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Energy Technology Area

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Disclaimer

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Beyond Widgets – Systems Incentive Programs for Utilities

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ABSTRACT

Utility incentive programs remain one of the most significant means of deploying commercialized, but underutilized building technologies to scale. However, these programs have been largely limited to component-based products (e.g., lamps, RTUs). While some utilities do provide 'custom' incentive programs with whole building and system level technical assistance, these programs require deeper levels of analysis, resulting in higher program costs. This results in custom programs being restricted to utilities with greater resources, and are typically applied mainly to large or energy-intensive facilities, leaving much of the market without cost effective access and incentives for these solutions. In addition, with increasingly stringent energy codes, cost effective component-based solutions that achieve significant savings are dwindling.

Building systems (e.g., integrated façade, HVAC and/or lighting solutions) can deliver higher savings that translate into large sector-wide savings if deployed at the scale of these programs. However, systems application poses a number of challenges – baseline energy use must be defined and measured; the metrics for energy and performance must be defined and tested against; in addition, system savings must be validated under well understood conditions.

This paper presents a sample of findings of a project to develop validated utility incentive program packages for three specific integrated building systems, in collaboration with Xcel Energy (CO, MN), ComEd, and a consortium of California Public Owned Utilities (CA POUs) (Northern California Power Agency(NCPA) and the Southern California Public Power Authority(SCPPA)). These program packages consist of system specifications, system performance, M&V protocols, streamlined assessment methods, market assessment and implementation guidance.

Introduction

Energy efficiency improvements in buildings have historically been opportunities accessed in one of two ways - through equipment level upgrades as part of light retrofits, or for new construction and deep retrofits, through a more complex analytical and design process. Utility programs have followed suit with their offering of 'widget' based deemed savings incentive programs, and custom programs which target whole building evaluations and incentives. Deemed programs have enjoyed wide appeal in the utility market, for small and large providers alike, due to their streamlined, simplified approach to incentivize single products based on their efficiency rating. Custom programs however require significantly more time and resources to analyze and evaluate energy efficiency options, and are thus relegated towards building types that present higher density energy savings potential per building, such as large commercial offices, labs and data centers. Custom programs are often scaled down due to the complexity and increased costs of more intensive analysis. This is especially true in markets such as small commercial, where in aggregate the sector presents large energy savings potential but individually a building's energy cost savings often are too small to justify involved analysis and design efforts.

The equipment-level upgrade strategy is inherently limited in its energy savings impact, because energy savings are typically only obtained from the devices that are upgraded. Further, with increasingly stringent energy codes, utilities are finding fewer cost-effective single component technologies that save energy beyond code minimum levels to incentivize. In order to reach the market sustainably and at scale, a new approach is needed for all utilities large and small to unlock the savings potential of end use and integrated systems without the burden of full custom program customer evaluations. This paper presents an approach to develop, evaluate and package three integrated systems for streamlined deployment in utility incentive programs, unlocking deeper levels of energy savings than 'widget' based programs while reducing the complexity and effort of administering them compared to custom incentive programs.

Integrated Systems – Technologies, Opportunities and Savings

Deemed utility incentive programs currently focus on incentivizing 'widget' or component level technologies, with a few exceptions such as retrocommissioning. These components include items such as improved efficiency air conditioning units, water heaters, programmable thermostats and so on. Custom programs take this a step further where whole building energy analysis is conducted and packages of energy efficiency measures are evaluated. The benefit of this approach is that improvements on some elements in a building system, such as envelope insulation or glazing upgrades, can result in load reductions and reduced capacities and sizing of space conditioning equipment. In short, opportunities exist both at the end use system level, and as integrated systems, where one system impacts another's energy use, as well.

End use systems in buildings include HVAC, lighting, water heating, plug loads and the building envelope may be considered a system as well. Each of these systems consists of multiple components working together, actively or passively, to achieve a desired outcome such as maintenance of an indoor temperature setpoint, or a desired light level in the workplace, or protection from the elements. At the component level efficiency improvements include improved Energy Efficiency Ratios(EERs) and Coefficients of Performance (COPs) of HVAC equipment, reduced watts/lumen for lighting equipment, and improved insulation or glazing properties. At the end use system level further energy savings may be realized by utilizing efficient strategies across the end use system. An example would be low pressure drop ducting, extended surface low pressure drop filters, VFD motors and controls on an air handling system. These components can be designed together as a system to produce a more efficient outcome, such as reduced motor size on the fan, and overall lower fan energy use. A component based approach however might have only targeted a higher efficiency motor, rated at the same size as the existing motor.

