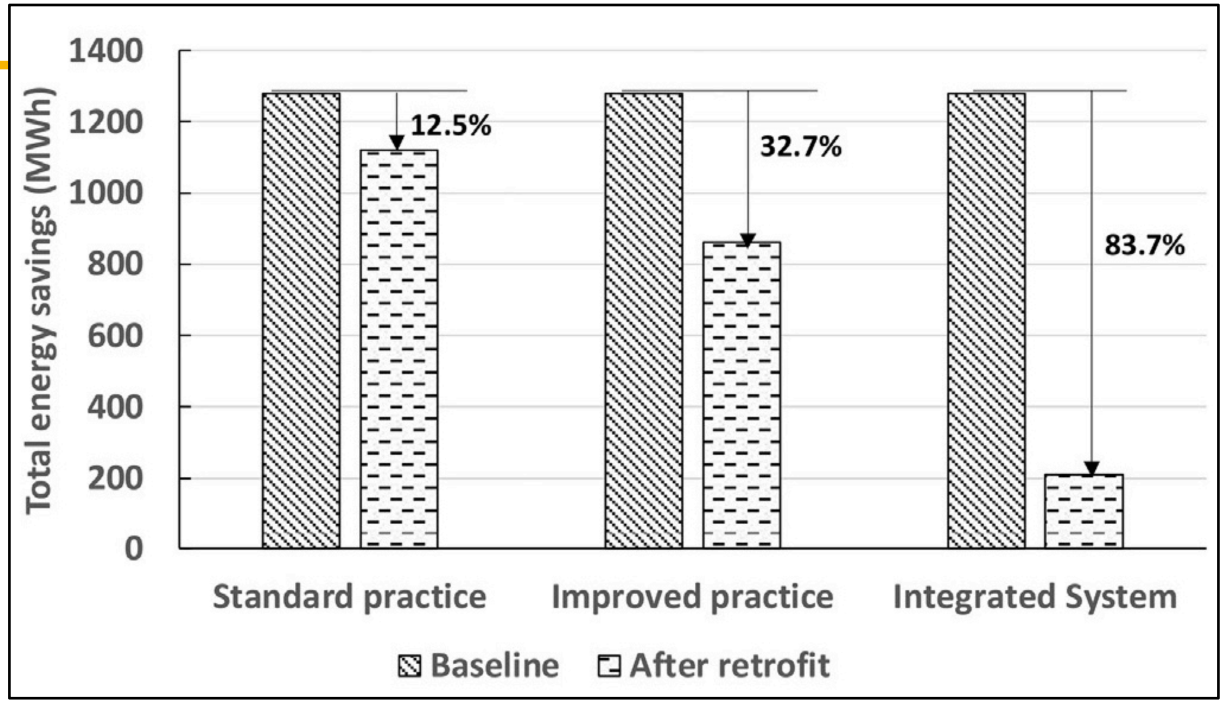


Figure – Regnier et al, Energy and Buildings, 2017 (Regnier et al, 2017)

However, a number of barriers exist:

- Systems are inherently more complex and disruptive; need simplified approaches to access savings, understand interactions[1]
- Lack of industry awareness of how systems provide deeper savings, about the state of systems deployment in industry, and the R&D needed to increase uptake

Ref: 1. DNV GL, 2016

Utility Interest in System Retrofits

Utility Demand Side Management (DSM) incentive programs are a major EE deployment channel - Investor Owned Utilities in 41 U.S. states expended $13.4B (2009 – 15) on Commercial & Industrial programs, lifetime gross savings of 836,241 GWh[2].

Utilities are interested in systems

- As code becomes more stringent, opportunities for cost effective 'widget' based technologies are dwindling
- Program energy efficiency goals are increasing
- Other drivers include electrification, and grid efficient strategies

Programmatic challenges

- Streamlined 'deemed' programs emphasize widget-based technologies
- 'Custom' programs can address systems, but inherently more complex, costly to implement
- Must pass cost effectiveness test (e.g. Total Resource Cost)

2. (Hoffman, 2018).

Project Phases, Partners and Deliverables

FY15-17 First Utility Cohort, Systems Development

- 3 system packages developed
- Validated energy savings using FLEXLAB over a range of customer conditions
- Created specifications and simplified customer savings assessments

