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Burlington also has a particular sense of "pride and spirit" that lends it a cohesiveness that may be important to testing the program's effectiveness (Duffy and Niewald 2012). In other words, Burlington was seen to be a reasonably controllable environment for the "experiment" that is the Way to Save, Burlington! program, and serves as the program's main "brand."

Several other innovative features of Way to Save, Burlington! include "programs within the program," such as energy makeover contests, an energy-saving pledge tied to an annual 1% city-wide savings goal, and a rewards program with local businesses. The Home Energy Makeover contest called for households to submit videos describing their homes' energy use and their own energy-using practices; the videos were voted on by Burlington residents through the Way to Save, Burlington! website (WTSB 2012), and the winning household was awarded $5000 to make energy efficiency retrofits.[54] A similar contest for local businesses is taking applications as of this writing, with two winners each to get $2500 for retrofits.

The Way to Save, Burlington! pilot will be evaluated by a third-party evaluator after its conclusion in 2013, and depending on the results, the program may be recommended for scale-up across the state of Wisconsin. Preliminary results for the commercial sector presented at AESP's May 2012 conference show a significant uptick in savings activity. Net gas and electric savings activity increased by14.6% and 71.5%, respectively, over the first 15 months of the program (Duffy and Hanna 2012) when compared to the control community.[55] Additional anecdotal evidence suggests that the program has met its goals: there has been increased participation in existing efficiency programs implemented by Focus on Energy, the community has already exceeded its 1% annual savings goal (considered fairly aggressive pre-launch), and the program has also succeeded in either directly or indirectly "touching" every member of the community, with some early adopters become "repeat customers" seeking more ways to save energy (Duffy and Niewald 2012).

One challenge for the final year of the program is to how to broaden its appeal. The finalist videos submitted for the Home Energy Makeover contest (WTSB 2012) exhibited some self-selection: many of the households described ways in which they were already making significant efforts to cut down on energy use, while seeking to do even more if awarded the $5000 prize. While self-selection bias is a problem for efficiency programs, in this case—where community engagement and social media are core components—anecdotal evidence suggests a balancing force: these early adopters may serve as champions for the program, helping to get the word out and thereby increase participation.

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[54] Energy Trust of Oregon has been running a similar program since 2009 as a statewide awareness builder. http://energytrust.org/library/case-studies/video/hem-bend.aspx

[55] These figures represent a change in savings activity, not in absolute kWh or therm savings. The impacts were observed in comparison to the "control" community of Watertown, which is similar to Burlington in several respects, but does not have the Way to Save program in place.

A challenge beyond the end of the pilot is whether this "experiment" can be successfully implemented in larger urban areas without Burlington's blend of cohesiveness and "pride and spirit." Several trends point to its potential: larger urban areas, especially if tackled at the neighborhood scale, may have a larger community of early adopters to draw from, have more opportunities for synergies between households and businesses, and may exhibit greater speed in communicating about the program, compared to a small community such as Burlington. Experience with a similar pilot in Oregon in the 1990s, however, points to remaining difficulties in moving this type of program beyond the pilot stage. Community-based programs can be logistically complex and expensive, and it may be difficult to gain participation from stakeholders with the largest loads (and thus the greatest potential for savings), such as universities and industrial facilities (Garth 2012). Overcoming these types of transaction costs may require making programs more "plug and play" through the creation of tool kits or other resources.

Recommendations

Behavior-based energy efficiency programs in the residential sector have the potential to contribute to significant energy savings as they move out of pilot stages and into the mass market, although programs utilizing enhanced billing are nearing scale more quickly than those that utilize real-time feedback or community marketing. Program designs that depend on engaging customers through already well-established channels such as websites and smartphones appear to be cost-effective due to low costs of acquisition and wide reach. These types of programs include both enhanced billing measures as well as web-based real-time feedback programs.

In contrast, while programs that depend on the installation of new hardware to provide real-time feedback have resulted in higher per-household savings than other types of behavior-based programs, they appear not to be as cost-effective because of higher technology costs and lower customer adoption.

Over the next one to three years, we recommend that program administrators focus on behavior-based programs that feature an opt-out design, that include both historical and social contextual information on energy use, and that are delivered through already well-established channels. In-home displays that provide real-time feedback, in contrast, may for the time being be most effective as one technology offering in a broader program, such as a residential energy audit, at least until costs decline with greater market penetration and smart metering becomes more widespread.

Intensive community based social marketing along the lines of the Way to Save, Burlington! program appears to be a promising approach to increase participation in existing programs and to increase savings. We must wait, however, for further data on evaluated savings before providing recommendations on this particular approach.

The savings potential reflected in the tables above are likely somewhat conservative. Laitner (2012) models a range of program savings that agree with the potential percentage savings used in this paper, but he also argues for a significant upside based on both behavior-savvy program design and technological innovation. It is clear from the conversations that serve as the background for this section that encouraging innovation in technology, policy, program design and evaluation—and understanding of human behavior around energy use—will be critical to capturing the energy savings potential in this area.

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Commercial Program Profiles

COMMERCIAL LIGHTING

Synopsis

Lighting is a major savings opportunity for the commercial sector, as lighting can be more than one-third of the total commercial electric load. In the past, the bread-and-butter of commercial lighting replacement programs had been initially providing rebates to promote reduced wattage T12[56] fluorescent lamps and ballasts and more recently the substitution of T8 for T12 linear fluorescent lamps. This will change substantially with the full implementation of new federal minimum efficiency standards.[57] The impact of new federal standards for fluorescent lamps and ballasts will affect the baselines commonly used by energy efficiency programs. However, not all states are addressing these changes uniformly. Impact evaluation and regulatory decisions could result in program administrators getting credited for less energy savings resulting from programs unless they go beyond the new standards to improved energy saving fixtures, controls and lighting design approaches.

To reach the higher bar required in the new environment, next generation commercial lighting programs take a more holistic, systems-oriented approach that incorporates advances in technology, rather than the simpler traditional approach of replacing lighting products and equipment with similar, yet more efficient ones. Barriers to comprehensive next generation lighting ramping up to scale include high up-front costs for advanced controls and equipment, including changing the arrangement and wiring of fixtures, and shortage of trained lighting contractors. Targeting larger customers and lighting designers/electrical engineers to promote advanced lighting systems and the integration of lighting with HVAC and other measures improves cost effectiveness. Programs should place greater emphasis on training contractors to take more complex and sophisticated approaches, which are customized to the needs of the commercial customers and the characteristics of each market segment.

Background

Commercial lighting energy efficiency measures often comprise a substantial part of C&I retrofit programs and small business and small/medium C&I programs.

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[56] The numbers in "T8" and "T12" refer to the number of eighths of an inch in diameter of the fluorescent tubes. For example, a T8 lamp is eight eighths of an inch, or one inch, in diameter.

[57] This does not mean that T12s will disappear. A recent study by NYSERDA projected that a significant inventory of non-compliant T12 lamps (over 7,000,000) will be in place in New York State until 2017. This analysis is backed by DOE's estimate underlying the Amended Fluorescent Lamp Standard in which they projected T12 lamps will still be in use in 2026. (DOE "Final Rule Technical Support Document: Energy Conservation Standards for General Service Fluorescent Lamps and Incandescent Reflector lamps—July 2009;" Ch. 11; pg. 11-12) In addition, manufacturers now offer compliant and exempt T12 lamps, which will further impact the length of time T12 lamps remain in the marketplace.

Historically most commercial lighting programs have been relatively simple in design, providing rebates or other financial incentives to replace linear fluorescent T12s with T8s or high-performance T8s (HPT8s, also called "super" T8s) lamps, ballasts and fixtures. The lamp and ballast may be replaced one-for-one, or two-for-four ("de-lamping"), without replacing the luminaire. One of the reasons this has been so prevalent is that there are so many T12s in use; some of the fixtures have been in place for decades. As a result, there is still vast energy-saving potential available in the installed base of linear fluorescent lights, especially in states without long histories of energy efficiency programs. The T8s featured in energy efficiency programs are commonly replacing T12 lamps, which until very recently represented almost one-third of all linear fluorescent lamps sold annually. More than one-third of all commercial and industrial fluorescent sockets are still filled with T12s (Delouie 2012). Other benefits to these basic equipment-replacement programs are that they are simple, highly cost-effective, readily understandable, and can be done by lighting contractors without specialized training in more advanced technology or lighting design. Replacing an older magnetic ballast and 34 Watt T12 with a 25 Watt T8 and high-performance electronic ballast can cut energy use almost in half with minimal reduction in perceived light output (PG&E 2007).

Some of the larger traditional commercial lighting programs use an upstream incentive paid to participating lighting distributors for qualified lighting equipment sold in the utility or program administrator service territory. This is more common for utilities with large service territories. Product eligibility for incentives may be based on technical specifications. Today, high-performance T8 (HPT8) lighting equipment, including fixtures, ballasts, and lamps are still among the most common technologies in commercial and industrial lighting programs. This program structure provides several advantages. It provides an incentive to the distributor to have high efficiency lighting products in stock, which increases the availability and access to them for lighting contractors and other trade allies. The end consumers do not have to fill out paperwork in order to get efficient lighting at lower prices as there is no application process for the consumer to be eligible for rebates. Upstream rebates also tend to be less expensive to the program administrator per unit, because incremental costs are highest at retail, making more efficient use of program incentive dollars.

Drivers for Change

New DOE Lamp and Ballast Standards

In 2009 DOE set new fluorescent lamp standards that effectively prohibit the manufacturing or importing of most of the T12 fluorescent lamps currently on the market as of July 2012.[58] While the standard has eliminated a majority of the T12 lamp types, the big three lamp manufacturers have responded to the standards by developing lamps that are either compliant (i.e., they meet the efficacy requirements of the standard) or are exempt (i.e., they have a high CRI that exempts them from meeting the efficacy requirements of the standard). Standard T8 lamps were given a temporary two-

[58] "Compliant" and "exempt" T12 lamps are being offered by lamp manufacturers, allowing customers to remain with T12 lighting technology.

year waiver before the standards will generally require use of either T5 lamps or "super T8 lamps".[59] Likewise, in 2011, DOE set new efficiency standards for the ballasts that operate fluorescent lamps, requiring only the highest efficiency units as of November, 2014. These standards cover both standard and energy-saving four- and eight-foot linear fluorescent lamps and ballasts.

Once the higher baseline is uniformly implemented, it will substantially reduce energy used by fluorescent lighting systems but will also have the overall impact of substantially eroding the savings that may be claimed by commercial lighting efficiency programs focused on replacement of linear fluorescents. For example, until recently a four-lamp T12 fixture with magnetic ballasts using 45W per lamp, or 180W total, could have been replaced by T8 lamps and electronic ballasts, cutting the energy use in half or better. This has been providing a cost-effective source of savings to the programs and a large pool of customers for lighting contractors. Now that standard T8s are the new baseline, not to mention the even higher baseline in 2014, much of the low-hanging fruit will be harvested, which creates a huge incentive for change in commercial lighting programs.

New Technology Creates New Savings Opportunities

The incentive for innovation in commercial lighting programs due to higher standards has been anticipated by the industry. Manufacturers, trade allies, and utility-sector programs have been aware since the standards were set that these standards would have a large impact on energy savings and remaining energy-saving opportunities. While this creates a great driver to transform program designs, delivery, and technology it does not mean that it has produced a single solution, only a wide proliferation of new technology options and an array of new program approaches.

Emerging Trends

To continue to achieve high savings, commercial lighting programs will need to incorporate new technologies and serve greater numbers of customers. One direction for next generation lighting programs will be to support advanced efficient lighting systems that get "deeper" savings, those that arise from more comprehensive lighting redesigns and introduction of new, more efficient technologies, such as lighted electronic diodes. Lighting redesigns are common when tenants change. Such redesigns can include high-efficiency lighting fixtures such as direct-indirect fixtures, use of one- and two-lamp fixtures instead of the three- and four-lamp fixtures that were popular in the past, and use of task-ambient lighting approaches in which overall ambient lighting levels are sufficient to do most work for the average person and task lights are used for particularly demanding tasks or people with below-average vision. In addition, use of advanced lighting controls is one area of technology development and innovation that holds great promise and is the subject of pilot programs and some leading full-scale programs. Programs may also add new incentives or channel approaches to get customers to take additional measures and multiply savings.

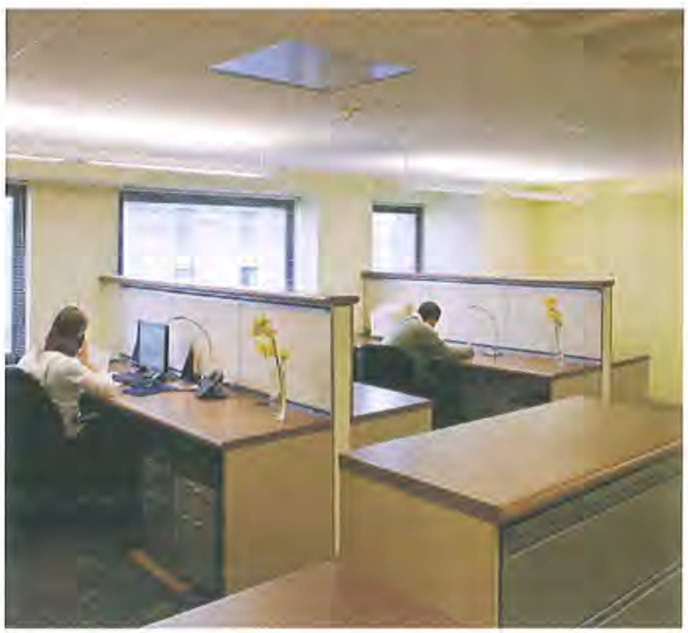
[59] T12, T5 and T8 refer to the lamp diameter, in eighths of an inch. Thus, a T8 lamp is one inch in diameter, a T12 lamp 1.5 inches. Smaller diameter lamps are generally more efficient as the smaller diameter means less internal losses.

LED lighting is clearly prominent among new lighting technologies. LED lighting may save 10% to 20% more energy than high performance T8s and even more relative to the halogen reflector lamps commonly used in retail stores and a variety of other applications. LEDs also provide non-energy benefits relative to fluorescents, such as greater control and being mercury-free.

The creation of a complete lighting system by design, with efficient equipment, sensors and integrated controls, has the potential to reduce lighting energy use by 50% or more (Bisbee 2012). This combination of new lighting technologies and comprehensive design can yield significant savings for participating customers. Such system-based or integrated projects can offer participants savings based on efficiency gains, load flexibility (demand management) and demand response. However, measure level cost-effectiveness requirements can provide a challenge to going deeper. The up-front costs to achieve these deep savings may result in longer payback times, although still typically five years or less. They are more attractive for complete lighting retrofits and for larger customers that have sufficient capital to invest.

In addition to achieving deeper savings, another approach for the next generation of lighting programs will be to increase participation. This can be done by gaining new participants to programs and by offering services that provide new opportunities for past participants.

Figure 1. Example of an Office with Single-Lamp Direct-Indirect Fixtures with Task Lighting



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Technologies

In many ways, commercial lighting systems are on the cusp of a revolution. New DOE standards are clearly driving changes in this market, changes that were underway but are now accelerating due to these new standards. The technological changes are occurring in luminaires and controls as well as light sources. There are related changes in lighting design itself as lighting designers and electrical engineers are gaining a multitude of new technologies to work with, many of which offer new capabilities and yield much higher quality lighting.

Reduced-Wattage Linear Fluorescent Lamps

To obtain energy savings beyond the new codes, dozens of programs include incentives for reduced-wattage T8 and T5HO (high output) lamps, which can save more than 20% of the energy consumed by traditional T8 lamps and last up to twice as long. Reduced-wattage linear fluorescents are likely to remain a very important part of the future of commercial lighting programs. Some newer reduced-wattage T8s and T5HOs maintain their rated light output levels longer and have superior color-rendering qualities, so lit areas appear more natural. For applications where troffer or other linear lamps are the best choice, light emitting diode (LED) lighting technology has not caught up yet with a competitive combination of price, features and benefits (see section below, *Linear LED*).