A further opportunity for deeper energy savings exists when end use system strategies are integrated together, leveraging their benefits towards a greater outcome. In these cases a system is designed to work together with another, such as through integrated controls. Integrated systems are a building design that explicitly exploits synergies between end use systems in order to achieve whole building goals. One example could be automated shading systems with its controls integrated with daylight dimmable lighting and HVAC systems to optimize for best use of daylight in reducing lighting energy, while maintaining visual and thermal comfort and reducing HVAC energy when possible. Other opportunities exist to share data across end use systems for similar advanced controls benefits. Integrated systems can also provide the opportunity to reduce loads through one end use system, to enable new options or sizing of another end use system that would not have been possible otherwise. An example would be an improved envelope, façade and lighting design that lowered cooling loads to the point where a radiant cooling system would be viable to comfortably condition the space. Radiant cooling systems tend to have lower cooling capacities than air based systems, and might not otherwise have been a viable choice for the space.

Simulation analyses and real-world case studies have shown the potential for reducing energy use by 50 percent in nearly half of all the commercial floor area by utilizing best practice whole-building integrated approaches (Griffith et al. 2007). This paper focuses on an approach to the deployment of three integrated systems in utility incentive programs – integrated system technology solutions packaged for rapid deployment, reducing customization currently required for each application.

Utility Programs - Opportunities and Barriers with Integrated Systems

Utilities across the U.S. vary considerably in size, customer base and regulatory context. This study focuses on three utility groups in the West, Mountain Region and Midwest regions operating under different regulatory schemes. ComEd is a major utility serving the Greater Chicago area, regulated by the Illinois Commerce Commission. Regulated by the Colorado and Minnesota Public Utilities Commission, Xcel Energy (CO, MN) serves these territories. The consortium of California POUs(NCPA and SCPPA) is regulated by local entities, and represents areas in Northern and Southern California including locals such as Anaheim, Burbank, Alameda, Silicon Valley and Los Angeles.

While many of the larger sized utilities have been able to provide custom level incentive programs for their higher energy utilizing customers, most of the smaller utilities lack the resources to do so. This is true of the smaller public owned California utilities that participated in this project. For example, customers of NCPA member utilities consumed about **3%** of the state's annual electricity usage, and NCPA member utilities collectively spent **$12.6 million.** In FY13/14, Non-Residential Lighting projects represented **36.3%** of the energy savings from public power EE programs and **39.7%** of EE program expenditures.

At the same time, the California Public Utility Commission process is slow, DEER, the database of component based energy efficiency measures, is opaque and complex, so the California POUs have developed their own Technical Reference Manual (TRM) to develop component level efficiency savings metrics. However, as energy codes have become increasingly stringent the opportunities for utilities to find component level technologies that cost-effectively save energy beyond code has been dwindling. These factors have lead utilities to become interested in deeper levels of energy savings through systems, yet they also need simplified, reliable methods to deliver these incentives to customers. The transition to system-based measures will be predicated on reliable energy savings methodologies.

A Packaged Approach to Developing Systems Incentive Programs

The objective of this effort is to provide utilities and their customers with a streamlined package of information, tools and validated data necessary to implement system-level projects, achieving deep energy savings, without the complexity and cost associated with custom programs. This would reduce transaction costs for incentivizing integrated systems in utility programs. Three systems packages are being developed in collaboration with three utility partners (described further below). Each systems package will consist of the major elements shown in Figure 1 and described below:

- System specifications, with appropriate adaptations for selected market segment(s).
- System performance and savings metrics for baseline and retrofit conditions and assessment tools to help utilities and their customers identify and prioritize opportunities for investment in these systems.
- M&V specifications tailored to incentive programs – with a graduated approach that allows different levels of M&V effort based on the desired level of savings certainty.
- Validation of testing protocol and validated systems savings data based on testing in the recently commissioned LBNL FLEXLAB test facility designed to simulate real-world conditions of energy efficiency interventions.
- Operational protocols to ensure savings persistence.
- Implementation guidelines to ensure successful assessment, testing, and delivery of systems in the context of incentive programs.

The validated savings data and other resources could also inform the development of outcome-based codes.