FY18- Analysis: Systems vs Component; System Retrofits in Practice

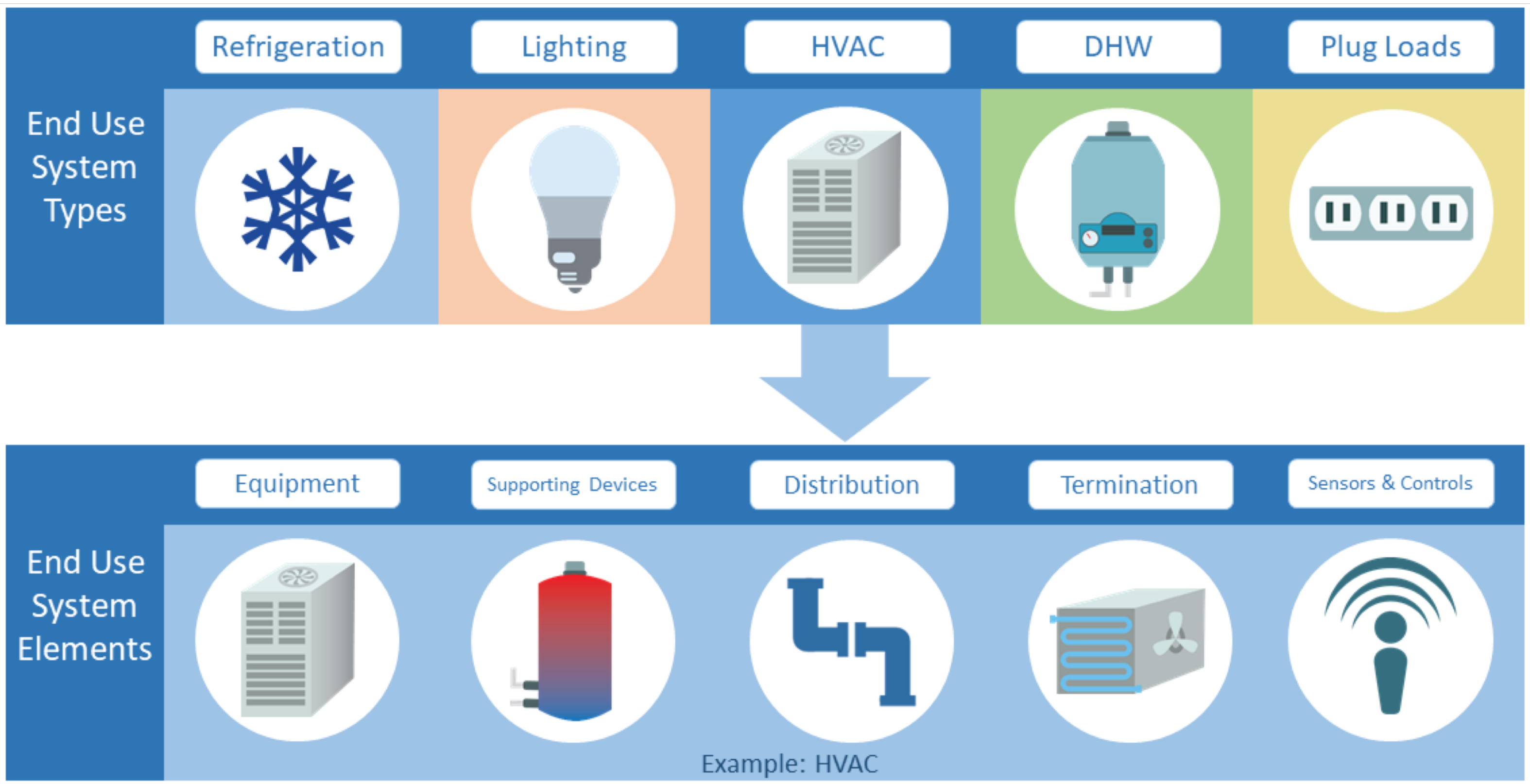
- Analysis of 3 systems packages vs component equivalent
- Study of industry retrofit program data on state of systems adoption; compares utility DSM, ESCO, FEMP/GSA

FY19- Second Utility Cohort, Systems Development

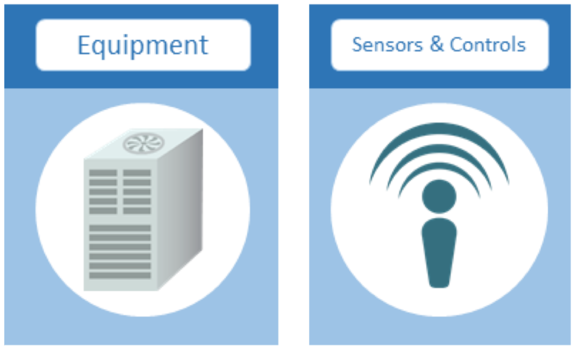
- Analysis of ~2 dozen EEMs and their system packages
- Develop 2 or more systems packages

What is a System?

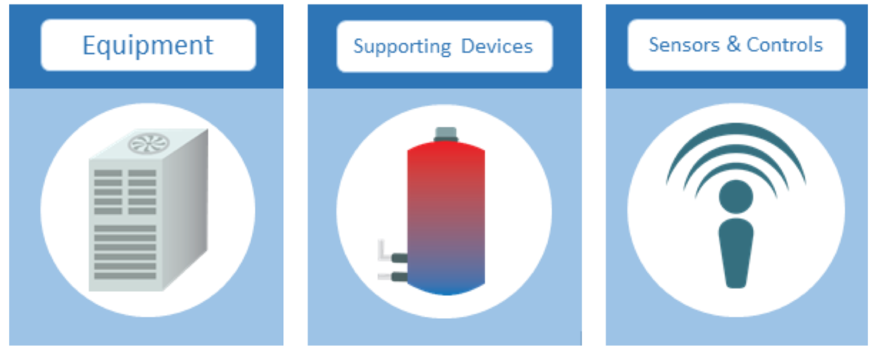
"A building system is a combination of equipment, operations, controls, accessories and means of interconnection that use energy to perform a specific function." (ASE, 2016, 2017)



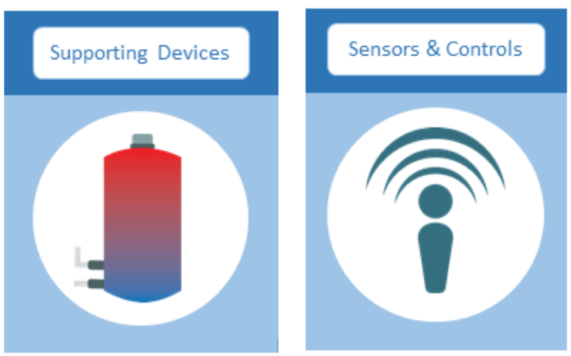
End Use System Retrofit Examples



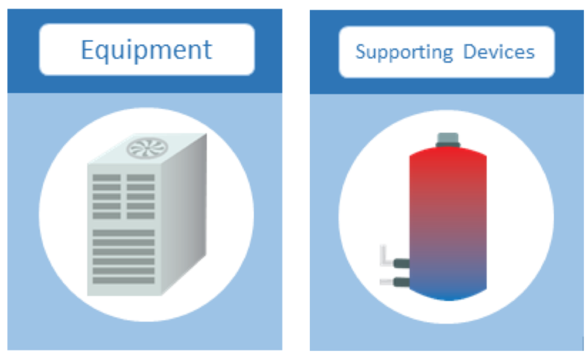
e.g. Air Source Heat Pump with Demand Control Ventilation