One- and Two Lamp Fixtures and Task-Ambient Lighting Design

In the 1970s, fixtures containing four lamps were commonly used. By the 1980s, three-lamp fixtures became more common. By the 2000s, two-lamp fixtures were common. The reduction in the number of lamps per fixture was made possible by improved fixture designs that allow more light to leave the fixture, along with improved higher-output lamps, and changes in recommendations regarding ambient lighting levels. Whereas in the 1970s the philosophy was to brightly light offices so that a person with below-average vision could read a carbon copy in the corner of an office, by the 2000s individual computers were widespread, lighting levels were reduced, and other steps were taken to reduce glare. For example, the Illuminating Engineering Society recommended lighting to 30 foot candles in offices with computer screens in their 2000 Handbook, down from 75 foot candles in their 1981 Handbook. Use of two-lamp fixtures will often produce more than 30 foot candles in an office, whereas 30 foot candles can often be reached with one-lamp fixtures and high output lamps or ballasts.

Generally, the fewer lamps in a fixture, the lower the wattage will be. For example, a four lamp fixture in the 1970s might have used 180Watts, while a one lamp fixture with a high output ballast might use about 40 Watts. Larger offices may require two or more one-lamp fixtures, but these can be "tandem wired" so that a single two- or three lamp ballast controls all of the fixtures, reducing connected wattage and energy use. For demanding tasks, a task light can be used to provide additional illumination at the work surface.

Efficient High Intensity Discharge (HID) Lighting Sources

While fluorescent lighting predominates in offices, high-intensity discharge lamps are more common for larger spaces. Efficient options include pulse-start metal halide lamps and high-pressure sodium lamps. High-output fluorescent fixtures are also being employed for high- and low-bay settings, most often with T5 or super T8 lamps.

LED Directional Replacement Lamps

Often used for spot and track lighting applications, directional LEDs generally replace halogen lamps. Benefits include longer life (and the resulting reduction in labor costs and the cost of purchasing new lamps) and energy savings. Directional LEDs also give off less heat than halogen lamps, which can reduce air conditioning costs. While LEDs are more expensive than halogen lamps, there are many important non-energy benefits that make the switch attractive to businesses. These include instant-on capability, high quality natural light output, dimmability, and the absence of toxic mercury and lead. Thousands of products are readily available from retailers and online (several databases of available products are discussed below).

Linear LED

LED linear replacement lamps are rapidly improving in quality and decreasing in price, although the question of "Are LEDs the next T8?" has yet to be answered, and it may be several years until linear LEDs become a viable, cost effective alternative. Currently there are a variety of LED troffers and retrofit panel kits listed on the DLC Qualified Products List that provide adequate light levels and efficacy. Many some program administrators (mentioned later in this section) rely on the DLC Qualified products List to determine which LED products they will provide incentives for. However no LED linear lamps have met the DLC's specifications to be listed. LED lamp manufacturers must overcome significant barriers including low light output and narrow light distribution when configured in existing fluorescent fixtures, and a high cost per lamp of $40 to $50 (versus about $2 to$6 for a fluorescent tube). There may also be additional wiring costs because of the different types of ballasts. Fluorescent lamps still compare favorably in many applications to LED when considering the overall combination of dimmability, cost, service life, light output, and color. T8 and T5 lamps maintain their light output above 94% for their rated life.

Other LED Applications

LED lighting for refrigerated and frozen food display cases in supermarkets offers technical advantages compared with the fluorescent lamps that have been used traditionally. Light output from fluorescents more than halve in colder temperatures below optimum operating conditions of 60 to 80 degrees Fahrenheit. LEDs provide both better performance as well as higher efficiency at low temperatures, resulting in energy savings of up to 50%.

Street lights are also emerging as another future opportunity for saving energy with LEDs. Several large cities have begun pilot projects for LED street lighting, including Boston and San Francisco. To municipalities, one advantage of LEDs is the reduced maintenance costs due to the very long lamp life. In comparison to the markets for LED traffic signals and LED pedestrian signals, which have been transforming rapidly as many commercial lighting programs provide incentives, LED street lights are at an earlier stage.

Basic Controls: Timers, Occupancy Sensors, Bi-Level Dimming

Examples of basic controls include step dimmers with a high and low setting rather than continuous dimmability, room-by-room occupancy sensors, and lighting on-off timers. Providing financial incentives for businesses to adopt basic controls alone does not constitute a next generation program; the incorporation of controls into a system to obtain deeper savings does. Over 100 programs currently offer set incentives for occupancy sensors and daylight/photocell sensors in their prescriptive commercial lighting programs. For many businesses investing in both advanced controls and LEDs at the same time does not meet their cost effectiveness requirements. Simpler, more basic control systems combined with LEDs may be the solution.

Advanced Lighting Control Systems

Advanced addressable lighting control systems enable individual end-users in commercial facilities to control each lighting fixture. Devices are centrally controlled through a computer network with a software interface for both switching (on/off) and dimming. This allows for the possibility of integrated management of both light and energy use. For energy management, the system enables energy-saving strategies including "harvesting" daylight, time scheduling, task tuning, use of occupancy sensors, and personal control. Using the software interface, facility managers can monitor lighting energy use and gain the data to inform decisions and enhance efficiency over time.

Ensuring Quality in Commercial Lighting Program Products

Next generation commercial lighting programs require that incentivized products meet good technical specifications. The Environmental Protection Agency's ENERGY STAR label creates technical specifications for a limited set of commercial lighting fixtures, such as task lights, downlights, and recessed lights. Common business and industrial fixtures, including troffers, are not covered by ENERGY STAR qualified product lists. Regional energy efficiency organizations have created institutions to meet this need. The most notable, geared toward LED lighting, is the Northeast Energy Efficiency Partnerships' DesignLights Consortium™. DesignLights qualifies thousands of fixtures by reviewing independent test data to confirm the products meet the technical specifications set for them. Another is Lighting Design Lab, begun in 1989 in the Northwest. The lab provides an LED Qualifying Products List for products not already on ENERGY STAR or DesignLights Consortium lists, among many other services such as education and technical assistance. The Lab is run by Seattle City Light with support from Northwest regional utilities and the Northwest Energy Efficiency Alliance. Some, but not all, program administrators look to the qualifying products lists to determine program eligibility.

Program Design

Comprehensive Lighting Programs

In response to the same drivers cited above, including new federal standards that will phase-out non-compliant T12s and standard T8s from the US market, higher savings goals, and emerging technologies, the Consortium for Energy Efficiency (CEE) Advanced Lighting Committee initiated a process to define and establish a framework for comprehensive lighting program design (CEE 2009). They defined "Comprehensive Lighting Programs" as those that:

1. Incorporate existing technologies, emerging technologies, controls and/or daylighting,
2. Involve lighting designers in each project,

3. Promote full facility upgrades (70% of qualified floor area),
4. Are promoted to lighting providers and end users,
5. Take a non-linear incentive approach (and base incentives on performance compared to code), and
6. Require baseline lighting assessments of spaces.

These features and elements of comprehensive lighting programs, taken together, represent a categorically different program profile. Whereas traditional programs may have some of these characteristics, a truly comprehensive program that has many or all of them is a significant evolution beyond that and will generate more energy savings.

Integration: Beyond Lighting-only Programs

Innovations in lighting energy efficiency programs are not confined to "Commercial Lighting" programs as traditionally defined. Lighting equipment and systems are often the primary and even the majority end-use sources of energy savings in other types of commercial/industrial energy efficiency programs, including comprehensive retrofits, custom, and small business. Some small business programs are almost exclusively lighting programs. A clear trend across the country has been integration of lighting upgrades and redesigns into more comprehensive programs serving lighting and other principal end-uses. In Connecticut and New Hampshire, for example, there are no stand-alone commercial lighting programs. Instead, business energy efficiency programs are organized by customer size, e.g., large commercial, commercial retrofit, and small business.

Lighting controls are sometimes integrated with HVAC, miscellaneous plug-load, and other controls to gain cost efficiencies from integrating the systems. We do not address this further here as the focus of this profile is on lighting programs specifically, and integrated controls and energy management systems are incorporated in other program area profiles (e.g., Commercial HVAC, and Building Operations).

Upstream and Statewide Programs

Paying incentives "upstream" to distributors and manufacturers rather than customers has been well established in residential product programs, and some leading commercial lighting programs have also used this program approach. Now a new coordinated approach has made it applicable in places where it previously was not and it has become a part of a trend than can result in higher savings. In some parts of the country, commercial and industrial lighting programs have faced the barrier of smaller utility territories limiting the participation of lighting distributors and the issue of allocating savings among utilities. This was an issue in the Northeast, where there are small states, many utilities, and many business customers. Program models organized at the statewide level have removed some of the limitations. By creating a brand that crosses service territory boundaries, utilities only have to work with a small number of distributors rather than thousands of business customers, creating multiple economies of scale including greater cost-effectiveness for the programs.

Lighting Design

Next generation programs will emphasize greater engagement with lighting designers, as many leading programs do today. A program may pay for the cost of hiring a lighting designer to audit the commercial building and make recommendations for reducing lighting power density (LPD).

Lighting design principles may be applied to existing buildings via lighting-only programs, small and medium sized business programs, retrofits or tenant improvement projects. New construction is not addressed here directly.

Reduced LPD, or the number of watts per square foot of commercial building space, is increasingly being achieved by a variety of lighting design strategies:

- Eliminating over-lit spaces
- Matching lighting characteristics and light qualities with appropriate lighting applications
- Employing higher color temperature lamps[60], which the human eye perceives as brighter. degrees
- Integration of daylighting into system design. Daylighting has emerged as a major energy reduction strategy, particularly as an element within more advanced, integrated approaches to optimize lighting quality and levels while minimizing energy use. A common misconception is that daylighting consists of adding windows, but increasing the reflectances of interior surfaces and reducing obstruction of exterior light are better examples.

Training Programs for Contractors

Another barrier to the widespread adoption of next generation commercial lighting programs is the lack of a sufficient network of trade allies prepared to implement them. Therefore, a major determinant of the rate of deployment of sophisticated next generation commercial lighting programs is the availability and readiness of skilled lighting contractors capable of designing and installing advanced, integrated lighting systems.

From the point of view of the lighting contractor, the desirability of their participation in training programs for lighting design, systems, and controls depends on their target market. Many contractors have been focused on maximizing profit under traditional program designs that pay incentives for more simple change-outs of T12 lamps and magnetic ballasts with T8s and electronic ballasts. With EISA requirements to be in place in beginning in 2012, there is a rush to capture as much of the remaining opportunity as possible before the window closes. Contractor training will be important for next generation programs because the technologies, programs, and customer objectives have changed, requiring more knowledge and new capabilities.

There have been significant efforts in some regions of the country to provide contractor education and training to elevate their capacity to meet the commercial lighting programs demands. The training has been effective. A sampling of initiatives and resources can be found below:

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[60] "Color temperature" is how "warm" or "cool" the light appears. It is measured in Kelvin. Daylight is over 5000K, whereas lights below 3000K appear yellowish and less bright, requiring more energy for the same perceived light output.

- The New York State Energy Research and Development Authority (NYSERDA) offers the Commercial Lighting Program (CLP) which is a mid-market-centered program providing tools and training on lighting design and implementation, cash incentives for projects including bonuses for the installation of advanced technology and for exceeding code efficiency, competitions for the most lighting projects with cash awards, and cash for exemplary designs, marketing, and professional lighting certification. Business Partners eligible to participate in the program may be almost any type of electrical or lighting contractor, distributor, lighting designer, architect, engineer, energy service company (ESCO), manufacturer, or other lighting decision maker.
- The National Council on Qualifications for the Lighting Professions (NCQLP) offers the Lighting Certified Professional designation.
- The Northwest Energy Efficiency Alliance (NEEA) has conducted pilot projects with program administrators and utilities in the Northwest to assess the effect that the right combination of training, coaching and other program elements will have on contractor effectiveness. Specifically, the project considered the ability of the lighting contractors to sell and implement more comprehensive lighting retrofits.
- The California Advanced Lighting Controls Training Program (CALCT) is a statewide collaboration of the community college system, the large utilities, and the California Energy Commission, that works to increase the use of lighting controls in commercial and industrial buildings.
- The Energy Center of Wisconsin provides webinars on the U.S. Department of Energy's Commercial Lighting Solutions. This is a free online tool not only for contractors but for building owners and facility managers of office and retail space. The tool demonstrates how to reduce lighting energy use by providing best practice examples for systems, daylighting, and design.

Savings Potential

The amount of energy savings per square foot achieved by next generation lighting programs varies widely. Savings from comprehensive lighting retrofits may exceed 75%, although typical savings generally range from 15-55% (Bisbee 2012, Samla 2012, Wiener 2012). Prescriptive lighting programs comprised primarily of linear fluorescents and basic controls such as occupancy sensors are often in between those extremes.

Commercial Lighting	Electricity	Notes
National energy use affected	322 TWh	For 2030 from AEO 2012. Commercial lighting, not industrial lighting.
Average percent savings	35%	Program savings range from 15% to 55%
Ultimate net participation rate	80%	1% current market share, by 2030 programs will reach 80% of all commercial lighting.
Potential long-term savings	68 TWh	Estimated annual savings in 2030.

Examples

Sacramento Municipal Utility District (SMUD) Commercial Lighting Programs

SMUD provides its commercial and industrial customers with a suite of lighting programs including traditional bulb replacement programs and several next generation options including custom, LED, and advanced lighting controls offerings.

Custom lighting incentives

SMUD provides an incentive of $0.05 per kWh saved for custom lighting retrofits that exceed California Title 24 code requirements by 10% or more, including such eligible measures as:

- HID and T5 lamps and fixtures
- Lighting control systems
- LED traffic lights
- Day lighting systems and dimmable ballasts
- De-lamping measures performed as part of an integral lighting efficiency upgrade

LED incentives

SMUD pays incentives at a rate of $0.13/kWh, up to $50,000 or 30% of a project's cost, whichever is less, for lights and fixtures qualified and listed by ENERGY STAR or the DesignLights Consortium.

Advanced Lighting Controls Program

SMUD provides a high incentive of $0.30 per kWh saved, up to a maximum of $200,000 or 80% of the total project cost, to drive adoption of high energy-saving advanced lighting control systems. Rebates are performance-based rather than prescriptive because the amount of energy saved depends on the customer, which adds risk for the program administrator as to whether or not the expected savings will materialize. With this Advanced Lighting Controls program combination of technology and program design, there is no need for an independent outside consultant to verify the energy savings because the computerized control systems have been tracking the cumulative energy use and savings in near real time.

While such advanced lighting control systems currently account for less than 1% of total commercial lighting program savings at SMUD, this could increase dramatically if and when major energy control systems manufacturers were to expand the availability of sophisticated lighting controls that are sold as a package combined with the fixtures and lamps. The combination that yields savings of 50 to 75% for larger commercial and industrial customers is LED lighting combined with control systems featuring a graphical interface. Similar to an energy management system (EMS) for lighting, they enable facility managers to adjust set points for turning lighting on and off and for using continuous-dimming capabilities (in contrast to stepped dimming) and to monitor energy use in near real time. LED lamps provide the advantage of instant-on, which is a necessary feature when using occupancy sensors in applications such as a warehouse that otherwise may be using high pressure sodium lights (HPS). HPS may take two minutes or more to reach full brightness, and consequently tend to be left on all the time.

Efficiency Vermont RELIGHT Lighting Design Program

RELIGHT is an example of the paradigm shift away from one-for-one equipment replacement programs to more comprehensive and systematic lighting retrofits, yet the program is simple. Traditional programs install efficient equipment in the same layout and light level as the old, inefficient set up, leaving savings opportunities on the table. These "lost opportunities" reduce savings per project and increase program costs in the long run, because it will cost more in the future to do another project with the same customer—more marketing and administrative expense, and fewer remaining EE opportunities.