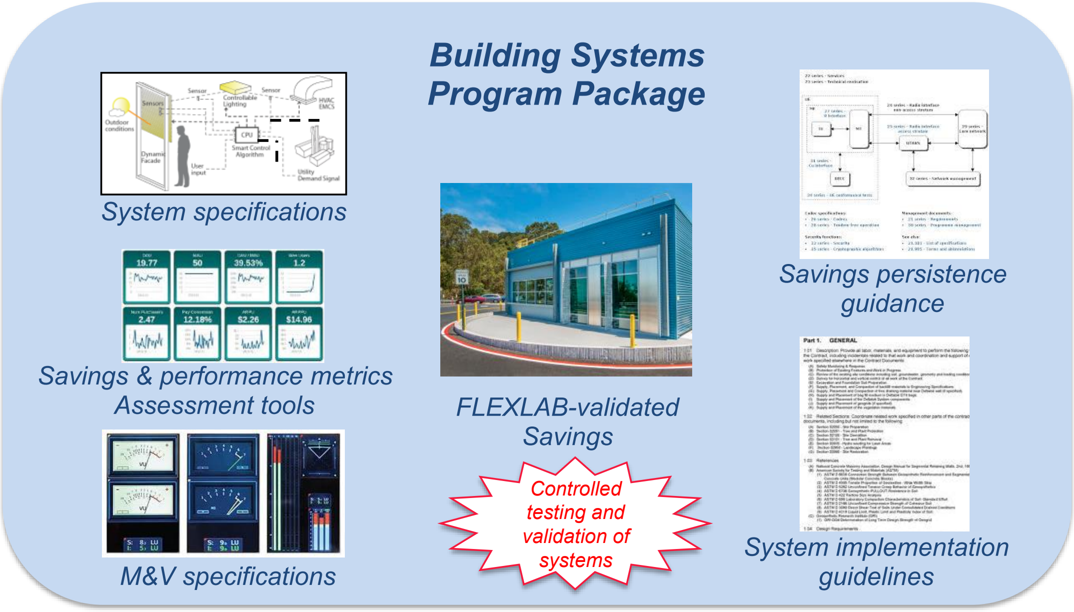

Figure 1. Key elements of the building systems package for utility programs

The testing and performance validation of selected systems is being conducted in LBNL's experimental FLEXLAB facility (LBNL 2016). FLEXLAB consists of highly controllable and instrumented test cells and an occupied lighting and plug loads testbed, where integrated design concepts may be design, developed, and tested. Performance of systems, subsystems or components may be measured to a degree of accuracy impossible in occupied buildings, with side-by-side testing against alternatives providing high levels of confidence in the results of such evaluations under identical test conditions. FLEXLAB tests are conducted with real occupants in some tests, for example in the case of the CA POU occupancy controls based task/ambient lighting system, and unoccupied for others. When occupants were used they had access to operating the system (e.g. task lights) as desired. Along with system performance, this project will test and validate the measurement and verification methods proposed for assessment of system energy savings potential at customer sites.

Simplified assessment methodologies will be developed as part of the project are anticipated to play a key role in helping prospective utility customers implement system upgrades – these will be targeted and tailored for the specific technology package and market sector. These methodologies will include comparisons to current conditions, or to a baseline energy code, as applicable, and for the applicable market conditions, with results of test use cases providing validation of calculations and assumptions. Ultimately, these products will enable utility DSM programs to access deeper energy savings with a reduced overhead as typically experienced with custom programs utilizing full scale whole building simulation models to achieve these system level savings assessments. Utilities may choose to integrate these methods into existing tools for customer use, or as options for program implementers.

Packaged Systems: Energy Savings and Market Potential

A total of three integrated systems were identified in collaboration with their respective utility partner(s) for development into a packaged streamlined incentive program. The intent is to allow a range of different component technology options that meet the system features set described for each system below, and are nominally capable of meeting the respective systems performance specification. The program incentives would be paid based on system performance as a whole. The following sections describe the system selected for each utility partner.

ComEd – Automated shading with daylighting and HVAC controls

ComEd considered several systems and selected automated shading integrated with lighting and HVAC controls. The key features of this system are:

Automated Shading: The automated interior shading element is roller shades. The functional requirement is for the shades to control solar gain through perimeter windows so that envelope-related thermal loads are minimized while meeting daylighting requirements. In unoccupied perimeter areas, the shades are deployed according to the prevailing HVAC mode of operation (deployed in cooling mode, retracted in heating mode).