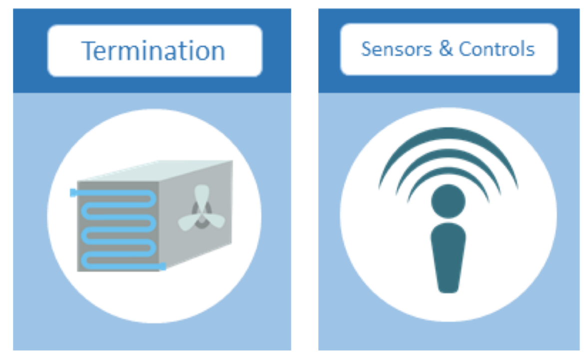
e.g. Air Source Heat Pump with hydronic storage and Time Of Use controls



e.g. Thermal storage and Time Of Use controls



e.g. Air Source Heat Pump with Heat Recovery on Relief Air

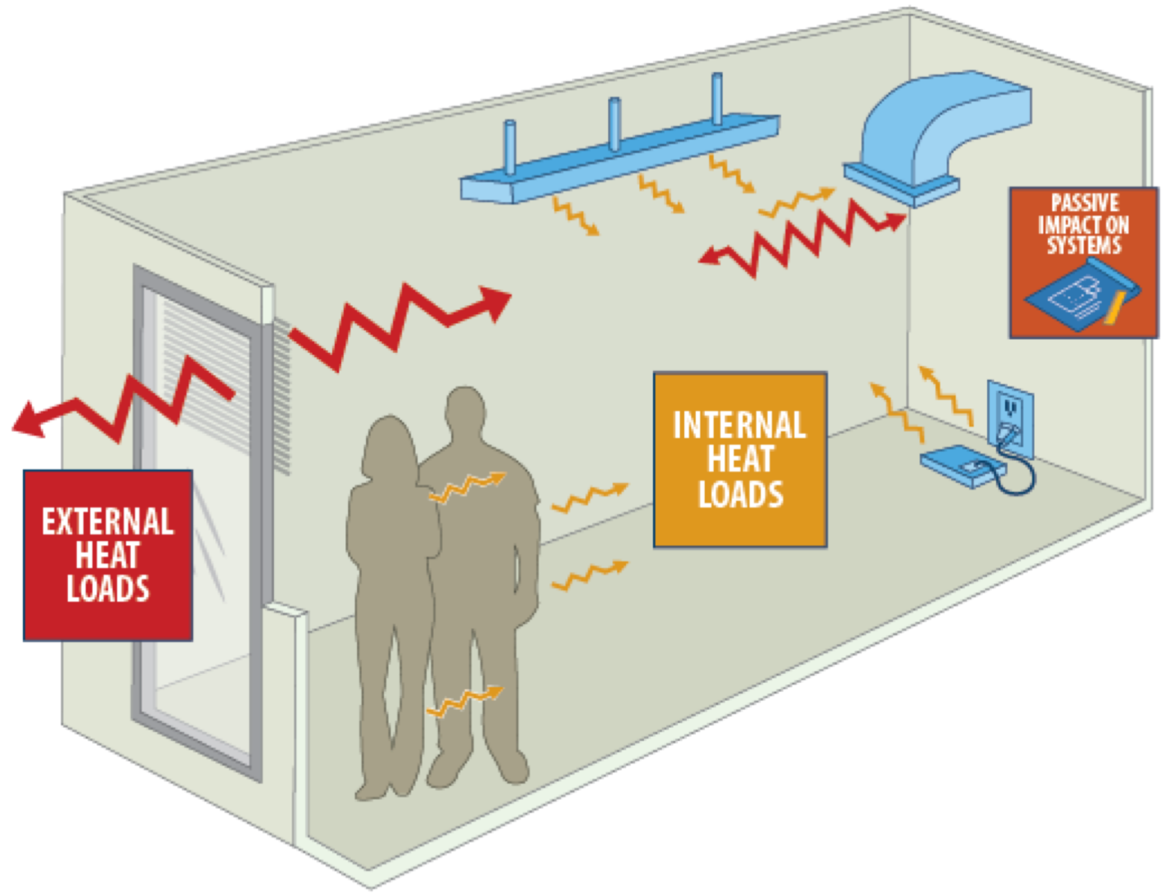


e.g. Hydronic fan coil with occupancy controls

Other System Retrofit Approaches - Interactive Systems

Interactive Systems:

- No physical communications link between systems
- One system responds to behavior of another via impacts to the environment