RELIGHT promotes the hiring of professional lighting designers to commercial utility customers for their lighting retrofit projects in order to advise them on lighting design and equipment for maximizing energy savings. Efficiency Vermont pays financial incentives to reduce the upfront costs of engaging the lighting designer.

The program delivers substantial savings. Efficiency Vermont claims that the program averages savings 40% greater than the one-for-one programs, a dramatically deeper overall level of savings. Only Vermont-licensed engineers or nationally certified Lighting Certified Professionals may participate in the program.

http://www.efficiencyvermont.com/for_my_business/ways-to-save-and-rebates/commercial_lighting/lighting_design/relight.aspx

Mass Save Bright Opportunities: Commercial & Industrial Upstream Lighting Program

Massachusetts has 11 utility energy efficiency program administrators. They are aligned under a common umbrella, Mass Save, for branding and marketing energy efficiency programs. This approach has been highly successful. Called the "Commercial Upstream Lighting Initiative" when first rolled out, the program realized over 50,000 MWh of new annual savings within the first 90 days of operation. Mass Save works with electrical distributors to provide discount prices on the most-efficient LED directional lamps and reduced-wattage linear fluorescent lamps to customers including the lighting design community, architects and other contractors. Mass Save effectively buys down the cost to the point where the best high efficiency replacement lights end up priced close to or at the same as the level as conventional lights.

Mass Save exemplifies the next generation of commercial lighting. In addition to the cost-effective upstream incentive program design, consistent branding and marketing communications across program administrator service territories, there is also an emphasis on high product quality. All LED directional replacement lamps in the program must be ENERGY STAR qualified. All linear fluorescent lamps must be CEE qualified.

http://www.masssave.com/professionals/incentives/upstream-lighting.aspx

NYSERDA Existing Facilities Program

NYSERDA's Existing Facilities Program (EFP), which serves commercial and industrial customers, has a performance-based track that provides incentives at a rate of $0.12 per kWh saved upstate and $0.16 per kWh saved downstate for custom lighting retrofit projects. Most of the program's lighting projects go beyond one-for-one replacement to include some amount of redesign, and controls are often integrated into the new system. Eligible lighting-related technologies include T5 and T8 linear fluorescent lamps and fixtures, hard-wired and pin-based CFLs, LEDs, HID, HPS, hard-wired occupancy sensors, daylighting, and EMS. All four-foot T8 fixtures and ballasts must be high performance or low wattage, as defined by the Consortium for Energy Efficiency. In addition, LED technologies must appear on the qualified products lists of either ENERGY STAR or the DesignLights Consortium™ to be eligible for incentives.

Recommendations

Commercial lighting programs will continue to be one of the largest contributors to overall portfolio savings. To maintain and increase energy savings in the face of new higher efficiency standards and to help meet state EERS requirements, programs are at the cusp of revolutionary change. The proliferation of literally thousands of new qualified lighting products provides new opportunities for program managers to work with their customers to achieve energy-savings and financial goals. Taking advantage of the advances in lighting technology and improvements in product quality, efficacy, and affordability represents a key opportunity for next generation commercial lighting programs to acquire cost-effective kWh savings.

To do so, we recommend programs adopt a comprehensive, coordinated systems approach built around:

- Reduced-wattage linear fluorescent lamps,
- One- and two-lamp fixtures,
- Task-ambient lighting design for offices,
- Efficient high-intensity discharge lamps for larger spaces (such as pulse-start metal halide and high-pressure sodium lamps)
- LED directional replacement lamps, and
- Targeted LED applications.

We recommend creating commercial lighting programs with the capabilities and flexibility to be promoting these lighting technologies and products in combination with advanced lighting control systems and involving certified professional lighting designers. By offering multiple lighting program components including upstream prescriptive programs, efficient lighting involving lighting designers or trained contractors as part of custom retrofit and tenant build-out projects, and programs geared toward small businesses (discussed in a separate section of this report), utilities and program administrators can achieve deeper savings per business and broader program participation.

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COMMERCIAL BUILDING OPERATIONS AND PERFORMANCE PROGRAMS

Synopsis

Commercial building operations and performance programs provide another valuable approach to energy efficiency in the commercial buildings sector. Program administrators can pursue multiple strategies to achieve energy savings through improved commercial buildings operations. Building tune-up, retrocommissioning (RCx), monitoring-based commissioning (MBCx), and strategic energy management (SEM) programs are some of the ways to improve energy management. These strategies enable the identification of low- and no-cost efficiency measures, typically in large commercial buildings and institutional or government facilities. Training programs are also critical components to this sector, and approaches such as building operator certification (BOC) and subsidized energy manager programs are ways to expand expertise in the building operations industry. One important outlook for the next generation of these types of programs is improved access to real-time data and monitoring tools, which can improve initial customer screening, provide more accurate energy baselines and estimates of measure savings, and enable ongoing or monitoring-based commissioning. To increase customer participation, programs should first develop a well-planned outreach strategy that effectively and effectively communicates the business case to an appropriate base of potential customers. Programs will also need a strong base of qualified contractors, which in some cases may be partnerships between software companies and engineering firms. Finally, strong and ongoing relationships among all stakeholders, including customers, utilities/program managers, and vendors can boost participation by building on key account management for marketing to bridge customers to and/or from capital-improvement or demand response programs. The goal is to encourage customers to take advantage of multiple program offerings.

Background

Most buildings do not operate as originally designed, and there is ample potential for operational improvement and the resulting energy savings. Programs that target commercial building operations have been around for a long time, but they may not be in the first group of offerings for new program administrators. For the next generation of energy efficiency programs, these programs are a must in any commercial sector portfolio. As discussed next, many of the same challenges in commercial buildings persist today, and therefore these programs will continue to build on past lessons learned, while also considering new tools such as improved access to real-time data and monitoring tools, improved cross-program relationships to bridge customers between programs, and new arrangements to support onsite energy managements.

Unlike some of the other areas covered in this report, commercial buildings operational and performance programs do not focus on capital upgrades for equipment and therefore are minimally affected by new codes and standards. Building systems, especially HVAC and lighting, often do not operate as designed and can fall out of optimal working order even after tune-ups take place. Furthermore, building owners or operators often do not have dedicated staff for tracking energy management. And when buildings do have facility energy managers or operators, those personnel do not necessarily have adequate training or the tools needed to improve the efficiency of building systems, nor do they have sufficient time or resources. Furthermore, building personnel are often not rewarded for any energy savings they do attain. Inadequate maintenance in commercial buildings and lack of calibration based on changes to occupancy and use can lead to poor performance and high energy costs. These problems create the need for ongoing operations and maintenance (O&M) activities targeted to building energy systems, making changes, repairs, and tune-ups.

While improvements are very unique to a customer's individual facility, some typical measures include repairs and replacements of sensors, economizers, and steam traps, resetting schedules for heating and cooling equipment, air handling, and lighting runtimes to optimize with the building's demand schedule, discharge air reset strategy, multiple chiller sequencing, dual enthalpy control upgrades, daylighting controls, and chilled water reset. Behavioral elements play an important role in building operations programs as well for both occupants, owners, and operators, with education, feedback, and social norms all important strategies for energy efficiency programs. Emerging and evolving types of technology opportunities, particularly energy management systems (EMS) and energy information systems (EIS), also play an important role in building operations programs and can be leveraged in numerous ways to enable energy savings.

Building operations programs include a wide range of approaches, such as building re-tuning or tune-ups, retrocommissioning (RCx), monitoring-based commissioning (MBCx), strategic energy management (SEM), building operator certification (BOC) and training, and subsidized energy manager programs. Terminology can vary among these programs, and continues to evolve over time. Typically, building "re-tuning" or "tune-up" programs target quick-fix measures, while RCx or monitoring-based commissioning are more holistic assessments of operations and major building energy systems in large buildings (typically at least 50,000 to 150,000+ square feet). The average measure life of RCx improvements can vary significantly. Some estimates suggest that measures typically persist for 8 years; however there is still uncertainty around this figure and more research is needed (Roberts and Tso 2010).[61] The RCx programs we reviewed assumed an average measure life typically ranging from 5–7 years. The SEM and subsidized energy manager programs we reviewed, which address more behavioral and operational measures than RCx, assume a 3-year measure life.

Average energy savings can also vary within this range of program types. Based on interviews with several Rcx and MBCx program managers, 5–15% annual savings per participant seems most typical, whereas 3-5% savings were typical for the SEM and energy manager programs. While some of these programs may not specifically target more expensive capital improvements such as equipment replacement, they should serve as a bridge to other efficiency programs that do provide incentives for larger, economically attractive projects. If these programs can successfully enable larger capital improvements, participants can achieve higher levels of savings.

[61] Roberts and Tso (2010) reviewed the effective useful life (EUL) of 3 RCx programs using empirical field data to identify the average 8-year measure life; however they caution that there is still much uncertainty.

Building Retro-Commissioning

Through the commissioning process, building operators verify performance and design intent of various systems, and then correct deficiencies in existing equipment and systems rather than focusing on purchasing new equipment. The benefits of improved system operations include energy savings and reduced peak demands, as well as improved air quality, occupant comfort, and even employee productivity. Existing building commissioning[62] has several different names and slightly different approaches, including:

- Retro-commissioning: Process through which an existing building that has never been or was not fully commissioned is holistically assessed and calibrated for optimal efficiency;
- Re-commissioning: Process through which buildings are commissioned again to ensure that systems are functioning as originally planned and constructed and calibrated to operate the most efficiently based on current occupancy and use;
- Monitoring-based commissioning: An elongated version of this process that uses information or monitoring systems and metering equipment at the whole building and/or subsystem levels to measure energy use to diagnose problems, account for savings, and ensure ongoing savings persistence.

Building Operator Certification (BOC) and Subsidized Energy Manager Programs

People matter in the operation of energy management in buildings and facilities, and training and education are critical to awareness, interest, and knowledge of energy efficiency opportunities. Short of doing full commissioning services, efficiency programs can offer other training and financial support to help building managers and operators implement some behavior-based efficiency changes on their own. Building Operator Certification (BOC) training has been around since the 1990s, and is an important component of building performance program offerings to increase education and thereby improve the longevity and effectiveness of efficiency upgrades. Another option is a subsidized energy manager program, where a program administrator supports a share of the salary or guarantees the salary for an onsite building energy manger, or a manager that works with multiple customers.

Drivers for Change

While more stringent building energy codes and equipment standards are major drivers for change in some energy efficiency program areas, this area is largely unaffected by those trends because operations and maintenance (O&M) services and retrocommissioning do not focus on capital upgrades for equipment. In other words, the low-hanging fruit continues to grow back for building operations improvements. Rather, the major drivers for change in this program area are program managers' interest in greater participation levels to drive greater savings levels, improved training for building operators, building managers, and qualified contractors, and the increasing role of data and

[62] Commissioning new commercial buildings is also important to improve efficiency in the new construction sector. We address that area in the commercial new construction program chapter of this report.

feedback tools. On the demand side, overall there is an increasing interest in energy-efficient commercial properties, which have been shown to have higher occupancy levels, lease-up rates, and sales prices compared to less efficient properties (IMT 2012). While it's not clear that this increased interest in energy-efficient commercial building properties has yet driven greater interest in building performance programs, it has implications for effective marketing and customer outreach.

Program managers are trying to attract more participants by targeting the roots of customer reluctance to undertake programs. Despite their benefits, retrocommissioning and similar approaches are often a hard sell to customers for a number of reasons. First, the energy savings appear uncertain to customers. Unlike major capital upgrade measures such as a new HVAC or lighting system, which are highly visible and the energy savings calculations are fairly transparent, retrocommissioning measures are less visible and the calculations for savings estimates are less transparent and may require more assumptions than capital cost measures. Second, many program managers cite the lengthy process from start to finish (up to 2 years)[63] and the cost as burdensome to greater customer uptake. Finally, program managers and vendors trying to pitch the concept to potential participants run the risk of offending building operators by claiming their operations aren't as efficient as they could be. For all of these reasons, it can be difficult to attract participants and to see participants through the implementation of measures. Some may complete a feasibility study, but not carry through with measure implementation. As discussed in the next section, program design and technologies can help address these challenges, and can actually make retrocommissioning an easier sell to participants than capital retrofit projects that require major equipment changes.

Lack of education and training has been another important driver for change in building operations programs. Not only do building operators need better access to ongoing training opportunities, but often program contractors and consultants also need training especially with emerging new data tools. Some program managers cite the need for more qualified contractors for their programs.

New software and technology is allowing a shift toward greater amounts of energy data and real-time feedback in building operations, further stimulating improvements in this area. Energy management systems (EMS) or building automation systems (BAS), energy information systems (EIS), and web-based software applications are playing an increasingly important role in building operations efficiency. These systems and tools can be used to screen customers, validate savings, and in some cases monitor building operations to identify measures on an ongoing basis.

[63] This is highly dependent on the size and complexity of the building and the type of commissioning being conducted. The process can be much quicker in certain cases, especially if customers implement retrocommissioning outside of a program offering.

Emerging Trends and Recommendations

Technologies

BAS, EMS and EIS can provide more relevant and timely information for building operators, and for program managers and vendors they provide a way to validate customers' savings and persistence. And web-based software applications can be used to share a building's real-time energy usage information over the internet to a central web portal for access by both the customer and the engineering service provider. Improved technology tools follow into two general functions for building performance improvements, energy tracking and system tracking, however there may be overlaps between these two approaches (CEC 2011). Energy tracking makes use of EIS and better metering and submetering to gain a better understanding of energy usage in a building, whereas system tracking makes use of BAS or EMS to gain a better understanding of specific building systems (e.g., HVAC and lighting) and fault detection within those systems. Either type of tracking, or a combination of the two, can be used to improve building performance; however the distinction helps customers identify which tools can enable different functions.

These data and feedback tools can be used in several different ways to enhance programs (Reese 2012). First, better data can allow program managers to screen large customers prior to surveying the building in person and identify good candidates. This can streamline the vetting process and reduces program costs wasted on pursuing poor customer leads. Program administrators should first assess whether the costs associated with the data collection system, data vetting, and analysis can offer a payback on the cost and time of pursuing poor leads. Second, access to energy consumption data can provide a better first-estimate of potential energy savings, as long as there are sufficient monitoring points that are appropriately calibrated. This makes the more in-depth engineering analysis easier and also reduces the uncertainty to customers about the potential energy savings. And third, real-time data monitoring enables engineering providers and building operators to monitor issues with more fine-tuned data and on an ongoing basis. As a result, building operators can identify efficiency measures for implementation continuously through a monitoring-based commissioning approach. New data tools and software capabilities such as energy dashboards can provide more fine-tuned and frequent data access and can increase potential energy savings, both by better characterizing the necessary operational fixes and therefore increase measure savings, and by identifying new measures that may not have otherwise been detected.

Program Design

Most commercial building operations programs are designed to offer a combination of both financial incentives and technical assistance for participants. Retrocommissioning program incentives are typically provided in the form of technical assistance (free or reduced-cost engineering studies) and/or financial incentives (rebates per kW, kWh, or therm for installed measure savings). Other incentives for monitoring-based commissioning programs may be to defray the cost of software applications. And for subsidized energy manager programs, program incentives may support part of the salary for an onsite energy manager or guarantee the manager will save enough to cover their salary, or subsidize the costs for training energy managers. This next section describes some of the key program design approaches and challenges for retrocommissioning and strategic energy management programs.

Retrocommissioning

While the retrocommissioning process can vary, the following represents a typical program design approach: (1) Initial screening of customer eligibility and selection of commissioning provider; (2) survey phase by commissioning provider including implementing quick fixes while on site; (3) investigation/ study phase by commissioning provider with full analysis of measures, savings estimates, and cost proposal; (4) implementation phase of the approved energy saving measures; and (5) verification phase.