Lighting Controls: The lighting control is in response to occupancy and illuminance levels. Occupancy-driven control switches lights on/off or dim to minimum background levels. Illuminance-driven control dims lights continuously based on daylight availability.

HVAC Controls: The primary HVAC control is in response to thermostatic setpoints, with scheduled setup and setback for unoccupied periods. Additionally, occupancy sensors used for the shading/lighting system may be used for setup/setback in response to vacancy during occupied periods, as well as reducing ventilation air.

ComEd identified two target market segments for this system package: offices and schools. For offices, the focus will be on medium and large size buildings. The package targets both retrofit and new construction.

Daylight-based dimming is a proven but underutilized energy-efficiency technology, particularly within the context of utility programs which cater mostly to prescriptive component-based efficiency measures. An LBNL meta-analysis study (Williams et al. 2011) showed that daylighting alone yielded an average lighting energy savings of 27% (N=18 projects) for offices and 29% (N=7 projects) for education.

Integrating automated shading with daylight dimming and HVAC controls has the potential to yield higher savings, a better visual environment, and higher savings realization. For example, post-occupancy study of the New York Times headquarters building (Lee et al. 2013) showed 38% lighting energy savings compared to code, with a simple payback of 4.1 years. The automated shades caused daylight to be well-managed irrespective of differences in daylight availability – for lower floors with greater urban obstructions, the shades were automatically raised more often and for upper floors with less urban obstructions, the shades were lowered more often to control sun and glare. These and other non-energy benefits (e.g. lower cost for reconfiguring a lighting system compared to hard-wired systems) serve as an added incentive to increase adoption.

California Publically-Owned Utilities (CA POUs) – Lighting and plug load occupancy controls with task-ambient lighting retrofit

The CA POU membership selected two discreet packages of advanced lighting and plug load controls, for deployment in commercial offices. The key features of this system are:

<u>Lighting and lighting controls:</u> overhead lighting will be controlled by occupancy at the zone-level. Occupancy controls will switch lights on and off, with the first occupant in the zone triggering lighting operation. Output from overhead lighting shall be dimmed to a background level, the intent being that any lighting deficit perceived by the individual occupants may be supplemented by the use of a personal task light. This strategy is generally referred to as a task-ambient approach.

<u>Plug load controls</u>: desktop equipment shall be controlled by occupancy at the cubicle level. Occupancy controls shall switch power on to controlled power receptacles. All desktop equipment, except for computers, should be powered via the controlled power outlets to ensure maximum energy savings – this shall include the task light used to supplement light levels at the work plane.

Two packages are identified as variations on meeting the performance requirements, differentiated by the degree of intervention required to install them and therefore their need to meet Code (in this case California Title 24). The ‘basic’ package is intended as a ‘plug and play’ system, requiring no rewiring or deep system intervention, and consists of an overhead lighting lamp change-out and installation of software-enabled controlled power outlets over the top of existing power receptacles. The ‘advanced’ package consists of replacement of controls and/or fixtures for overhead lighting, with a plug load control solution that requires rewiring.

The LBNL assessment of energy savings to date is based on results of field testing and measurements for plug load control equipment and hand calculations for the energy performance benefits of dimming of overhead lighting. These separate analyses suggest that energy savings of between 2.7 and 4.5 kWh/sqft/year, which translate to between 16%-21% of whole building energy savings.

The CA POUs identified offices as the target market for this system, with the basic package anticipated as being more attractive to small and medium-sized buildings due to the lower costs and the absence of a Code trigger.

Xcel Energy (Colorado and Minnesota)– Daylight redirecting film with integrated lighting and HVAC controls

Xcel Energy considered several system options and selected daylight-redirecting window film and deep daylight dimming zone- or occupant-level, intelligent networked lighting controls, including HVAC interactive effect savings.

Daylight-redirecting window film (e.g., Meso-optic film) directs additional natural light entering the building through vertical glazing with high visible light transmittance, up to 35 feet along the ceiling plane to improve and increase the daylight zones and to reduce visible glare. This will enable enhanced photosensor-driven lighting savings.