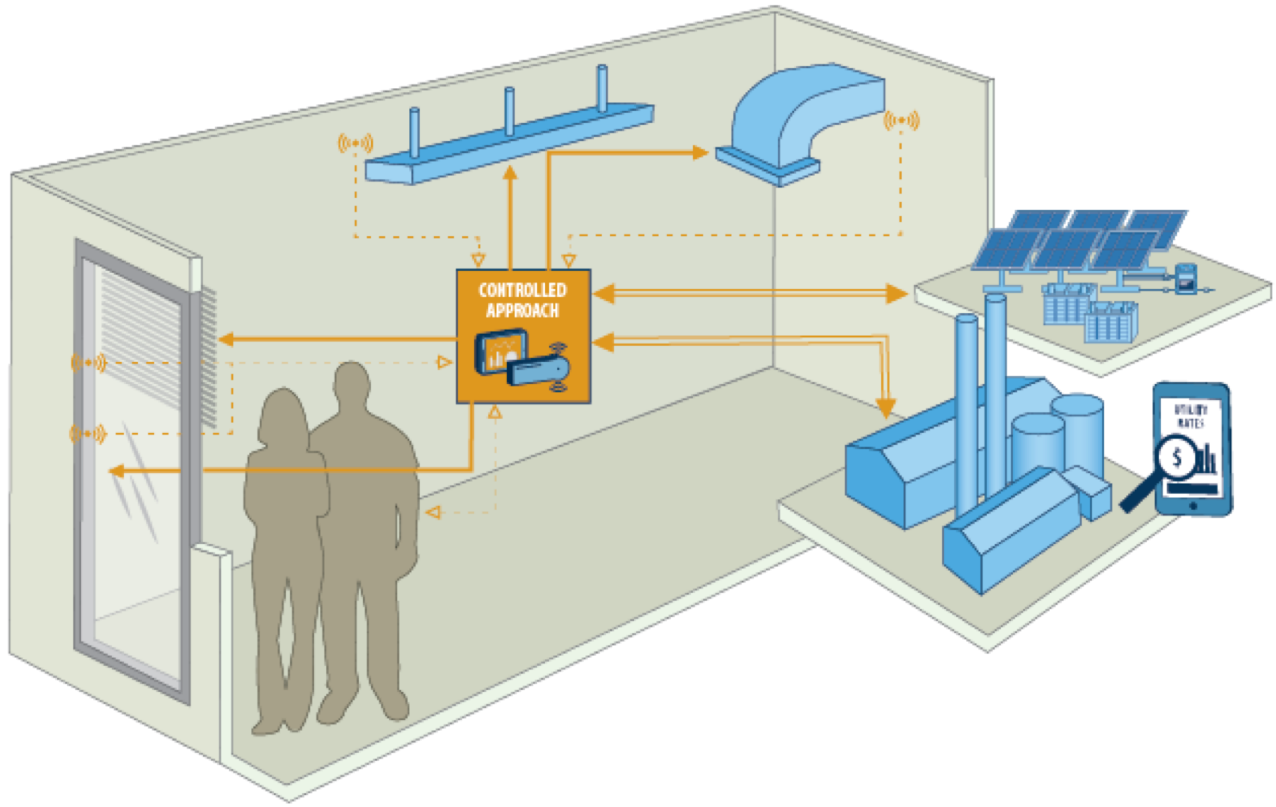


- E.g. lighting dimming systems responding to lower daylighting due to shade operation

Other System Retrofit Approaches - Integrated Systems

Integrated Systems:

- Active controls communications between end use systems



- E.g. Automated shading controlled to reduce HVAC energy use while optimizing daylight availability (communicates with HVAC system to determine mode of operation, cooling or heating)

What Systems are Currently Being Implemented?

Stakeholder and Data Insights

- Lighting most common retrofit due to ease and cost
- Larger buildings more likely to do system retrofits
- <10% of utility implementers/programs currently address systems

Barriers

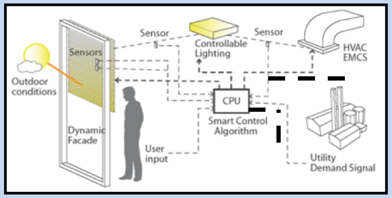
- Systems are inherently more complex and disruptive – design, Cx, operations, takes more time
- Cost and payback key, esp. where utility rates low
- Regulations can deter – such as one utility regulator that requires measures be cost effective *individually*
- Implementation channels can create complex transactions

System Development & Validation

First Utility Cohort

Developed streamlined validated Building Systems Packages to simplify adoption of systems.

Building Systems Package



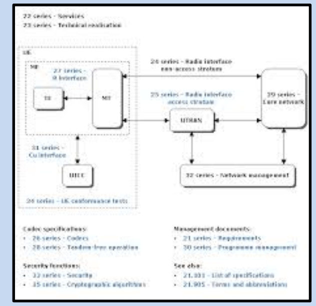
System specifications

Savings & performance metrics

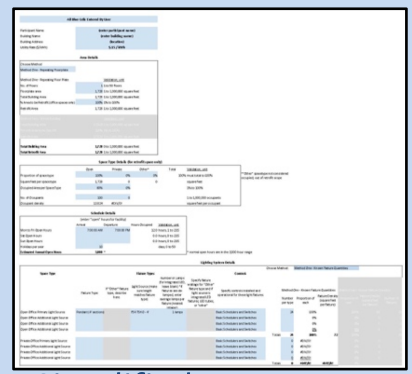
M&V specifications

FLEXLAB-validated Savings

Controlled testing and validation of systems



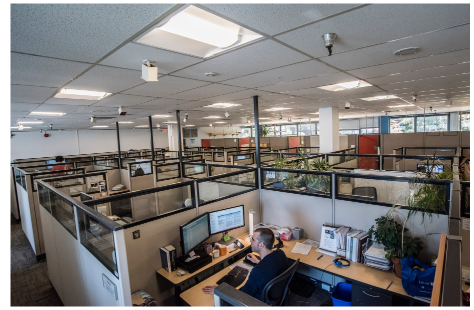
Implementation & savings persistence guidance



Simplified assessment method

Materials in utility language, structured in alignment with DSM program needs to support incentive program development