One challenge for retrocommissioning program design is that the projects take a long time from the initial screening to implementation and follow-up verification. Based on interviews with several program managers, many projects can take 18–24 months to complete this whole process, though as previously discussed the timing can vary significantly. In addition to better initial screening of good candidates, another approach to reduce project length is to speed up the customer implementation process after receiving the study. One example of how this might be done comes from Xcel Energy, who is offering a new implementation bonus that the customer is only eligible to receive if recommended measures are implemented within 9 months of receiving the commissioning provider's full study. Another program administrator finds that for projects to be successful through the final phase of the project, commissioning providers should be retained through the verification phase to ensure timely completion.

Another challenge is the vetting process to ensure that customers are indeed good candidates for program measures and to ensure that commissioning vendors provide and document a consistent set of measure options. Program managers have developed new contractor tools to overcome these challenges, such as pre-verified and required list of eligible measures and savings calculators to estimate measure energy savings. Access to customer energy usage data prior to enrollment could also improve vetting, as discussed above, to ensure the best candidates are identified and to reduce costs of pursuing leads that do not offer cost-effective savings.

Strategic Energy Management

Strategic energy management (SEM) is another program design system, which employs key company managers and leaders to conduct ongoing assessments, trainings, and improvements to building operations. Key staff members periodically develop strategic goals for improving energy efficiency practices. SEM utilizes energy and production data to tune facility operations, and uses continuous improvement approaches for engaging employees and enabling leaders to embrace goals. Similar to commissioning programs, SEM targets energy savings from low- and no-cost actions in O&M and behavioral measures. SEM differs from retro-commissioning approaches, however, in that it is a strategic and ongoing system for a company's managers and leaders, with training and equipment incorporated into a path of continuous energy management improvement.

While there is a long history of success with SEM in the industrial market in regions such as the Pacific Northwest, there is also emerging focus on the commercial sector. The Energy Trust of Oregon, for example, has launched a pilot that engages a cohort of commercial customers who have committed internally to improving efficiency and also have an executive level champion from within the company or organization (Kesting 2012). The Energy Trust brings the group of customers together several times a year (including both executive level sponsors and maintenance staff) for training, a facility operational assessment, and to engage individuals on developing goals for improving O&M practices. This process addresses both organizational and technical challenges, which are both fundamental to the way participants manage energy.

Target Markets

Large commercial, institutional, and governmental customers of at least 50,000 or 100,000 square feet are typically good candidates for retrocommissioning programs. Smaller facilities may also present good opportunities for building operations improvements. For example, Xcel Energy allows customers of any size to participate in its recommissioning program. Still, many other programs cite low cost-effectiveness as a reason to avoid smaller buildings, while larger customers tend to have more cost-effective savings potential. One of the reasons is that for some programs customers must have an EMS to participate or in the case of monitoring-based commissioning, have data software, which means that only larger customer facilities would be able to offset these high-cost investments in lower energy bills.

Marketing

Building operations programs may tap into existing marketing channels from other commercial and industrial energy efficiency programs and through large customer key accounts. Programs may also turn to key market players, such as the commercial real estate and hospitality sectors, to encourage market penetration throughout entire portfolios of buildings. While existing marketing channels can identify good candidates for retrocommissioning, program managers should explore ways to expand outreach strategies to significantly improve customer participation. Effectively and efficiently communicating the business case to customers can increase participant uptake rates. The potential benefits of efficient lease space on tenant occupancy and sales prices should also be included. Also toward the goal of greater participation, improved access to real-time data and monitoring tools can improve initial customer screening to help communicate the benefits to customers. And when capital improvements are recommended for participants, program managers should encourage customers to use those other program opportunities to offset the cost of designing and implementing capital projects, e.g., a high-efficiency lighting replacement program.

Savings Potential

Individual building savings from retrocommissioning vary substantially from one customer to the next, but savings potential for these programs typically range from 5–12% whole building savings. Monitoring-based commissioning can provide higher savings compared to traditional retrocommissioning, according to some on the order of 12–20% (English 2011; LBNL 2009). Monitoring-based commissioning program offerings are still new, however, and not many have yet reported EM&V energy savings results across a portfolio of buildings.

Below we present estimated potential savings that could be generated through 2030 by commercial building retro-commissioning programs.

Commercial Building Performance Programs	Elec.	Gas	Notes
National energy use affected	588 TWh	975 TBtu	AEO 2012 predicts commercial floor space of 98 billion s.f. in 2030; Assume large buildings over 100,000 s.f. are targeted. EIA estimates these large buildings constitute 35% of commercial floor space for electricity usage and 27% for natural gas usage (CBECS); These larger buildings use 17.1 kWh per s.f. and 35.5 cu. ft. per s.f. per EIA 2003.
Average percent savings	10%	10%	5-12% whole building savings typical for RCx; potentially up to 20% from MBCx; To be conservative, we assume 10% savings per project.
Ultimate net participation rate	85%	85%	Current programs may be reaching 1 to 2% of eligible participants per year; we estimate 5% participation per year
Potential long-term savings	50 TWh	83 TBtu	

Notes: We estimate that large buildings over 100,000 s.f. are a primary target for this program, however smaller buildings of 50,000 s.f. may also be targeted by programs. Industrial customers may also be eligible, but for simplicity we assumed savings from those customers are counted under industrial process.

Examples

Below we provide some examples of utilities or program administrators that are offering retrocommissioning, monitoring-based commissioning, and subsidized energy manager programs and are noteworthy for incorporating innovative strategies in order to drive greater participation and savings.

Retrocommissioning

Xcel Energy has developed new tools that have helped streamline their Recommissioning Program, which is offered for customers in both their Minnesota and Colorado service areas and covers both retro and recommissioning projects. First, they have developed an Excel-based calculator tool for vendors, which most are now using to estimate savings. Also, the utility developed a list of 38 measures for vendors to refer to during the completion of their study. Vendors must make recommendations of specific measures from the list or include reasons why some measures aren't recommended. Both of these tools have led to a better vetting process to identify good project candidates. To encourage greater participation, the program roughly doubled implementation rebates in the last couple of years to $400/kW and $5/dekatherm (Dth) and also offers to pay up to 75% of the cost of the upfront engineering study, not to exceed $25,000. Another recent change in Minnesota has been a 9-month "implementation bonus" of 3 cents/ kWh and/or $3/Dth, which customers earn only if they implement measures within 9 months after receiving the final study. In 2011, 108 customers participated in the Minnesota program, either by getting the recommissioning study and/or implementing recommended measures (Volkert 2012). Most of these customers were in the commercial sector, typically schools, universities, office buildings, or government facilities, and a few industrial customers participated. About 90% of customers that get a recommissioning study go through with the recommended work (Volkert 2012). Those that go through with the recommended work typically achieve whole building energy savings of 5-15%.

The Connecticut Retro Commissioning Program targets large facilities of 100,000 square feet or greater, and offers financial and technical assistance to help customers improve the efficiency of their building operations. Customers must have direct digital control (DDC) trending capability and an EMS, and must have first completed Energy Star benchmarking to enroll. Like Xcel, program managers developed a streamlined list of measures for possible upgrades as a reference to vendors. There is a list of five pre-qualified providers, and the program is looking to take on more contractors and offer more training efforts for contractors. Typical savings are 8-12%, and in some cases savings have reached 35% (McIntosh 2012).

Monitoring-Based Commissioning

Monitoring-based commissioning is a fairly new program trend. Commonwealth Edison (ComEd) in Illinois offers both a traditional retrocommissioning program that has been in operation for four years, and a new Monitoring-Based Commissioning (MBx) program which began in June 2012. Like the retrocommissioning program, the new program will be administered by Nexant, and will target large commercial buildings such as office buildings and hospitals with over 150,000 sq. ft. of conditioned floor space and that have a building automation system (BAS) to track and verify savings. The difference with the MBx program is that customers must provide an upfront investment in software that will enhance detailed monitoring of energy usage, and over a period of at least 18 months the vendor will first identify a baseline and then look for efficiency measure opportunities and implement them on an ongoing basis. Customers can earn a financial incentive to defray the cost of the software, and can then earn an incentive for kWh and therms saved through commissioning measures. In ComEd's RCx program, the utility pays for a full engineering study in exchange for a commitment by the customer to spend a minimum amount on implementation that varies by size of the project. Program managers face less financial risk with this MBx approach than traditional RCx because the incentives are performance based—the customer earns incentives directly tied to their energy savings (Tonielli 2012).

The New York State Energy Research and Development Authority (NYSERDA)'s monitoring-based commissioning is unique in that the offering is a part of their deployment programs. This union allows NYSERDA to influence the installation of other efficiency improvements such as automated controls, demand response-enabling equipment, and capital improvements in concert with the commissioning software. Customers who take advantage of multiple deployment offerings are eligible for overlapping incentives and an increased cost-share. NYSERDA's comprehensive deployment program is part of their overall effort to encourage the development of more sophisticated buildings.

Energy Manager Program

Puget Sound Energy's Resource Conservation Management (RCM) program offers a 3-year agreement with a customer who hires a dedicated staff member as a resource conservation manager and who completes a statement of work with specific deliverables and targets. The utility agrees to provide financial incentives and a salary guarantee for the resource conservation manager. PSE has 110 customers participating as of 2011 and 86 active RCM contracts for a total of nearly 160 million square feet (PSE 2011). School districts, government buildings, commercial buildings, and military represent the majority share of participant square footage. Typical savings per customer are 500,000 kWh and 40,000 therms, and the program assumes a 3-year measure life for behavioral savings. The program has found that consumption increases if the manager leaves or the program is stopped for some reason, suggesting the need for ongoing support. Total utility support, including cash incentives and a suite of technical training and support, covers 70% of the cost. After the 3-year contract, the utility offers performance-based incentives payable upon reaching a 5% energy reduction goal, and offers continued access to value-added services (PSE 2011).

Recommendations

Here we offer several recommendations for retrocommissioning programs to encourage greater participation and energy savings:

- Develop tools and calculators that make it easier for vendors and customers to identify current baseline consumption and potential savings from improved operations in buildings, and develop a consistent set of measure options.
- Expand and improve marketing and outreach efforts to increase participation rates; effectively communicate the benefits of retrocommissioning and how it complements other program offerings, e.g., how it can serve as bridge to greater energy savings.
- Consider establishing incentives for customers who install measures within a certain time frame to speed up the lengthy process.
- Develop a highly-qualified contractor base by providing training opportunities for both facility managers as well as for contractors.
- Recommend that customers participate in other program offerings when applicable, such as capital equipment replacement for HVAC or lighting projects, prior to doing retrocommissioning. This will encourage greater fluidity between program offerings for customers and potentially increase participation in other programs.
- Consider monitor-based commissioning programs or incorporate real-time data tools into existing programs, such as energy management systems (EMS) or energy information systems (EIS) in combination with web-based software applications to: (1) screen customers and vet savings potential; (2) validate savings after measures are implemented; and (3) in some cases monitor building operations to identify measure opportunities on an ongoing basis.
- In addition to retrocommissioning, consider developing an energy manager program to help customers who do not currently have dedicated energy managers; the customer would set energy savings requirements, and the program would provide a share of the energy manager's salary. Ultimately, energy savings from the installed operations and maintenance efficiency measures pay for the energy manager's salary. Program managers should also identify ways to retain energy managers for an extended period of time.

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COMMERCIAL MAJOR RETROFIT AND RENOVATION

Synopsis

Major renovations of existing buildings provide great opportunities to increase the energy efficiency of building spaces and systems. At such times entire systems can be re-designed and the spaces themselves can be reconfigured and changed so as to optimize energy performance of such key building systems as lighting and HVAC. Programs targeting major renovations to achieve high energy efficiency generally have not reached a large share of the possible market. To gain more participation and achieve high savings for individual projects, programs need to structure incentives to reward performance of the entire building or renovated space. Incentives should be based on integrated designs, not one-by-one equipment upgrades. Energy disclosure requirements and building ratings can be important to raise the visibility of energy use and allow owners and occupants to readily compare energy costs and use such comparisons to guide their choices in commercial buildings markets. Public recognition of high performance can also motivate certain customers. Education and training are important to increase awareness and understanding of the "deep" energy savings possible with major building renovations and demonstrate the value of making such changes to building owners and occupants.

Background

Commercial buildings represent large energy savings opportunities. According to Pike Research (2010), owners of commercial buildings in the U.S. could save more than $41 billion a year in energy costs if $22.5 billion were invested over a ten-year period in energy efficiency retrofits. Capturing this large opportunity, however, can only be accomplished through comprehensive renovations that address multiple building systems in an integrated, "whole building" approach. To achieve "deep" energy savings from building retrofits requires going beyond simple one-for-one technology change-outs or single system upgrades. It requires careful, integrative design to guide the entire process. In many ways, major renovations are similar to new construction.

Energy efficiency programs targeting energy efficiency improvements in commercial buildings, especially lighting and HVAC systems, have a long history (Amann and Mendelsohn 2005). Such programs typically provide incentives for customers to upgrade lighting or HVAC equipment to more energy-efficient replacements. These types of changes can be highly cost-effective. However, by focusing only on individual pieces of equipment or even single systems, such improvements may not capture the full cost-effective energy savings potential in a given building. Experience has demonstrated that comprehensive retrofits (or renovations) can yield higher overall energy savings for a variety of reasons. System designs can be re-examined and improved to ensure high quality indoor environments in terms of lighting quality, thermal comfort and air quality. Too often such lighting and HVAC systems are "overbuilt" and poorly controlled, which results in higher energy use than necessary. Integrative design also helps to identify and capture savings that result from interaction among building technologies. For example, reducing lighting load through better design and more energy-efficient technologies can reduce the cooling load in a building, which can then allow down-sizing of cooling equipment and yield additional system savings.

Utility-sector programs for major building retrofits are not new. Earlier research by ACEEE (Amann and Mendelsohn 2005) surveyed experience and program status across the U.S. Many programs have long had custom programs that would address more extensive system upgrades and major building retrofits. Such programs generally have been an option for customers making improvements that couldn't adequately be addressed through prescriptive lighting and HVAC programs—programs that pay specific rebates for specific technologies. These custom programs generally pay incentives based on a dollar amount per unit of saved energy as estimated by engineering analyses of the project before it is completed, and are sometimes structured and referred to as "standard offer" programs.

Drivers for Change

To date, programs have only captured a small fraction of the great energy savings potential possible through major building retrofits. The custom nature of such projects requires more program time and resources. They also are more complicated than single change-outs or equipment upgrades, requiring new design and engineering. The projects themselves typically span a long period, perhaps 2-3 years or more from project inception through design, demolition, rebuilding and commissioning. Such extended project periods do not always mesh well with overall program planning, funding and implementation schedules which often are done on an annual basis. These approaches can also face regulatory hurdles stemming from screening of measures for cost-effectiveness. The nature of more comprehensive retrofits makes it difficult to isolate individual measures for estimating energy savings and implementation costs. While a bundled set of comprehensive measures can yield significant cost-effective savings, regulatory policies and protocols may not allow consideration of such bundles of measures. And some measures, if not included in such bundles, may not individually pass screening tests. This creates "lost opportunities" because such measures may then be too expensive or difficult to implement at a later date as a separate project.

While more stringent codes are raising the baseline energy performance of new buildings and major renovations, EERS requirements are pushing program administrators to achieve higher savings across their full program portfolios. Since major retrofits offer such a large savings potential, program administrators are looking to such programs to serve much greater number of customers than past programs and to achieve higher savings per project than may have been achieved from past projects served by custom programs.

Another key driver—and perhaps the source of greatest potential for achieving much higher energy performance in the market for major retrofit and renovation—is internal to the market itself. A small, but increasing number of key stakeholders in buildings markets are demanding energy-efficient, "green" spaces in buildings, whether such spaces are classrooms, offices, retail shops or manufacturing plants. Markets for commercial office space are especially competitive in most cities today. Occupants are demanding more of these spaces and have more choices. Building owners will have to respond accordingly. In short, energy efficiency can be part of a larger value proposition for building spaces. Programs can foster this change in building renovation markets by raising awareness among both building owners and occupants of the very real value of high performance buildings and by offering incentives and services that support and facilitate projects that achieve this end. A number of cities have established mandatory energy disclosure requirements for commercial building markets to make energy use a visible attribute of a given building space, allowing potential owners or tenants to make comparisons to other buildings (Burr 2012).