Lighting control will respond to occupancy and illuminance levels. Occupancy-driven control switches lights on/off or dim to minimum background levels. Illuminance-driven control dims lights continuously based on daylight availability. The primary HVAC control will respond to thermostatic setpoints, with scheduled setup and setback for unoccupied periods.

Key aspects of the lighting system functionality include (1) enterprise-level, zone control; or (2) enterprise-level, intelligent granular control at the workstation level. Systems approaches require a different perspective on assessment and validation depending upon these functionality levels, with an emphasis less on installed product and more on performance/outcome, e.g., kWh/sf/year.

The performance-based systems specifications allow a range of different system technology options.

Xcel Energy identified the large and small commercial office target market segments for this system package focusing on medium and large size buildings. The systems-based approach targets both retrofit and new construction projects with appropriate system types and glazing systems.

Market Analysis Results

LBNL commissioned a major utility program evaluator and consultant to identify energy savings potential for each of the three systems for their target utility areas and market segments (e.g., offices) and sub-segments (e.g., large offices owned by the tenant). Table 1 presents the most notable findings of this study.

Table 1. Market Analysis Results

Cost Effectiveness	The systems selected tend to be cost-effective from the utility Total Resource Cost (TRC => 1.0) perspective for office building applications for the Northern and Southern California POUs and in larger office buildings for Xcel Colorado. These systems selected are not as cost effective for Xcel Minnesota. For ComEd, these systems are cost-effective, but only for specific sub-segments and only when evaluated using incremental system costs.

	The differences in cost-effectiveness, and thus economic potential, are due more to levels of utility avoided costs[1] rather than the system costs or their savings on a per square foot basis. For example, the avoided cost stream average was $0.22 per kWh in California and $0.15 per kWh for Xcel Colorado. ComEd in Illinois and Xcel Minnesota were much lower with an average of $0.04 per kWh.
	From the customer perspective, the simple payback for these systems (depending on application and location) ranged from approximately 7 years to 35 years in the retrofit scenario and 6 years to 22 years in the replace-on-burnout scenario, prior to the application of incentives. Individual utilities are expected to tailor incentive rates for their individual markets to gain acceptable customer paybacks. Some of this difference is due to the wide variation in customer energy rates. Over the analysis period of 20 years, commercial rates in California average approximately $0.19 per kWh. For ComEd in Illinois, rates in the analysis averaged $0.10 per kWh. Xcel CO and MN have average rates of about $0.09 per kWh.
Awareness	Interviews with subject matter experts found sufficient general market awareness of these systems but their benefits in terms of energy savings and operational efficiency improvement are not well understood by facility managers and building owners. Since benefits in terms of energy savings, maintenance and operations savings, and building operational control are key drivers of adoption; a lack of knowledge in these areas implies that adoption will be slower than that of well-understood widget equipment.
Payback	The adoption decisions and installation of these systems are much more involved and disruptive to building tenants than typical widget replacement projects. As a result, experts interviewed for this study asserted that, given the longer paybacks of these systems and with no program intervention, only 13% to 20% of the market would adopt these over the next 10 years.
	Reducing payback times to 2 years or less, through market cost reductions or maximized utility intervention, will increase expected market saturation to between 24% and 43% over 10 years.

The total technical potential of energy savings for each utility partner in GWh is in Table 2. Areas of higher technical potential are due to the combination of the energy savings potential of a technology package and the applicable market size that could adopt it in the utility area.

Table 2. Technical potential (GWh savings)

Utility partner	Package 1 - low	Package 1 - high	Package 2 - low	Package 2 - high
Northern California	412	752	833	883

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[1] Avoided costs are the proxy used to reflect the benefits to the utility. In this study, they refer to eliminating, or significantly delaying utility expenditures for infrastructure upgrades and fuel costs due to a reduction of energy consumption by customers.

Southern California	479	876	1,028	1,028
ComEd	519	633	NA[2]	NA
Xcel Colorado	370	370	743	908
Xcel Minnesota	148	148	296	962

FLEXLAB Test results

A series of tests were designed to be conducted in FLEXLAB (flexlab.lbl.gov), a controlled, highly instrumented building technologies test facility that offers unparalleled granularity in performance measurement to assess the energy savings potential of each system, under a range of conditions expected to occur in the market place. Test scenarios include a range of different baseline conditions to represent either existing conditions or code minimum conditions, which are the baseline for comparison for some utility programs. A range of existing technologies were specified, including fixture and lamp types, as well as controls. The integrated task/ambient lighting system coupled with plug load occupancy controls chosen by the California Public Owned Utilities is presented in this paper. This system was tested in FLEXLAB's occupied Lighting and Plug Loads testbed, which consists of a permanently occupied commercial office environment, with power measurement and controls capabilities at the device level.