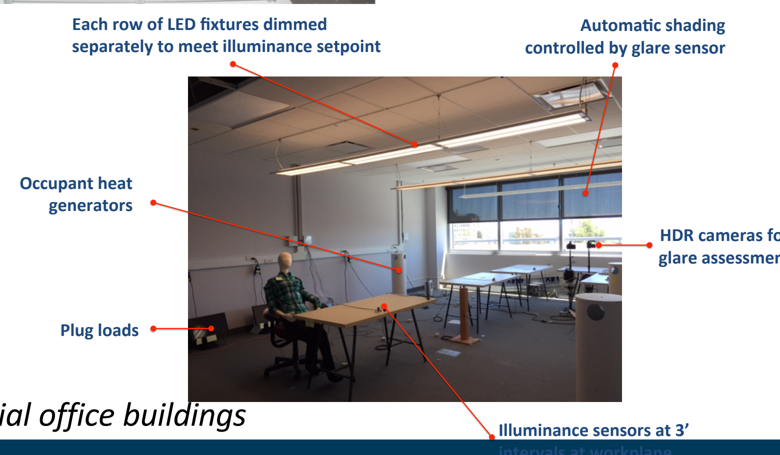
Cohort #1 – Three Systems Packages



<u>Systems & Validated Savings</u>

Integrated task/ambient lighting with plug load occupancy-based controls (interior core application)
*12-28% whole building savings**

Integrated workstation-specific lighting with daylight dimming (south perimeter application)
*5-8% whole building savings**



Automated shading integrated with daylight dimming lighting control (south perimeter application)
*3-5% whole building savings**

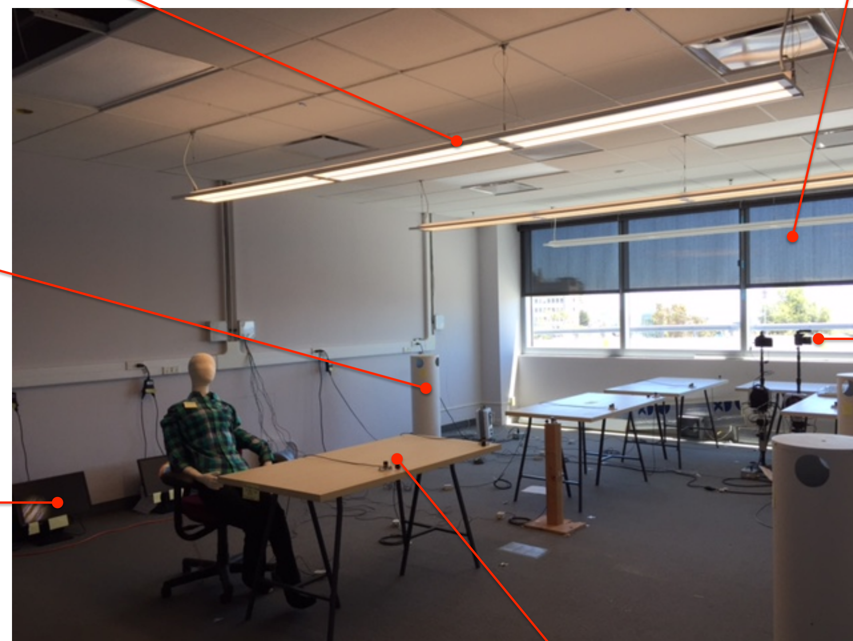
**Whole building savings are estimated for application in medium and large commercial office buildings*

System 1 – Automated Shading, Daylight Dimming

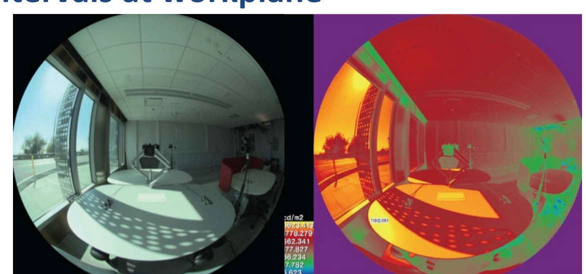
Automated shading integrated with daylighting controls

Market:
Med-large office
K-12 Educational

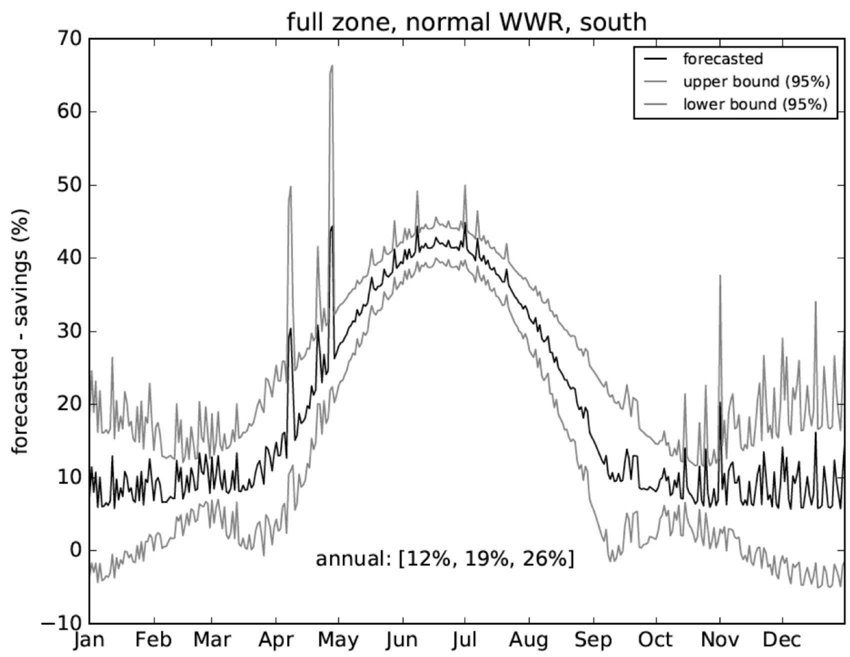
ComEd
519–633 GWh savings potential, simple payback for shading and lighting controls only (no light upgrade) >20 years; simple payback w/ lighting upgrade 10.9 years



