Beyond Widgets:

Building Systems for Utility Incentive Programs

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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.

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 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 GWh².

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

- **Equipment**
  - e.g. Air Source Heat Pump with Demand Control Ventilation

- **Sensors & Controls**

- **Supporting Devices**
  - e.g. Thermal storage and Time Of Use controls

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

- **Supporting Devices**

- **Termination**
  - e.g. Hydronic fan coil with occupancy controls

- **Sensors & 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.

- **System specifications**
- **Savings & performance metrics**
- **M&V specifications**

**Building Systems Package**

- **FLEXLAB-validated Savings**
- **Implementation & savings persistence guidance**
- **Controlled testing and validation of systems**
- **Simplified assessment method**

**Materials in utility language, structured in alignment with DSM program needs to support incentive program development**
Cohort #1 – Three Systems Packages

 Systems & Validated Savings

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)

HDR cameras for glare assessment
Illuminance sensors at 3’ intervals at workplane
Occupant heat generators
Plug loads
Each row of LED fixtures dimmed separately to meet illuminance setpoint
Automatic shading controlled by glare sensor
Cohort #1 - Shading + daylighting System – Annual Energy Savings Models

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

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

Simple Payback Analysis

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<th>Lighting Type</th>
<th>Years</th>
<th>Retrofit</th>
<th>Replacement on Burnout</th>
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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” (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

Next Steps

• 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
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


3 Systems vs Component based upgrade comparison paper