Another related market trend is the growth of certification programs for green buildings, including major renovations, such as LEED (Leadership in Energy and Environmental Design) and ENERGY STAR. An increasing number of both building owners and tenants are demanding such designations, indicating the growing interest and associated market for high performance buildings. Such ratings have value in buildings markets and demand for them is growing accordingly.

Key barriers to "deep energy renovation" according to an experts workshop convened by the Northwest Energy Efficiency Alliance (2010) are:

1. A lack of localized, relevant financial best practices and tools, coupled with traditional lease structures that fail to monetize energy efficiency.

2. A scarcity of shared knowledge, common vocabulary, clear communication and collaboration to connect deep energy renovation to values that matter to key stakeholders.
3. Complicated, non-standardized measurement and verification of energy savings are confusing to key decision makers, including lenders, owners and tenants.
4. Building owners lack motivation to connect building performance to a clear business case for energy efficiency.
5. Lack of a predictable roadmap for opportunistic, whole-system efficiency measure integration that bundles investment strategies and building types with strategic energy management principles and practices.

NEEA defines "deep energy renovation" as "A long-term, systemic approach to achieve aggressive (40-60%) energy savings in existing building stock." To achieve this, NEEA concludes:

> It requires comprehensive, inclusive and collaborative re-education and market behavior change—from finance to utility to owner to tenant—so that energy efficiency presents clear, tangible value.

We see "next generation" major renovation programs are those that develop approaches following such a guiding philosophy in order to achieve deep savings. The New Buildings Institute has been working extensively to examine barriers in major renovation projects to achieve deep energy savings and to develop tools and resources to facilitate such changes (NBI 2012).

Emerging Trends and Recommendations

The key distinguishing characteristic of next generation major commercial retrofit programs is their objective of achieving deep savings—energy savings as much as 30-50% (or more) from pre-retrofit performance. There is a growing portfolio of projects that demonstrate that such savings are indeed possible through integrative design and use of a wide and growing array of advanced building technologies and equipment (Smith and Bell 2011). Some of these are high profile examples, such as the renovation of the Empire State Building, a project that will achieve almost 40% savings. There are many more examples of just everyday buildings that undergo major renovations capable of delivering high savings. The Rocky Mountain Institute and the New Buildings Institute are working to establish a portfolio of such examples (RMI 2012) that demonstrate what is possible. This will build on a set of case studies compiled and described previously by NBI (2010).

Technologies

Other program area profiles in this report provide details on building technologies that are more energy-efficient and can therefore yield lower building energy use. These are addressed in the profiles of commercial lighting, HVAC and new construction profiles. Major retrofits typically involve changes to all major building systems, electrical and mechanical, as well as the building envelope: walls, windows and roofs. Major retrofit energy efficiency programs generally encompass the full array of building technologies and systems in order to achieve low energy use. Major renovations have a lot in common with new construction; consequently, some new construction programs also serve major retrofit projects. ComEd takes this approach as the same whole building, integrated systems design approach needed to achieve high performance new buildings also is needed to achieve deep savings through renovation and retrofit. Commercial retrofit programs also emphasize advanced control systems that optimize performance of given building systems. Building commissioning is typically integral to major renovations just as with new construction to ensure that building systems perform as intended and therefore achieve projected energy savings. Installation practices are yet another key factor for achieving targeted energy savings; poor installation of equipment and systems can result in significant energy waste. Major retrofit projects also can benefit from incorporating information and control technologies in order to automate and optimize performance of building systems. They also can be used for monitoring and benchmarking of energy performance as a way to assure high performance and make adjustments as indicated.

Program Design

A number of organizations are leading efforts to understand the markets for major renovation and to develop programs that will support and facilitate a move towards deeper savings. The New Buildings Institute and the Northwest Energy Efficiency Alliance are collaborating with numerous buildings experts and stakeholders to identify and provide case studies of successful deep retrofits of commercial buildings (Lyles et al. 2012). They found 50 projects that underwent a major renovation or equipment upgrade since 2000 that yielded actual energy savings of 30% or greater compared to the national commercial building average for energy use intensities. More detailed examination of 9 of these projects revealed commonalities among the factors that contributed to their success:

- Integrated design, undertaking multiple measures and monitoring are more critical to low-energy buildings than any given technology (e.g., lighting or HVAC).
- Ratings, labels and recognition appear to be valuable motivators for energy-efficient renewals.
- Commissioning, measurement and tracking, along with on-going improvement are critical to achieve and sustain low energy use.
- Leveraging available incentives and tax credits is critical.
- Strong leadership from owners throughout the process is essential, including a willingness to share their stories.

These lessons are relevant in designing next generation programs for major retrofits. Program designs can incorporate these lessons by taking the following steps:

- Focus on integrated designs, including structuring financial incentives for integrated approaches and overall building performance, rather than structuring financial support measure by measure or even in bundles of measures.
- Promote disclosure requirements for building energy use and provide recognition for successful projects through labeling or other distinctions. Also document and publicly recognize successful projects.
- Require commissioning as well as robust measurement and tracking.
- Provide incentives based on performance and leverage other available financial resources, such as tax incentives, to make projects financially viable.
- Provide education and training targeted to building owners, managers and operations staff to motivate them to take action with their buildings.

One approach for the major retrofit programs is an approach most commonly referred to as "pay for performance" (RMI 2012) (the concept is also referred to as "deep energy efficiency pays" (DEEP) by Smith and Bell (2011)). In essence, "pay for performance" involves determining an energy-savings threshold for an entire building and providing incentives for energy savings beyond that threshold. One example of a utility exploring this approach is Seattle City Light (RMI 2012).

Another key to unlocking the potential in the renovation market is addressing financial barriers encountered by many customers. Pike Research (2012) identified financial barriers as a primary obstacle keeping owners from moving ahead with major energy retrofits. Successful major retrofit programs likely will need to include options for financing projects. On-bill financing is emerging as a solution that can enable more customers to go ahead with major renovations, although such options face certain regulatory and other legal hurdles in many jurisdictions. Appropriate local policies may be necessary to enable such programs. Another option is "property assessed clean energy" (PACE) financing, which are bonds provided to building owners to finance energy retrofits and renewable energy systems. The bonds are then paid back through an annual assessment on property tax bills.

While PACE for residential homeowners has stalled due to rulings as to treatment of PACE tax liens by the Federal Housing Finance Agency, commercial PACE financing is still viable in some local jurisdictions, including San Francisco, California and Boulder, Colorado. Commercial PACE financing is expected to expand gradually according to Pike Research (2010).

Not all owners and projects may need financing through programs, but having such options available may be critical for some potential customers and their projects. State and local policies can provide such options, too. For example, legislation was introduced in 2012 in California to create a financing method for private owners to pay for energy efficiency investments in existing buildings (Alsup 2012). The proposal is to funnel building owner debt into revenue bonds issued by the state, which are secured by a lien on the deed of the building. This would offer increased security for financiers and the obligation for repayment rests with the holder of the building deed, which would transfer with building ownership.

Final keys to successful major retrofit programs are effective program administration and consistent, long-term support. Major retrofit programs rely heavily on establishing and maintaining effective collaborations between program staff and building owners. In tandem funding commitments must be stable and secure over the longer periods involved with major retrofits compared to smaller, short-term projects. With such long-term support owners can plan a number of multi-year projects and gradually implement them since this type of schedule better coincides with the regular schedule of the few buildings that undergo a major gutting and rehabilitation in a given year. In this way a program creates a set of qualified projects ready to go when they are initiated.

Target Market

As with many customer programs, a "one-size-fits-all" approach will not work well across the spectrum of commercial building owners and building types. The needs and preferences of the owner of a multi-story Class "A" commercial office building are clearly going to be different than the owner of a small restaurant. Both may seek to achieve an energy-efficient, high performance building, but the available resources and applicable technologies vary widely. For programs to be successful, they need to recognize and respond appropriately to these differences.

Commercial building markets are diverse along many dimensions, including ownership, building use, size and climate. The corresponding renovation markets reflect this fundamental diversity. Experience shows that owners of buildings that are mission-driven are good candidates for deep retrofits due to their long-term commitments to their organizations. Owners of rental commercial office spaces generally are less likely to be interested in major renovations to achieve deep energy savings. As discussed earlier, though, mandatory disclosure requirements for building energy use and growing awareness and interest of building tenants in high performance, low energy-use spaces is beginning to change these markets.

Marketing

Marketing of these major retrofit programs needs to address key actors engaged with any project, namely:

- Building owners, including executives, building managers and financial staff;
- Building contractors and trade allies (including architects, engineers, designers, equipment suppliers, skilled trades, etc.)
- Building occupants (tenants).

The messages and information needs of these actors are different. A chief financial officer will use different criteria to assess the desirability of a retrofit project than will a building manager. The architects, engineers and skilled tradespeople involved with design and construction must be driven by the common objective of achieving high building performance. Establishing a "basis of design" early in the renovation process that expresses common objectives, including high energy performance is helpful guiding the process and decision-making of all project team members. Tenants also must be educated on their roles in achieving project goals for low energy use.

Savings Potential

Commercial Retrofit	Electricity	Natural	Notes
	TWh	TBtu	
National energy use affected	1,285	2880	For 2030 from AEO 2012; excludes small business use, which is 20% of total commercial use according to CBECS data
Average percent savings	30%	30%	
Ultimate net participation rate	30%	30%	
Potential long-term savings	116	259	

Examples

Pay for Performance Program, New Jersey Office of Clean Energy

The New Jersey Office of Clean Energy launched the "Pay for Performance Program," a whole building energy efficiency incentive program designed to achieve deep energy savings in commercial and industrial buildings. The program is modeled after the Multifamily Performance Program created by the New York State Energy Research and Development Authority (NYSERDA) in 2007. A similar program was initiated in New Hampshire in 2011.

The core elements of the Pay for Performance program are for building owners to:

- Develop a strategic "Energy Reduction Plan" for each facility, which is created to guide buildings owners to determine: (1) where they are, (2) where they want to be, (3) how to get there, and (4) status relative to goals.
- Contract with an approved trade ally (termed "Partner") to act as their energy expert and point of contact, along with the Program Administrator, throughout the project. The Partner is responsible for a number of services, including: (1) completing a benchmark energy audit, (2) creating a building model, (3) providing oversight of project design and construction, and (3) completing post-retrofit monitoring and savings verification. Partners may team with other partners or use sub-contractors in providing any of these services.

The basis of the Energy Reduction Plan is a building benchmark that establishes existing energy use; Partners use the ENERGY STAR Portfolio Manager for this purpose. The next step is to conduct a whole building energy audit. The results of this audit are used to develop a calibrated model using ASHRAE-compliant modeling software, such as eQuest or Trane Trace™. The resulting model is used to simulate building energy performance and assess the energy effects of recommended measures on the building. It is designed to account for the interactive effects of different measures and building systems (for example, lighting and cooling). Program requirements are:

- A minimum reduction of 15% in total source energy consumption from the baseline benchmark,
- at least two unique measures where lighting makes up no more than 50% of total projected savings, and
- an Internal Rate of Return (IRR) of at least 10% for the entire project.

Once a building owner's Energy Reduction Plan is reviewed and approved by the Program Administrator, the Partner oversees and works with the owner during the installation phase to ensure that the plan is implemented. Once installation is complete the Partner must monitor post-retrofit utility data of the building, as well as other measure-specific metrics, for 12 months. These data are used to complete to verify savings and determine final Program incentives.

Financial incentives in the following amounts are provided at specified milestones as follows:

Incentive #1

- $0.10/sq. ft. capped at $50,000.
- Paid upon review and approval of Energy Reduction Plan.

Incentive #2

- $0.11/kWh and $12.50/MMBTU saved capped at 25% of project cost.
- Paid upon Installation completion.
- Based on projected savings outlined in the Energy Reduction Plan.

Incentive #3

- $0.11/kWh and $12.50/MMBTU saved capped at 25% of project.
- Cost Paid upon completion of post-retrofit benchmark.
- Based on actual first-year energy savings.

This tiered, sequential incentive structure provides funding at key points throughout a project rather than providing a single lump sum upon a project's completion, an approach that has been successful in some custom programs in the past.

Energy Opportunities Program: Connecticut Light and Power Company, The United Illuminating Company, Connecticut Energy Efficiency Fund

This program brings together a number of services provided through other Connecticut utility programs targeting specific building systems and technologies. Similar to other custom programs throughout the country, these services include:

- co-funding studies to determine the cost-effectiveness of potential energy efficiency measures,
- studies to qualify emerging technologies, and
- financial incentives to reduce the installed costs for measures.

To promote deeper savings, in 2007 the program added a component to encourage participants to implement larger, more comprehensive sets of recommended measures. The mechanism requires participants to bundle multiple energy savings measures into a comprehensive project-level proposal, rather than individual measures. A bonus incentive is paid for installing multiple measures. This comprehensive bonus incentive provides additional funding needed to buy down the project to a 2-year payback as long as the project passes the utilities' cost test.

Recommendations

Programs that promote and reward whole building approaches are necessary to achieve the large energy savings potential available through comprehensive retrofits of commercial and industrial buildings. Energy needs to gain visibility within commercial building markets and customers must value high performance, low energy buildings. To be successful next generation major retrofit and renovation programs should:

- Reward high performance by structuring financial incentives to be based on successful achievement of overall building performance metrics;
- Engage in long-term relationships with large campuses and portfolios. Set energy utilization targets and develop a plan to achieve those targets over a period of years,
- Emphasize the benefits to participants of taking a significant, robust, comprehensive approach to M&V of performance increases.
- Explore and develop new business models for developing, contracting and executing deep energy savings in large campuses or portfolios.
- Structure incentives and determine cost-effectiveness based on integrated, bundles or measures and entire building systems, not individual technologies or pieces of equipment;
- Publicly recognize and label successful projects for achieving high performance;
- Educate owners and the full array of building stakeholders on the benefits and value of high performance, low energy buildings;
- Train building designers, contractors and operators on how to achieve and sustain high performance;
- Document success.

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COMMERCIAL HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

Synopsis

Buildings consume about 40% of total US energy. Commercial buildings account for almost half of this, with commercial heating, ventilating, and air conditioning (HVAC) using about 3 quads of *site energy* for HVAC in 2003.[64] Commercial buildings, their uses, and their systems are highly diverse. This requires more specialized and sophisticated programs for the future than generally seen in the past. This section focuses on leading-edge and potential programs for roof-top units for mid-sized and big-box applications (air-conditioning, heating, and ventilation; chillers and chilled water systems for large buildings; ground-source heat pump systems, and condensing boilers for schools and other larger buildings with large heating loads. Programs can span the system life cycle, including incentives for advanced designs (system approaches), incentives for installing advanced systems for new construction and retrofits, and performance-based approaches to operations and maintenance (O&M) programs. All have high potential, but vary in their maturity level for replication by program administrators.

BACKGROUND

The Energy Information Administration (EIA) Commercial Buildings Energy Consumption Survey (CBECS) includes 14 categories of commercial buildings (Education, Food Sales, Food Service, Health Care, Lodging, Mercantile, Office, Public Assembly, Public Order and Safety, Religious Worship, Service, Warehouse and Storage, Other, and Vacant).[65] This discussion uses the term *commercial buildings* in the same sense as the EIA, to include institutions of all kinds. However, some programs will differentiate programs by ownership type. The two most important classes, mercantile and office,

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[64] http://www.eia.gov/emeu/cbecs/cbecs2003/overview1.html
[65] http://www.eia.gov/emeu/cbecs/building_types.html

include about 1/3 of total buildings, floor space, and energy consumption. The eight CBECS size classes range from 1000-5000 sf. to over 500,000 sf.[66]

Over half (53%) of all commercial buildings are <5,000 sf. Although they use only 11% of the sector's site energy, they are rich in program opportunities. These tend to use residential or similar equipment (furnaces, boilers, split system and roof-top air-conditioning, and without systematic ventilation). These buildings are the most amenable to traditional equipment-centered incentive programs.