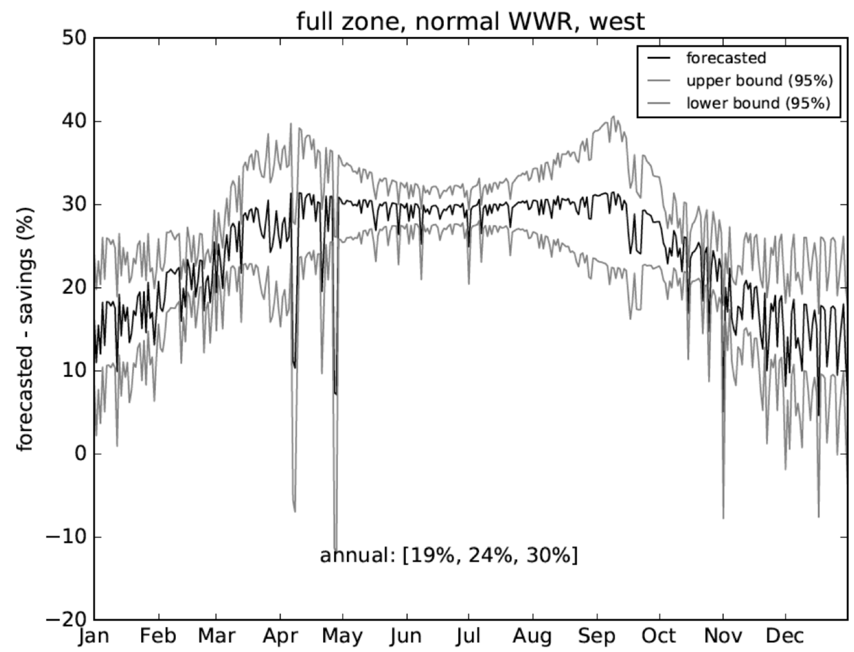
Annual Energy Savings Potential:
20%+ Lighting Savings
3-5% Whole Bldg Savings (based on DOE Reference bldgs)



Cohort #1 - Shading + daylighting System – Annual Energy Savings Models



Annual lighting savings for configuration 1S
(25ft deep zone, south orientation)



Annual lighting savings for configuration 1W
(25ft daylight zone, west orientation)

Using TMY data, the model** predicts:

South - mean of 19% annual lighting savings
West - mean of 24% annual lighting savings

**System Assessment method derives simplified calculations for energy savings potential, based on exterior horizontal illuminance data for site (e.g. historical TMY weather data).

System 2 – Workstation Specific Lighting, Daylight Dimming

Xcel Energy℠

Workstation specific lighting system with daylight dimming controls

Market:
Med-large office

Colorado 120–672 GWh savings potential, 8 to 12 years simple payback* at $0.12/kWh

Annual Energy Savings Potential:
90%+ Lighting Savings
5-8% Whole Building Savings (applied S, SW, SE only)

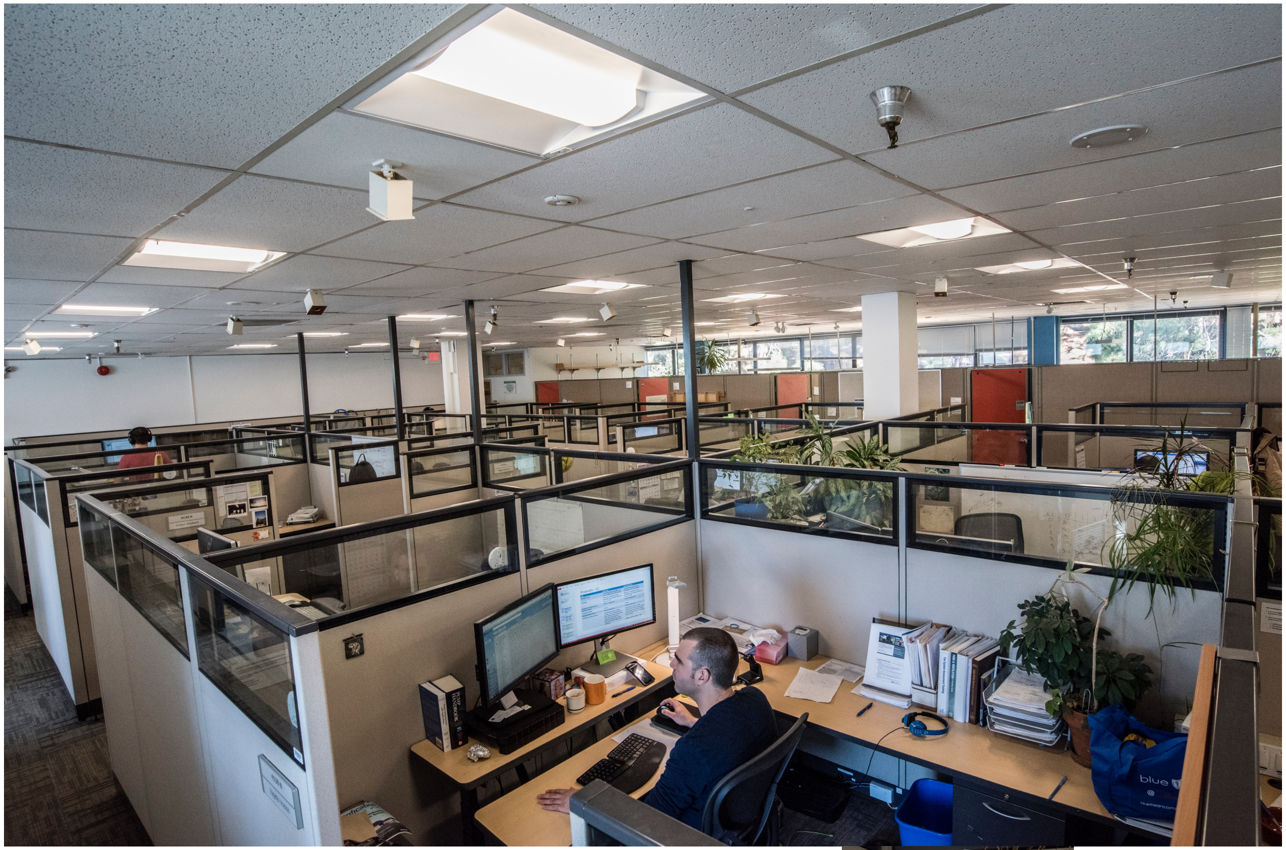
FLEXLAB Setup, Workstation Specific Lighting, 100sf/person