For this system the following test cases were developed, representing the range of existing or baseline conditions, as well as a range of applicable system applications. The retrofit system packages were selected to allow for a range of technologies to be applied, from relatively simple and low cost (without requiring an electrician for the work), to more advanced, deeper retrofit (requires electrical work). Table 3 describes the packages and baselines studied.

Table 3. Task/ambient lighting and plug load occupancy controls retrofit and baseline packages

	Baseline	**Retrofit Package**
Package 1	Existing building condition – commercial office	'Plug and play' LED lamp retrofit for task-ambient lighting and wireless plug load control of desktop loads, including task lighting, via receptacle overlay
Package 2	Existing building condition and CA Title 24 – commercial office	LED lighting fixtures replacement / lighting controls retrofit for task-ambient lighting and wired plug load control of desktop loads, including task lighting

A range of test scenarios was then developed to allow for performance data to be collected across the range of possible baseline conditions, as well as the new technologies. A

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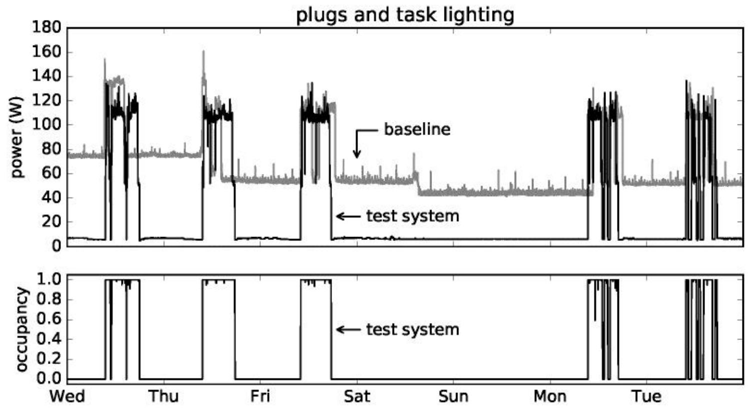
[2] No package 2 was specified for ComEd.

minimum of 2 months was targeted for testing under each condition. The complete test scenario conditions are shown in Table 4. All packages allow for the occupant to be able to modify task lighting or plug load operations, and occupancy based controls.

Table 4. Test scenario conditions

Test Description	**Baseline**	**Test Condition**
1. Reduced overhead lighting power density (LPD) without controls and plug load controls	Existing building conditions (multiple measured baselines / empirical measured data from field tests)	Linear LED lamp replacement (with integrated driver) in existing fixtures, and schedule and/or occupancy control of plug loads.
2. Test #1 with controls for overhead lighting added.	Existing building conditions (multiple measured baselines / empirical measured data from field tests)	Linear LED lamp replacement (with integrated driver) in existing fixtures, and schedule / occupancy control of plug loads.
3. Existing overhead light fixtures with new lamps and /or controls, and plug load controls.	Existing building conditions (multiple measured baselines / empirical measured data from field tests) and Title 24.	Retrofit of LED replacement tubes and controls to existing lighting system, and schedule / occupancy control of plug loads.
4. Overhead fixture replacement, reducing operational LPD, and plug load controls.	Existing building conditions (multiple measured baselines / empirical measured data from field tests) and Title 24.	Retrofit of LED fixtures with comprehensive controls functionality, and schedule / occupancy control of plug loads.

Operating performance and early results for Package 2 (an overhead lighting controls retrofit and wired plug load occupancy control; test description 3 from Table 4 above) – shown below in Figure 2 and in Table 5 - are encouraging, although it should be noted that at this stage that the sample is limited to one of the cubicles in the test area (there are a total of 9). The remaining packages are tested following Package 2. The energy savings results will change as the sample size expands and sample period increases. The energy savings quoted assume equivalent performance over a year, extrapolated from the sample period of one week.