Mid-sized buildings, up to perhaps 50,000 s.f. (and big-box stores) tend to use "applied" HVAC systems, typically single- or multi-zone roof-top units (RTUs) for air-conditioning and ventilation. Heat may be provided by the same units as heat pumps, or with resistance heat or auxiliary gas heating sections (the latter are called "gas-paks"). Program opportunities include advanced equipment, improved controls, and maintenance programs.

The largest buildings are generally cooling-dominated in almost all climates and seasons because their internal loads are high relative to their surface area. They use "engineered" or "built up" HVAC systems. The "engines" of these systems are "chillers" that make cold water that is distributed to heat exchange coils in large air handlers.

Opportunities for Savings

Opportunities for improving commercial building HVAC systems can be isolated into several different classes, recognizing that in the real world these classes often overlap and have potential synergies. One of these areas would be consideration of emerging technology opportunities. Several organizations have catalogued opportunities for "emerging technologies."[67] Many of these, such as commercial ground source heat pumps, chilled beam cooling, and condensing boiler systems, are much more about the system than the equipment "boxes." There are five key categories of energy savings opportunities, which are described below.

Equipment efficiency ratings. Commercial heating, ventilating, and air conditioning equipment programs have long been available. Traditional programs have provided financial incentives to install equipment with higher performance on the federal, ASHRAE, and/or AHRI rating methods. There are still opportunities for improved mainstream equipment. As one example, the lowest-rated condensing boiler will be rated about 10% higher than the best non-condensing unit, and these savings warrant incentives in many areas (system savings with condensing boilers are discussed below). There are similar opportunities with many classes of compressor driven equipment, notably

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[66] Table A1. Summary Table for All Buildings (Including Malls), 2003.

[67] For example, Sachs & others. 2009. *Emerging Energy-Saving HVAC Technologies and Practices for the Buildings Sector.* http://aceee.org/research-report/a092. Washington, DC: American Council for an Energy-Efficient Economy.

small roof-top units and packaged terminal air conditioners and heat pumps (PTAC/PTHP, commonly used in motels and analogous housing).

Efficient equipment features. Performance ratings for commercial air conditioners and heat pumps of all sizes are based strictly on the performance of the vapor compression or refrigeration cycle, ignoring other components, controls, etc. Other features, often optional, promise substantial savings. For example, in relatively dry regions with substantial diurnal temperature swings, a RTU economizer can provide "free" cooling with 100% outside air, offsetting about 50% of the compressor energy otherwise needed. In this context, an "economizer" is a damper and controls designed to bring in maximum amounts of outdoor air instead of running the refrigeration cycle, whenever outdoor conditions are cool (and dry) enough to save energy this way. This can be so important that proper economizers are now required for most regions in ASHRAE Standard 90.1, which is a key national building code for commercial buildings. Fault detection and diagnostics (FDD) for improved alarming in case of malfunctions, and better controls can also improve performance—if there are good operations and maintenance (O&M, see below). Areas to watch include advancements in economizer controls, such as those that offer demand-controlled ventilation (DCV).[68]

System approaches. Consider the most typical residential HVAC technologies. Most people would think of the furnace and air-conditioner, but the *system* also includes the ductwork, registers, and controls (thermostat). Typical attic equipment and ductwork lose 20–30% of the energy between the equipment and the room registers. There are often even larger opportunities with commercial systems. A proper condensing boiler system that regulates system temperature typically saves 40% or more over the pre-existing non-condensing boilers run at high temperatures, whether needed or not. The auxiliary systems of a chilled water system for a large building include pumps and piping for the cooling tower and for the internal chilled water distribution, cooling tower fans and air handler fans, and the internal ductwork and terminal units within zones. Together, these can use as much energy as the chiller, and this can be reduced substantially with optimized design and installation. This approach has been harder to convert to programs; it could start in custom programs.

Operations and Maintenance. At least for medium-sized buildings (perhaps above 5000 s.f.), there is substantial evidence that regular maintenance saves energy and money. There is also evidence that too few buildings have regular service or preventative maintenance programs. Some utilities are beginning to offer incentive programs to partially defray the costs of such programs. A separate section of this full report address commercial buildings operations and performance programs.

Design Assistance. Program administrators may wish to recognize the barriers to innovation faced by many in the design community: Design fees are generally too small in traditional service models to allow designers to investigate alternative systems that might deliver energy savings or non-energy

[68] https://customer.honeywell.com/resources/techlit/TechLitDocuments/67-0000s/67-7483.pdf

benefits (such as improved comfort). Some designers would welcome support in the form of mentoring (by a non-competing expert) and a stipend to cover the cost of learning to properly design a system new to them, such as ground source or chilled beams. The challenge is determining the savings attributable to such programs, but the catalytic effect can be large. Other sections of this report address design assistance for new commercial construction and for major building retrofits and renovations.

Drivers for Change

As state energy efficiency resource standards ramp up savings requirements on utility-sector energy efficiency programs, commercial HVAC is a promising area for additional effort. DOE sets commercial equipment efficiency standards for some equipment classes. For others, ASHRAE sets the levels, based on a consensus of the 90.1 Committee.

Standards have become more stringent for a decade. More stringent equipment energy efficiency standards leave less "headroom" for incentives for even more efficient equipment, which forces programs to identify and develop additional program opportunities to save energy. Ironically, one of these will be to obtain credit in the efficiency portfolio for investments in more stringent codes and standards, which avoid investments in incentives. This opportunity is discussed in the Commercial New Construction section of this report.

Opportunities for further equipment efficiency improvements vary by equipment type. For example, as discussed further below, very high efficiency RTUs are becoming available. In addition, for most climate regions (except those that are very humid with relatively small diurnal temperature swings), economizers allow direct cooling with 100% outside air whenever it is cool and dry enough. This area is ripe for programs. Organizations such as the New Buildings Institute have crystallized lessons learned from these pioneering efforts. Similarly, condensing boilers are becoming more common and better understood. In contrast, there is probably less "headroom" for more efficient centrifugal chillers and some other products.

Equipment standards generally focus on stringency of ratings, but ratings do not include many features that save energy, such as economizers for RTUs (in most regions). The search for savings naturally leads to incentives for equipment that includes such features—and ways to know that they are working properly. In turn, this leads toward operations and maintenance (O&M) programs focused on preventative maintenance and regular service. ASHRAE Standard 180 provides a framework for what programs should include. ASHRAE Standard 180 is specifically for setting minimum levels of inspection and maintenance that preserve satisfactory energy efficiency, comfort, and air quality in commercial buildings. As discussed below, several programs are successfully capturing these savings.

There is also growing interest in the USGBC LEED program and environmentally sustainable buildings in general. Advanced design strategies are captured (in part) in ASHRAE Standard 189.1, ICC's International Green Building Code, and other efforts. In many cases specific energy savings goals are included, providing incentives for use of high efficiency equipment and also for much better integrated system design.

Another driver may be owner and tenant interest in occupant comfort and satisfaction and owner interest in integration of controls for larger buildings. Good systems design can improve occupant comfort as hot and cold spots are eliminated. Regarding controls, if a single system controls HVAC, lighting, and even security/access, it may offer opportunities for better control and simpler operation.

Finally, as noted above, program administrators can investigate the savings potential of nudging the construction industry toward fully integrated design-build approaches that promise better design and better quality control.

Emerging Trends

This discussion focuses on five technology areas:

1. Advanced Units for Small to Mid-Sized Buildings.

There are a number of new technologies which are promising. Controllers for RTUs and variable air volume (VAV) fans for air supply are two examples. Some of the largest utility-sector programs have now begun to include variable refrigerant flow (VRF) technology in their commercial HVAC equipment replacement program. VRF can achieve significant savings as part of a roof top box. Manufacturers are producing these units now and they are widely available in the United States. In addition, EPRI and others have been working to test, demonstrate and promote VRF systems that were first developed in Asia and that are essentially larger commercial versions of the "mini-split" air conditioner systems that now predominate in Asian and European residences.

Regarding RTUs, the Department of Energy has sponsored the voluntary Roof Top Unit Challenge to introduce very high efficiency equipment, ones that would achieve integrated part load efficiencies at least 18 IEER (against an ASHRAE Standard 90.1 with EERs just above 11). This is part of a larger goal of 50–60% energy savings through code changes. The first unit to qualify is the Daikin-McQuay Rebel, available in 3–12 ton capacities with a variety of configurations and heating options. All feature variable refrigerant flow compressors, ECM condenser and evaporator motors, and other advanced features. Carrier, Lennox, 7AC Technologies, and Rheem have all announced participation; qualified products are expected in early 2013.[69]

Other air conditioning technologies on the horizon, but not incorporated into energy efficiency programs yet, are indirect and direct evaporative cooling, which is most applicable for hot and dry climates. Third generation units are now in place that include a fully integrated evaporative cooling/heat pump. These are being tested in Boise, Idaho and show 50% cooling energy savings. However, these are still produced only by a small manufacturer, so there is a need to get a major supply chain to pick up the technology and to get more units in the market.

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[69] http://apps1.eere.energy.gov/news/m/progress_alerts.cfm?pa_id=733

2. *Improving Chilled Water Systems for Large Buildings.*

Chillers are often very efficient and sophisticated systems comprising a compressor, motor, evaporator, condenser, and controls. The equipment metrics in ASHRAE 90.1 are peak load (COP) and integrated part-load (IPLV). There is some head room for program incentives for even more efficient equipment, but other program foci may be more cost-effective. This is because the complete chilled water systems for large buildings are very complex., From end-to-end, they typically include at least one cooling tower with a fan to reject heat, pump(s) to circulate water between the cooling tower and the chiller's condenser, the compressor and its motor, the evaporator, and piping to carry chilled water to and from central or distributed air-handling equipment as well as numerous valves and sophisticated controls. Many of the motors may have variable frequency drives. Older systems typically use constant speed pumping instead of primary/secondary pumping instead distribution and/or 3-way bypass valves for chilled water, and do not utilize energy savings from variable flow through the condenser. Retrofitting such complex systems has required extensive analysis and custom programs for new construction, retrofit, or early replacement. Additional opportunities include:

a. Shift from air-cooled to water-cooled chillers. The savings potential is somewhat obscured by rating complexities but can be substantial. For example the minimum efficiency requirements in ASHRAE 90.1-2010 for a 100 ton air-cooled chiller is 1.255 kW/ton, substantially more than the requirement of 0.775 kW/ton for a water-cooled positive displacement chiller less than 150 tons or 0.634 kW/ton for a water-cooled centrifugal chiller less than 300 tons.

b. Focus on "balance of system." In general, it is more efficient to carry energy in water than in air. This suggests that systems that use water all the way to the terminal unit (with a separate ventilation system) are likely to use less energy than those with centralized air handlers serving whole floors. Even so, careful piping design and insulation, selecting sufficiently large cooling towers, and appropriately sized variable-speed drive pumps are essential for system efficiency.

c. Incentivize propeller (axial flow) cooling tower configurations instead of centrifugal, since they are almost twice as efficient at standard rating conditions (38.2 gpm/hp vs. 20 gpm/hp).There are no known cost advantages for centrifugal fan cooling towers.

d. Evaluate early replacement incentive programs with system upgrades for the oldest centrifugal chillers. New chillers using environmentally preferred refrigerants are almost twice as efficient as old high-ODP chillers that used CFCs. Unpublished work by AHRI and ACEEE has established the potential of a large-scale retrofit program to improve efficiency and reduce damage to the earth's ozone layer from leakage of CFC refrigerants.[70] This leaves room for cost-effective programs with large auxiliary benefits.

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[70] This analysis was in support of a tax incentive proposal to encourage retirement of old CFC-chillers that is contained in S. 3352 in the 112th Congress and similar provisions in a bill from the 111th Congress. See

e. Evaluate the use of incentives for re-piping existing chilled water systems configured with 3-way control valves to convert them to 2-way control valves. Three-way valve controls on chilled water coils require constant chilled water flow to the terminal device, thereby limiting the effectiveness and feasibility of variable speed pumping. The installation of a VFD on a pump is a relatively low-cost project, and programs providing incentives for the VFDs themselves are widespread; however, the piping and controls changes that are needed to allow these drives to operate optimally are often cost prohibitive.

f. Evaluate incentivizing operator training. Informed operators can reduce energy use by 20%. By providing training for the best operating methods, including energy usage characteristics of chiller, pumps, and cooling towers, operators will stage equipment more appropriately and use improved setpoints to achieve efficient operation.

Chillers and chilled water systems are complex; medium-sized utilities will only see a handful of new or replacement opportunities annually, across all capacities. Therefore, custom programs are probably appropriate. These should include 8760 hour performance simulations to assure that both peak load and energy concerns and opportunities are addressed. Pacific Gas and Electric (PG&E) has invested substantial resources in developing "Cool Tools" as design guidance for chilled water plants (Hydeman 2009).

According to Steve Taylor (2012a), one promising opportunity for program administrators would be a focus on optimizing design and control of chilled water plants (Taylor 2012b). For typical two-chiller, two-cooling tower systems with appropriate variable speed drive chillers and pumps, a well-documented process can lead to savings in the range of 20% for poorly-commissioned systems. Taylor suggests that this process could be largely automated with appropriate user-friendly software. In such a situation, a design engineer would enter a full description of the system in the building, run the model, and then supervise the technician establishing the control sequence in the building energy management system. ACEEE infers that the development cost of the software would be in the low six-figure range, but it would reduce implementation time to a day or so, instead of a week to many weeks. Particularly if considered as a form of retrocommissioning of existing buildings, it should be easy to measure and establish the value of the savings from improved control sequences.

Perhaps starting with PG&E's "Cool Tools" program over a decade ago, ASHRAE and others have allocated substantial resources to increasing understanding of chilled water *systems*. There is now a basis for collaborative program action.

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http://www.gpo.gov/fdsys/pkg/BILLS-112s3352is/pdf/BILLS-112s3352is.pdf. However, no new energy efficiency tax incentives have been considered since the proposal was developed.

3. Ground-Source Heat Pump Systems for Mid-Sized Buildings.

Ground-source heat pump systems have achieved great success in several regions and are ripe for wider use in schools and other commercial applications, particularly in the range from 50–500 tons[71]. The basic technology is very simple: small, high efficiency, unitary water source heat pumps exchange heat with a ground heat exchanger. In addition to the inherent efficiency of using water for carrying energy (instead of air), in many cases a multi-unit water source system can "recycle" energy between building faces calling for heat and those calling for cooling, such as mornings in an east-west oriented classroom wing.

The heat exchanger is typically built around high density polyethylene (or PEX) pipe "U-bends" installed in deep boreholes, at roughly 200 -300' per ton of heat exchange required. Successful programs are characterized by competitive vendors, experienced and disciplined design teams, and geology that is amenable to low-cost drilling (although horizontal installations have been quite successful in many cases) (Kavanaugh and Rafferty (1997). Under these circumstances, installed system cost may be less than for alternative high-amenity systems, partly because only minimal control systems are required. In many regions complete installed system cost is still in the range of $20/s.f., for very high performance systems (Mescher 2012).