Configurations studied: South orientation, Light output levels of 500 & 300 lux, Workstation layouts for 100 and 150sf/person occupancy. Venetian blinds manually adjusted seasonally.

* Simple payback varies by controls type (eg. Enterprise or local) and may be higher for some regions.

System 3 – Task/Ambient Lighting with Plug Load Occupancy Controls

Integrated task/ambient lighting with plug load occupancy-based controls



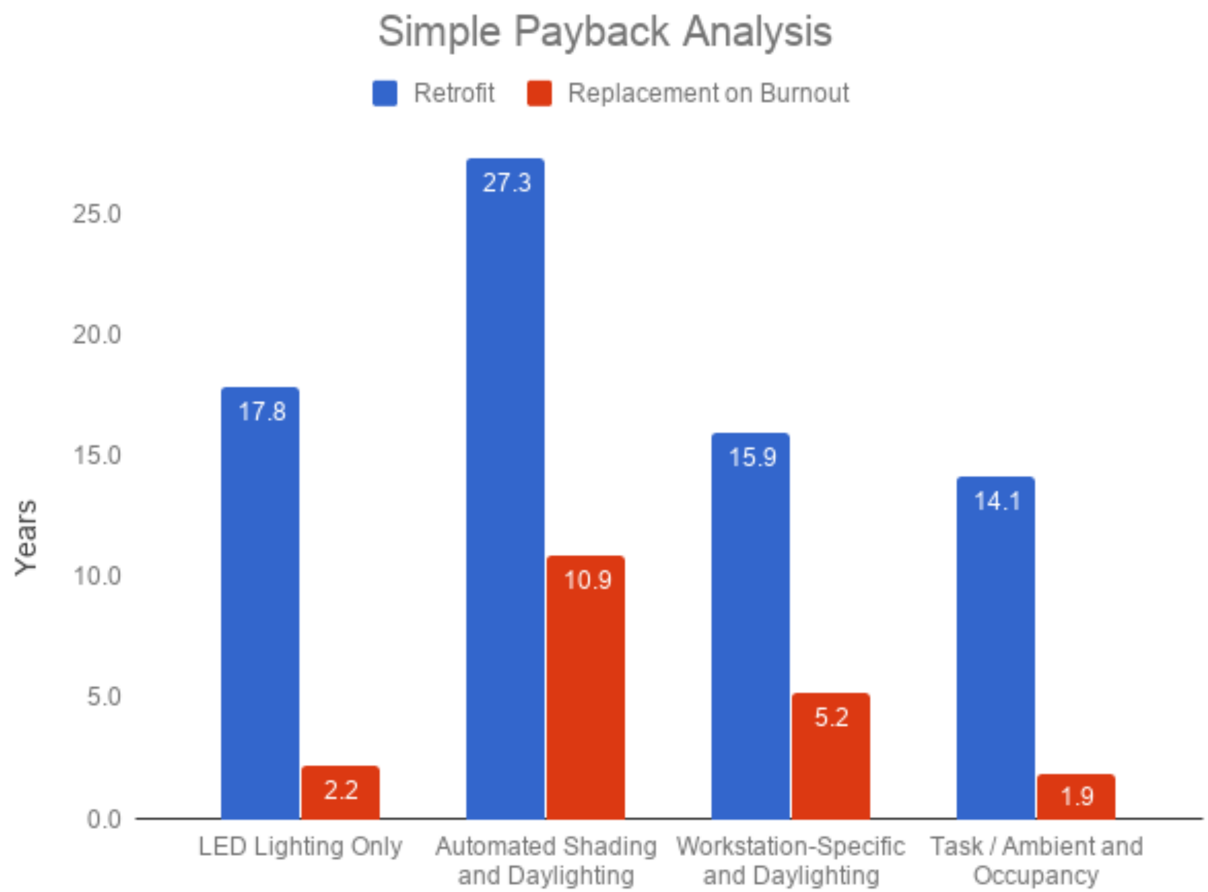
Market:
Small-large office

NCPA/SCPPA 319/372 GWh savings potential, 6-9 years simple payback at $0.16/kWh

Annual Lighting Energy Savings Potential:
50%+ (over T24)
70-80%+ (over existing bldg.)