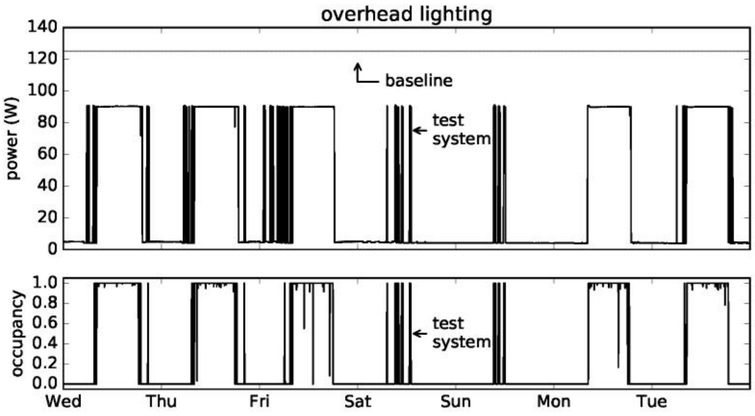


Figure 2. Overhead lighting and plug load operation in response to occupancy for baseline and test cases

Table 5. Early energy performance results for Package 2

System Element	**Baseline Energy (kWh/yr)**	**Test Condition Energy (kWh/yr)**	**Energy Savings (kWh/yr)**	**Energy Savings (%)**
Overhead lighting	1,092	312	780	71%
Plug load	563	224	339	60%

Anecdotal evidence suggests that task lighting is not used as often as anticipated. This is in large part due to the bright conditions that have prevailed during the early weeks of testing. During overcast periods, heavier task light use is likely, and plug load energy use for the test case is therefore very likely to be higher. In terms of implementation, commissioning and tuning of the controls was a time consuming exercise. Testing the technology in a mock-up space prior to roll-out in the occupied test area was a key intermediate step as it allowed a period of familiarization without exposing occupants to this learning process.

Early test results from the ComEd automated shading and daylight dimming tests are also indicating strong savings potential, at 45% savings over baseline.

Discussion

The potential for systems to provide deeper levels of energy savings in contrast to single component upgrades in buildings is clearly demonstrated through numerous case studies and evaluations (Griffith et al. 2007), as well as through the evaluations conducted for these three integrated systems packages. Test results from the task/ambient lighting and plug load occupancy based controls retrofit validate its savings potential under a range of conditions.

The challenge for the market is to develop streamlined packaged offerings to enable greater customer adoption of these approaches. Outreach conducted to utility program administration subject matter experts provided some insight into further opportunities and barriers for further deployment of these systems. In particular it was noted that deployment of some of these integrated systems might involve more than one trade. The building technologies industry is inherently siloed today, both in the manufacturing realm as well as in design and installation. As such, it is difficult to envision that many integrated systems will become commoditized ‘off the shelf’ offerings to the customer, although there could be some notable exceptions. In the short term, efforts can be made in the outreach and education of trade allies, designers and owners on the opportunities for savings through integrated systems.

Market analysis also indicates that the potential for economic deployment of systems in a utility area is in part significantly affected by the utility’s avoided cost of energy generation. These avoided costs vary greatly by region and energy mix, however the results of this study can be applied to different regions with this in mind. In cases where avoided energy costs are low, such as parts of the Midwest, utility programs might focus systems based incentive programs towards replace-on-burnout conditions rather than retrofits. In these cases the incremental costs of the technology can be considered in the cost and payback analysis rather than the full system cost, thereby improving its cost effectiveness.

Further opportunities exist to continue to explore and leverage the benefits of integrated systems that were not fully discovered in this project. One consideration is the interactive effects of a technology on heating and cooling loads, and consequently HVAC energy use. It is possible through the evaluations and FLEXLAB testing to determine these system impacts on the heating and cooling loads. However, the challenge then becomes how to translate this into HVAC energy use impacts. The markets studied for these systems span large and small commercial, where HVAC system configurations, sizing, controls, and overall performance can vary widely. Future work to characterize these existing systems using measured energy data could contribute significantly towards developing load and energy use profiles for these systems, which could then be used to assess energy impacts of load reducing technologies.

Further assessments will be conducted to complete the range of testing for all of the systems. These tests will be used to validate energy savings and provide utility program administrators with levels of certainty for different M&V approaches. Simplified assessment methodologies will also be validated. Integrated systems pose a significant opportunity for utility incentive programs, and when paired with simplified administration methods can open the door to greater levels of energy savings for customers, cost effectively. Future work in this area may also focus on the role of trade allies and education to enable increased adoption.

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