Two relatively low-cost approaches have been used to build volume and experience. In the mid-1990s, the Geothermal Heat Pump Consortium defrayed the cost of bringing in an experienced design engineer to mentor HVAC engineers in their first project, helping them avoid costly errors and over-design. For more than a decade, the Tennessee Valley Authority offered a model program to strengthen infrastructure, without generally paying direct incentives. In the mid-1990s TVA stimulated retrofit of a single school as an award-winning model to publicize the technology. They then embarked on a large-scale effort to build the intellectual infrastructure required for successful installations. First, they provided training—and software—to several hundred engineers, so they could confidently design systems. They supported research projects that led to better design manuals and a text on geology and drilling for ground-source system designers to provide essential background for designers working with drillers. Notably, TVA also paid the cost of a trial borehole heat exchanger and thermal conductivity test for each of about 100 schools, greatly reducing design uncertainty about cost and performance (Dinse 2012). From the data, they have been able to begin mapping thermal conductivity across their service territory.[72] Although the data are noisy, the patterns suggest that the sedimentary terrains in their service area are more likely to have higher thermal conductivity, so relatively short loops will suffice. Since this can substantially reduce construction costs, it will ease the transition to mainstream for ground-source in appropriate parts of the service territory—and minimize angst for those who might find challenging ground conditions. TVA continues research on

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[71] In *power* terms, 1 ton is energy transfer at a rate of 12,000 Btu/h (3517 watts). The term is also used for the amount of energy required to melt a ton of ice in a day, 288,000 Btu (84,000 watts).
[72] http://www.tva.gov/commercial/TCStudy/index.htm

these systems, but all incentives are now within the general commercial incentives program: Ground-source is now mainstream for TVA area schools, so incentives are based on kWh saved in the first year of operation. They are not tracking program impact in terms of installations in other building types, such as offices, but this is expected to diffuse out as more engineers and owners become aware of system advantages.

A program alternative that has been widely discussed, but rarely implemented, is for the program administrator to install and own the ground heat exchanger, selling the energy (Btus) of heat exchanged or leasing the loop to the school or other owner.

4. Commercial Natural Gas Boiler Programs

Gas-fired boilers provide heat (and often hot water) for about 34% of all commercial building floor area (EIA 2008). The industry standard in the US has been a non-condensing boiler, with a thermal efficiency of 80% or a little more above 85% for a few very large units. To prevent condensation and resulting corrosion in the boiler, these typically require that the water returning from the building circuit be at least 140F.[73] This leads to large distribution system losses from heat radiating from the pipes to unheated spaces. The alternative is to use condensing gas boilers. These have corrosion resistant combustion gas heat exchangers. The nominal potential efficiency increase from capturing the latent heat is about 10%. It is this low because the obsolete steady-state rating method does not show the annual operating advantage of being able to operate in condensing mode almost all the time, even with equipment that is not oversized. In fact, with good controls and appropriate radiation surfaces, typical savings are at least 40% (Durkin 2006). The secret is to use a 'floating' return temperature—the lowest return temperature that allows the building radiators to satisfy comfort calls at that time while operating continuously. In shoulder seasons, this might mean return temperatures <100F.

Gas boiler programs scale to almost every building size and class, but have been most extensively documented for schools. In 2011, the Consortium for Energy Efficiency established a High Performance Commercial Boiler Program[74] offering a Tier 0 (85% thermal efficiency, modulating burner) and a Tier 1 for condensing boilers (90% TE, modulating boiler, condensing). This consensus program was carefully developed by member utilities.

5. *Maintenance Programs*

Quality Maintenance Programs

Although system design, installation, and commissioning of commercial HVAC systems are rarely without substantial errors, operational defects are another major failure in the life cycle of these

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[73] When the return water is at temperatures much less than 140F, water vapor condenses from the flue gases, releasing its latent heat.
[74] http://www.cee1.org/files/CEE_GasComm_BoilerInitiativeDesc.pdf

systems. Thus, pioneering work by the Eugene Water and Electricity Board, PECI, and others has led to much greater awareness of performance deficits in installed equipment, and efforts by program managers to find ways to encourage better maintenance.

Substantial energy savings may be possible from programs that succeed in stimulating proper maintenance of HVAC equipment. Early work is typified by California investor-owned utility pilots and programs (discussed further below) to check and rectify refrigerant charge, air flow, and other installation-related parameters for roof-top units, since their performance defects were so conspicuous. Particularly for smaller units, it has been challenging to find routes that are cost-effective and have sustained quality so program designs continue to evolve.

Recently, both better diagnostic tools and better controllers have become available. Of particular note are products such as the Catalyst and the Honeywell economizer controls, which include some fault detection and varying amounts of "intelligence" to learn about building operations. Some even include demand controlled ventilation and the ability to control multi-zone variable air volume (VAV) systems. These features may support programs built around the quality maintenance (QM) stipulated in ASHRAE/ACCA Standard 180 (ASHRAE 2012).

Target Markets

The target market for these various program approaches vary by market. Equipment efficiency programs target building owners/developers, HVAC contractors, and mechanical engineers. Programs that target improved systems design generally target owners/developers and mechanical engineers. And RTU tune-up programs target HVAC contractors and the small and medium-sized businesses that do not have dedicated building managers or facility managers on staff.

Program Design

In the Emerging Trends section five different program types were discussed, each with their own design features. All of these program types involve some combination of marketing and technical assistance and incentives, with technical assistance being particularly important for approaches emphasizing systems design. Regarding incentives, the traditional program model provides incentives to building owners for purchase and installation of more efficient equipment, as demonstrated by higher performance ratings. As noted above, for some program types, several alternatives warrant consideration including:

- *Upstream incentives* for distributors, manufacturers and their independent representatives, or other trade allies. These are most likely to be useful for smaller buildings and equipment, where the role of the designer (professional engineer) is modest relative to the mechanical contractor.
- *Design assistance for systems design and emerging technologies.* This can take the form of paying for mentoring, paying incremental design costs, or help with infrastructure. For example, TVA has paid for trial boreholes and thermal conductivity tests for proposed ground source heat pump systems for schools in its service territory.

- *Pay for performance.* Just as ESCOs (Energy Service Companies) will contract to share the financial or energy savings from retrofits that they finance, program administrators can pay incentives per kW or kWh saved. This approach is generally used for custom programs.

Savings Potential

Commercial HVAC	Elec.	Gas	Notes
	TWh	TBtu	
National energy use affected: space heating	46	1680	From Energy Information Administration Annual Energy Outlook 2012 Reference Case, Commercial Consumption 2030.
National energy use affected: space cooling	152		From Energy Information Administration Annual Energy Outlook 2012 Reference Case, Commercial Consumption 2030.
National energy use affected: ventilation	178		From Energy Information Administration Annual Energy Outlook 2012 Reference Case, Commercial Consumption 2030.
Subtotal National energy use affected	378	1680	From Energy Information Administration Annual Energy Outlook 2012 Reference Case, Commercial Consumption 2030.
Average percent savings	20%	15%	% savings vary by project, program, and technology; Average savings estimated at 20% for electric and 15% for natural gas..
Ultimate net participation rate	70%	70%	
Potential long-term savings	53	176	

Examples

Southern California Edison (SCE)

Air Conditioning Equipment Replacement and Commercial HVAC Optimization

At SCE, the majority of the program activity and dynamism is on the maintenance and installation side, not equipment replacement. The majority of savings attributable to the programs are in upstream equipment rebates, predominantly for air conditioning. Direct-expansion air conditioning has been the area of highest savings within commercial HVAC for many years. SCE offers rebates for higher (relative to existing equipment) SEER HVAC equipment, but not for many of the newer technologies, such as indirect evaporative cooling, yet. They have added water-cooled chillers. Next generation program activities will not be the source of most of the savings, or even a significant part of the portfolio of savings during the current/next two year California program cycle.

Higher-SEER equipment replacement is the "bread and butter" of SCE's program. It is relatively inexpensive per unit of energy saved because it is an upstream program. SCE pays distributors to have high-efficiency units in stock. Some of the incentives money goes to lowering the prices paid by the end customer, however, what is key to the program success is that since customers generally buy new air conditioners when their old ones break; with the upstream incentives, distributors will have the efficient equipment on hand and the customer will not have to wait for weeks to get their new, higher-efficiency air conditioner.

On the quality maintenance side, SCE will be continuing their existing maintenance program to ASHRAE/ANSI Standard 180. ASHRAE/ACCA Standard 180–2012 is not an efficiency standard for equipment, but rather a standard of professional practice for inspecting and maintaining HVAC systems in commercial buildings. Their internal research has found that customers tend only to do very basic maintenance unless they are program participants in a quality maintenance program. The quality maintenance program, while it does generate some savings, is designed to do market transformation rather than resource acquisition. In this case, the market is the service contractor market: the program exists to demonstrate the value of well trained technicians to do good work and create a long term relationship between the customer and the contractor. In the past, during the 2006-8 program cycle, SCE found that the maintenance program ended up being about customers getting an incentive, rather than creating longer-term change to sustain energy savings with ongoing maintenance of HVAC equipment. The new program includes a financial incentive for the customer and contractor signing a three year service agreement. There are also additional incentives to improve efficiency such as for changing the refrigerant charge.

SCE is very focused on savings from economizers and demand control ventilation for air conditioning units, which almost "free cooling", because the outdoor temperature is much lower at night. Demand control ventilators, economizers, and temperature sensors can work together so that when the air temperature outdoors is low enough, the building can be ventilated directly from outdoor air, reducing use of the compressor. One example of a commercial building where this is the case would be a movie theatre, open at night, with a large number of people.

SCE provides incentives of $1,000 per ton installed for ice-ready HVAC Systems and $1,800 per KW for ice storage units.

http://www.sce.com/b-rs/commercial/hvac-optimization.htm

Pacific Gas and Electric (PG&E)

PG&E commercial HVAC continues to build on their long-standing equipment incentive program, which, like SCE's, is an upstream program working with distributors. Both of these large investor-owned California utilities have found it to be cost effective to run the program upstream, with some vendors passing on part of the incentive funding to consumers in the form of lower prices, some increasing inventory, or to provide bonuses to their sales force to sell more energy-efficient products.

The upstream aspect of the program lowers administrative costs of running it and it multiplies the impact of the incentive because it is multiplied by the distributor's margin.

https://www.cainstantrebates.com/

https://www.cainstantrebates.com/ca_media/er/img/PGE_HVAC_Incentive_Levels_2012.pdf

PG&E exemplifies major trends and important realities faced by commercial equipment replacement HVAC programs:

1. Utilities with performance targets should be given different incentives to get them interested in this market as the unit savings are becoming less due to increased standards
2. In the past, PG&E's offerings included air-cooled chillers and standard packaged equipment. Now, in response to tighter energy codes, they are creating additional tiers to "move up the efficiency ladder". That is, they provide incentives to higher and higher efficiency equipment to capture savings beyond code. Usually they have had one or two tiers that correspond to those established by the Consortium for Energy Efficiency (CEE). At times they have had five tiers.
3. The limits of the efficiency potential of the technologies are being approached, so they are now adding new technologies to the program, such as variable refrigerant flow (VRF) for heat pumps and VRF in general, continuing to seek out more efficiency.

PG&E also addresses commercial HVAC efficiency through their custom incentives, which is calculated based on energy used before and after the project. They have customer service representatives, who work with large and sometimes small- and medium-sized customers. Approximately 30% of commercial HVAC energy savings are the result of the custom program.

A third area is the Quality Maintenance Program, which is considered to be a market transformation program. PG&E is working through it with the California Public Utility Commission (CPUC) and with maintenance contractors. PG&E is conducting the program along with SoCalGas, San Diego Gas and Electric, and Southern California Edison. The program provides financial incentives to both customers and contractors to follow practices and standards of ANSI, ASHRAE, and ACCA. While there are some savings resulting from this program, the objective is to influence the market and create a new culture—that better maintenance will improve the customers' energy savings.

As of September 2012, there are 25 customers and 60 contractors in the PG&E service territory in the program. Total energy savings comprise an insignificant percentage of the portfolio. The program will expand over the next two years, to over 2,500 systems, 250 customers, and 100 contractors. By the end of the two year program cycle, Quality Maintenance could account for an estimated 10% of commercial HVAC program savings, although HVAC overall will increase. Energy savings per building of 50% of HVAC load are typical.

www.commercialhvacqm.com

Energy Trust of Oregon

Energy Trust of Oregon (ETO) is a leader in innovative commercial HVAC programs, serving major investor-owned utilities in Oregon and Washington. In contrast with the California investor-owned utilities, RTU tune-ups and control systems are the main sources of savings from ETO programs and are expected to remain so for the next few years. In 2012, RTU tune-ups and controls contribute approximately 20% of all portfolio savings, not just commercial HVAC. In 2013, it will likely be even more, about one-third of all savings. Savings levels vary widely from site to site, from negligible savings to 70% of usage. Typically, ETO can save a commercial customer 13 to 17% of their HVAC energy use, or 5 to 10% of a building's overall energy use.

ETO runs equipment replacement programs as well. The ETO commercial cooling program provides financial incentives for the installation of efficient air conditioning equipment with an energy efficiency ratio (EER) of 11.7 or higher, with the amount of the cash award varying by the size category of the equipment, from 6 to 25 tons. The ETO program also supports airflow management, air-side and water-side economizers, chillers and computer room air conditioning (CRAC) units as well as energy-efficient air-to-air heat pumps

http://energytrust.org/commercial/incentives/equipment-upgrades-remodels/HeatingAndCooling

New York State Energy Research and Development Authority

New York State Energy Research and Development Authority's (NYSERDA) open-enrollment Existing Facilities Program (EFP) offers a comprehensive approach to incentivizing energy efficiency projects at customer sites paying the System Benefits Charge across New York State. EFP offers two paths for participation: (1) a 'Pre-Qualified' fixed dollars-per-qualifying-unit for simple, straight-forward equipment changeouts or (2) alternatively, a 'Performance-Based' custom-incentive path that offers an incentive rate per annual kWh saved. Pre-Qualified equipment efficiency thresholds are aggressively set above and beyond standard practice and are also in effect for Performance-Based participation. Pre-Qualified incentives are offered in many categories, including lighting, motors, VFDs, HVAC, chillers, natural gas boilers, commercial refrigeration and cooking equipment.

Performance-Based participation requires an applicant-provided assessment of annual energy savings to be verified by an independent third party engineering firm that includes pre- and post-construction site visits and may require measurement and verification in accordance with program protocols (International Program Measurement and Verification Protocols, or IPMVP) used. Whereas the Pre-Qualified route has no minimum project size, Performance-Based participation is geared towards larger projects and requires a minimum project size of at least $30,000 worth of incentive. Incentive rates are $0.12/kWh in upstate NY and $0.16/kWh saved specifically in Con Edison electric service territory.

Chilled water system specific incentives include $300 per kW in upstate NY and $600 per kW in Con Edison Service territory for thermal storage projects and a Super-Efficient Chiller Bonus (SECB). The SECB is designed to bring down the incremental cost of high efficiency electric chillers and is custom to each qualifying chiller, based on its efficiency metrics compared to certain eligibility criteria. A technical guidance document is provided for chillers at NYSERDA's website along with a spreadsheet tool that estimates the Super-Efficient Chiller Bonus for qualifying chillers. Please see:

http://www.nyserda.ny.gov/Commercial-and-Industrial/CI-Programs/Existing-Facilities-Program/Performance-Based-Incentives/Electric-Efficiency-Incentives.aspx

NYSERDA focuses on chilled water system improvements that emphasize a "water to wire" approach that considers chilled water production and distribution.

Recommendations

Commercial buildings are more diverse than residential in almost every respect, but have HVAC savings opportunities that are very large. Ideally, HVAC savings opportunities are reviewed as the last step in comprehensive retrofits. That way, the HVAC can be down-sized to reflect improved building performance and smaller loads from other measures (shell and glazing, lighting, etc.)—a principle that has been understood for decades.

HVAC system improvements are likely to be second only to lighting in the size of the potential and its cost-effectiveness. However, since the largest savings opportunities are more about systems than upgrades to single pieces of equipment, this requires more sophisticated approaches by program administrators. A key is for program administrators to work more closely with local design engineers and other professionals. Appropriate programs will be built initially around custom programs authorized for commercial customers in many jurisdictions. This discussion focused on roof-top units, chilled water systems, ground-source heat pump systems, boilers, and maintenance, largely because they have been the best documented. Other opportunities for deep savings may exist—and some may have as wide applicability. For these additional opportunities, there is a need for trial installations and pilot programs to test technologies and program approaches prior to widespread implementation.