12-28% Whole Bldg Savings

Systems Savings Over LED/Component Based Upgrades



Lighting Energy Savings relative to Baseline	63.1%	84.8%	93.3%	81.3%

"Energy Cost Savings of Systems-Based Building Retrofits: A Study of Three Integrated Lighting Systems in Comparison with Component Based Retrofits" (Regnier, 2018)

Cohort #1 – Major Takeaways

General Insights

- Lighting remains an important technology for utilities
- **Systems can achieve considerably more energy savings than ‘widget’ retrofits**
- **Cost effectiveness can be competitive with widgets, although LEDs have a significant market advantage**

Utility Program Insights

- **Incentive programs MUST be designed to address all system elements collectively**
- **Deployment channels matter**
- Baselines vary by utility, need to have methods to allow for translation to other utilities
- Utility programs take a long time to launch, tied to regulatory decision making process

Second Utility Cohort

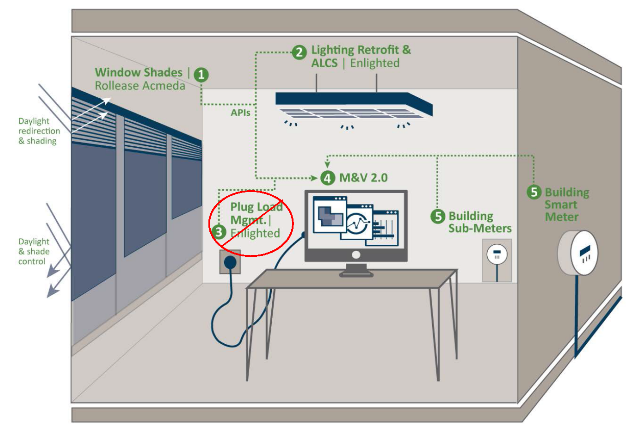
Utility partners:

- Identify EEMs and system packages of interest
- Provide input on regional info – baselines, rate structures
- Will prioritize packages for development

- Simulations by LBNL to analyze system package performance for each utility
- Two or more systems to be selected for further development in FY19/20

Industry Engagement & Spin-off Projects

- DOE/BTO – Integrated System Packages for Real Estate Life Cycle Events (Mathew PI)
- CEC EPIC – ZNE Small Commercial Office Retrofit Packages (Regnier PI)
- CEC EPIC – INTER system (NBI Prime, TRC & LBNL subs)



INTER System – Daylight redirecting louver, lower roller shade (w/ PV & battery for wireless install), daylight dimming, HVAC Cx; Includes M&V 2.0

Insights and Next Steps

- **Systems are an underutilized EE strategy, that can provide substantial energy savings over individual widgets.**
- **Utilities remain a largely untapped resource** for systems and they are motivated to deploy them.
- **Systems can be cost effective**, but demand assistance to reduce complexities, increase ease in deployment.
  - ✓ **Need R&D in technology development, and methods to reduce transaction cost**

<u>Next Steps</u>

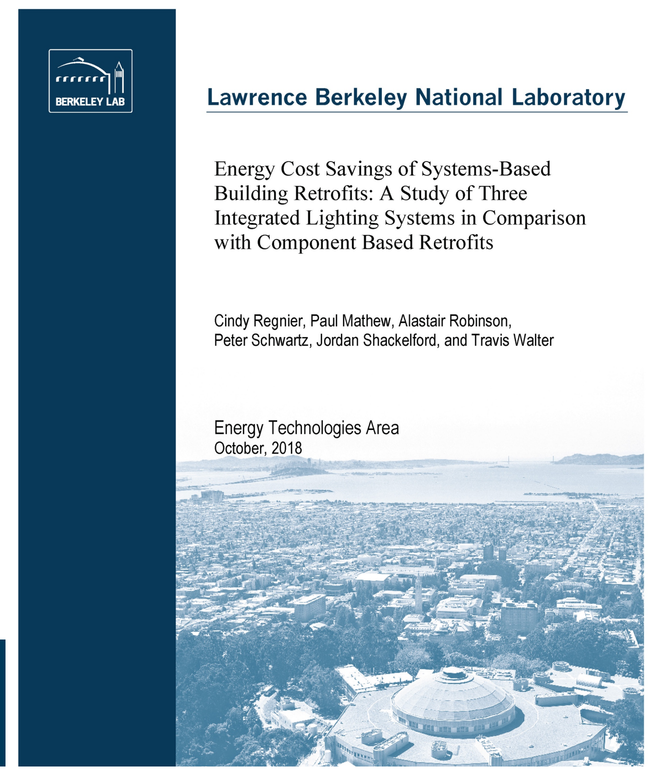
- Complete industry systems study, peer review & publish
- Second Utility Cohort – systems analysis and prioritization for development
- Continued outreach to industry partners, include A/E/C community
- Peer review

Systems Resources

3 Systems: *Simplified, validated assessment tools* (excel based) available for all three systems, including *system specifications and test results*: cbs.lbl.gov/beyond-widgets-for-utilities

ACEEE 2018 Summer Study paper: 'Beyond Widgets: Validated Systems Energy Savings and Utility Custom Incentive Program Systems Trends' https://aceee.org/files/proceedings/2018/index.html#/paper/event-data/p122

3 Systems vs Component based upgrade comparison paper https://eta-publications.lbl.gov/publications/energy-cost-savings-systems-based



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Energy Cost Savings of Systems-Based Building Retrofits: A Study of Three Integrated Lighting Systems in Comparison with Component Based Retrofits

Cindy Regnier, Paul Mathew, Alastair Robinson, Peter Schwartz, Jordan Shackelford, and Travis Walter

Energy Technologies Area
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