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Commercial New Construction

Synopsis

Building design is a primary determinant of energy use for the lifetime of buildings. Most design and construction processes are fragmented, fast-paced and driven by low first costs. Such processes are at odds with the design process needed to achieve high efficiency buildings, a process that requires more time to develop alternative designs and model their performance and energy use. Energy design assistance programs address this gap by providing resources and incentives to project design teams and building owners that enable them to consider a wider range of design options intended to minimize energy use. The objective is to take a whole building, systems approach to design that accurately models alternative designs and captures interactions between key building systems, such as lighting and HVAC. Next generation building design assistance programs will continue to take this successful, proven approach. Principal new directions for these programs will be to consider and include a variety of building technologies, including advanced lighting, high efficiency HVAC systems and high efficiency building envelopes. To reach and affect greater numbers of building projects, programs have developed tools that are designed to be practical and affordable for smaller size building projects. Another program direction is for utilities and related organizations to work on development and compliance with more stringent building energy codes. In these ways, the baselines for building energy use are moving toward higher efficiency, while the performance of the most efficient buildings is promoted through building design assistance programs. At the same time, private markets for green buildings have grown and continue to grow rapidly, suggesting an increasing number of owners and occupants value high performance, low energy buildings.

Background

Designing and constructing commercial buildings is a long and complicated process. It involves many different types of businesses—design firms, general contractors, equipment suppliers, and numerous specialty contractors to build and install building systems. Cost and scheduling pressures can be great, and the markets associated with building design and construction are highly competitive. The result is a building industry that is highly fragmented and driven by achieving lowest construction costs and moving quickly on to new projects. A variety of codes also govern these markets and resulting building designs.

Minimizing energy use and costs historically has not been a primary objective for most building owners involved in new construction. However, the building design itself (including all the various building systems) ultimately has the biggest impact on energy use and costs for the lifetime of the building. To achieve a low energy cost building requires careful design and analysis of the building's performance through the operation and interaction of its many systems (lighting, heating, cooling, ventilation, etc.). Such integrated, whole building design involves modeling of the building in the design phase to predict and compare performance of a wide variety of options for the building's configuration and systems. Such modeling and analysis takes time and effort early in the design process, which adds to building costs. As a result, building owners face the dilemma that it may cost more in the initial design phase to achieve a building that will be lower cost in the long run due to lower operating and energy costs. In the high paced, competitive markets for building design and construction, this "extra" cost prevents building owners from pursuing designs that would yield more energy-efficient buildings. Split incentives can also work against the design and construction of energy-efficient buildings since owners may not be responsible for energy and operating costs, but rather such costs are borne by the tenants.

The concept of integrated design is broader than modeling and analysis. It should include supporting and encouraging multi-disciplinary collaboration throughout the entire process of designing, constructing and operating new buildings. It involves not only design professionals, but also with key project stakeholders over the duration of the project. This begins early in the process with a project meeting/design charrette to set goals identify strategies for achieving the goals and desired outcomes. New construction programs should help facilitate these collaborative meetings and assure or encourage that energy savings, carbon reduction, or sustainability targets are established as part of, or integrated into the goals. This will allow a broader view of systems and of system solutions, including behavioral changes.

Program administrators (utilities or related organizations) have long recognized this problem inherent in conventional building design and construction processes. To address the problem programs have been developed to provide building design assistance. The main strategy taken by such design assistance programs is to provide resources and incentives to building owners during the design phase so that the project architects and engineers can model and analyze the energy performance of a variety of designs in order to yield an integrated, energy-efficient design—one that delivers high building performance and low energy use. Without this approach, designers miss the synergies and larger energy savings that are possible from integrated packages compared to one-by-one project savings focusing on upgrading single pieces of equipment or other building components. A related problem is the way that many energy efficiency programs have structured their incentives, which is to require individual measures to pass cost-effectiveness screening tests. This can work against providing incentives to integrated designs for whole buildings and whole systems as some individual elements of such integrated designs may not pass screening tests.

While design assistance programs seek to push the leading edge of high performance, low energy buildings, development and adoption of more stringent building energy codes is a means to raise the energy performance of entire affected buildings markets. A few states have enacted policies that allow utilities to gain energy savings credit for their efforts in developing such codes, as well as improving compliance with them. (Cooper and Wood 2011; Elnecave 2012).

Drivers for Change

Building energy codes are getting more and more stringent, meaning that baseline performance of new buildings continues to increase. This raises the bar for building performance, requiring designers to develop creative solutions to meet these higher performance requirements. It also drives building technologies to advance and deliver superior energy performance. More stringent building codes also reduce the potential savings to be achieved for buildings seeking performance beyond code, which affects cost-effectiveness criteria for programs. Stricter building codes also tend to reduce the number of prescriptive design elements that have been part of design assistance programs because many of these features become required by the more stringent codes. They no longer are optional. The need for integrated, whole building design thus becomes even greater to be able to achieve energy performance significantly better than code.

California, a long-time leader in building energy codes, just enacted updates to its Title 24 building energy codes (effective in 2013) that represent the largest increase in required building energy efficiency since the 1970s. In short, the "headroom" between codes and high efficiency has grown smaller and smaller as one expert put it. Since program incentives have largely been based on the incremental savings possible through more energy-efficient designs and associated technologies, the financial incentives are effectively shrinking, too. The result is that the value proposition to customers is diminishing; programs may need to re-think the value proposition of programs and provide other benefits that customers value. This could include public recognition and certification of the energy-efficient designs.

Other widely used codes and standards for commercial buildings continue to require higher energy efficiency. The ASHRAE 90.1 Energy Standard for Buildings provides a clear example. The most recent standard, ASHRAE 90.1-2010 is expected to be widely adopted in the U.S. by 2013 and reduces energy use by an average of 18% compared to the previous version (2007). Programs will have to analyze the impacts of such changes on their existing programs and determine appropriate responses. Xcel Energy completed such an analysis of its Energy Design Assistance program (based on achieving 15% better performance than ASHRAE 90.1-2007) and determined that a number of measures that have commonly been used to achieve program targets will essentially be part of baseline requirements. Their cost-effectiveness, therefore, is diminished or even vanishes as such features become standard. In response, Xcel Energy is pursuing two key strategies: (1) promote and provide incentives for emerging technologies, and (2) support codes and standards market transformation. (Elling et al. 2012).

Xcel Energy's interest in codes and standards reflects a new direction that some states are requiring utilities to take to support the development and enactment of more stringent building energy codes along with efforts to boost compliance with these codes. California has pioneered efforts for utilities to gain energy savings credits to meet their portfolio targets by their work to develop and support more stringent building energy codes. Similar efforts are underway in other states, such as Colorado. (Cooper and Wood 2011; Elnecave 2012). The key is for regulators, utilities and stakeholders to reach agreements on how to credit utilities for such efforts relative to program portfolio targets, especially those states with some type of energy efficiency resource standard. Another benefit of new commercial building programs is to help demonstrate new approaches that can be incorporated into future code cycles. That is, the experience gained from the design, construction and operation of buildings that are much more energy-efficient than those built to existing codes can show what is possible, leading to more advanced future building codes.

At the same time that building codes are getting more stringent, an increasing number of building owners and developers are interested in and demanding high performance buildings that meet a wide set of "green" criteria, including high energy efficiency. As witnessed by the relatively rapid growth of "LEED" ratings for new buildings as a way to identify and distinguish these buildings, there is change underway in building markets independent of the impacts of utility-sector programs.

Other policies are driving new commercial buildings to become highly energy-efficient. A prime example is the State of California's goal of having all new buildings be "net-zero energy" buildings by 2030. Such a design objective clearly sets a high target for the energy efficiency of buildings.

While there are numerous advances in building design, materials and systems that can yield high efficiency, low energy-use buildings, a counter trend for total building energy use is the growth of "miscellaneous" energy use, which encompasses all office equipment and "plug" loads. The EIA's *Annual Energy Outlook 2012* estimates that office equipment accounts for 41% of commercial electricity use in 2012 and will grow to 50% of use by 2035. So clearly there should be efforts to promote high efficiency among these miscellaneous uses, too. The variability and uncertainty associated with plug loads are challenges for building designers. Such loads clearly will affect HVAC demands. Greater research into and understanding of plug loads will be necessary to provide accurate data to use for building modeling and design. One example is integrating lighting and plug load controls; an analysis of such an approach suggests this is a promising strategy to yield cost-effective designs (Zhang et al. 2012).

Emerging Trends and Recommendations

Technologies

"Whole building" design is the guiding principle for yielding high performance, low energy buildings. Taking an integrated, whole building approach allows designers to test a wide array of options available to them for any of the many systems and components that comprise a building. For example, designs that effectively incorporate daylighting will greatly reduce the artificial lighting load of a building, which in turn, can reduce mechanical cooling requirements. If not modeled and analyzed together, such synergies may be missed, resulting in over-sized mechanical systems. In turn, such over-sized systems typically do not operate at optimal efficiencies, leading to higher energy use and costs. What really distinguishes a high performance building from conventional buildings is how equipment and associated systems are designed into the space for optimal performance and energy efficiency. Taking a whole building approach also enables designers to examine and reduce building energy loads from a systems perspective, yielding low energy demands as the starting point for specifying and designing the building systems (lighting, HVAC, etc.) to meet these various demands.

Building technologies continue to advance at a rapid pace, giving building designers and contractors more options that can improve building performance and lower energy use. Such progress can be seen across the spectrum of technologies used in buildings, from advanced glazing to high efficiency mechanical equipment to "smart" system controls. A growing number of building owners and occupants demand "green buildings" and even "net-zero energy" buildings. To achieve such low energy use, designers see three key areas offering the greatest potential energy savings. We discuss these below.

Advanced Lighting

Greater use of daylighting achieves large energy savings by reducing a building's lighting load and cooling load. Advanced lighting designs and technologies can optimize daylighting and significantly reduce lighting loads. Lighting controls (occupancy sensors, daylight dimming, etc.) can be used to manage lighting loads in accordance with available daylighting and specific end-use needs. Advanced lighting design seeks not only to reduce energy use but also to provide high quality lighting for building occupants. For example, there is growing interest in indirect-direct lighting systems utilizing one and two lamp fixtures with supplemental task lights in order to provide pleasing lighting without glare on computer screens. Improved dimming systems are available that are integral to advanced lighting design. Such systems automatically adjust lighting to occupant needs and available daylight. The New Buildings Institute has developed advanced lighting guidelines to assist building and lighting designers. While advanced lighting controls are available, getting them to work correctly can be challenging. It requires proper installation and operation. Some programs are working with electrical contractors and building operators to provide training and education to get desired performance from these systems.

High Efficiency Mechanical Systems

Building heating, ventilating and air conditioning (HVAC) systems constitute a major share of building energy use. In addition to specifying high efficiency technologies, effective design of entire building systems (e.g., looking at HVAC as a single integrated system) is critical to achieving optimal performance and low energy use. While some efficiency gains are still being made with conventional HVAC technologies, there are some larger gains that can be made in certain projects by shifting to less commonly used technologies, such as ground source heat pumps. Choices of high efficiency technologies are affected by other markets and technologies, however. For example, ground source heat pumps face barriers in many markets, particularly wherever competing fuels like natural gas are readily available. other promising technologies and designs to greatly reduce HVAC energy use include use of radiant heating systems, elimination of mechanical cooling systems by use of passive systems, plug load management, and metering of building subsystems to allow closer monitoring and management of specific building loads. It also may be possible to incorporate passive solar heating as a design to reduce a building's heating load.

High Efficiency Building Envelopes

The thermal efficiency of the envelope of a building clearly affects heating and cooling energy use. "Superinsulation" is one means to improve this efficiency; that is, use really deep insulation in wall cavities to minimize heat loss. Doing this in commercial construction is relatively new. Advanced windows are additional tools available to help achieve high performance of the building envelope. A "cool roof" (roofing materials with high reflectivity) is another building feature that can be incorporated into high performance building envelopes.

There are numerous other technological advances at play in new building markets. These include integrating demand-response (primarily load control) technologies into building systems along with a variety of smart technologies that can enable buildings to react to market changes and system needs. Some of these technologies also can be used to improve building energy efficiency. Building metering and monitoring systems can help buildings perform as intended and deliver anticipated savings. Such monitoring and diagnostic tools for building systems have advanced significantly and can play critical roles in achieving high performance.

Program Design

New construction programs for new commercial buildings generally include three services for building owners, design teams and building developers: (1) design assistance, (2) design tools, and (3) incentives. What follows is a discussion of how programs are changing to meet new demands for these services.

Design Assistance

The core service offered by building design assistance programs is additional technical expertise and analysis of building designs. Programs typically have staff or consultants available to work with qualified projects. These experts work with the building owner and the owner's design team at the earliest stage of the design process, which is before key decisions have been made about the building's shape, lay-out and systems. The program experts typically will review proposed designs and perform modeling of the energy performance of numerous alternative designs and building systems. A key to success is for these experts to be able to work effectively with the design team. Design assistance programs also may offer some funding to support additional costs incurred by the architects, engineers and other design team members in analyzing the energy performance of proposed designs. Generally, a much greater number of designs and system options will be proposed and modeled compared to more conventional design processes.

Design Tools

Modeling the energy performance of buildings can be time consuming and complicated. For medium to larger sized buildings (about 50,000 square feet or greater), the extra time required for such modeling can often be more readily justified given the larger overall building construction costs and larger life-time operating costs. Providing customized technical assistance for these types of projects will continue to be a central element of next generation design assistance programs. This type of customized assistance can be directed to the "whole building", or it can be directed to selected building systems, such as HVAC or lighting.

For smaller buildings there are two approaches to address the challenge of minimizing the time and costs associated with modeling the building energy performance of numerous alternative designs. The first approach is to model the performance of a smaller set of common building prototypes, that is, common small buildings such as retail stores, restaurants, and office buildings. There typically is much less variation in the designs of these smaller buildings. The New Buildings Institute (NBI) has been leading an effort to develop a set of design tools that target these smaller, common buildings. The design tools are sets of recommendations for these buildings based on extensive modeling of a wide variety of alternative designs. In this way a set of energy-efficient prototype designs for different climates have been developed that provide recommendations on all aspects of the building, including HVAC systems, lighting systems, control systems, wall construction, windows and roofing. Owners or designers interested in achieving a low energy building can readily access these recommendations online and quickly arrive at an optimal design without having to do modeling themselves. NBI's program, Core Performance®, is built around prescriptive design guidelines for a set of common small building types. These recommendations result in buildings that are 30% more energy efficient than model building standards. (ASHRAE 90.1-2004).

ASHRAE similarly has developed a set of design tools targeted to common building types in order to achieve advanced levels of energy savings without having to complete detailed modeling and analysis. ASHRAE's *Advanced Energy Design Guides* are a series of publications that contain design recommendations for achieving energy savings over the minimum code requirements of ANSI/ASHRAE/IESNA Standard 90.1. The original set of guides targeted 30% savings over 90.1-1999. A second set with targets of 50% over 90.1-2004 has recently been developed (Pless et al. 2012) and is available as a free download from ASHRAE. Both sets of guidelines address four building types: (1) small to medium office buildings, (2) K-12 schools, (3) medium to big box retail buildings, and (4) large hospital buildings.

The second approach for design assistance with smaller buildings is to provide a model to owners and designers that enables them to easily and quickly assess performance of a building design themselves. Such a self-assessment tool needs to be user-friendly and must not require a lot of time and modeling expertise to use. This requires the development of building energy models that use simplified inputs and algorithms. Wisconsin's Focus on Energy Program is taking this approach. The program contractor, the Weidt Group, is initiating a program in 2012 that will feature an on-line tool available to customers to use a simplified platform to model a proposed building's performance quickly and easily.[75] This simplified platform is based on sophisticated modeling of many alternative designs. From this extensive modeling, the program designers are able to reduce the number of key variables and options available to perform simplified modeling of building energy performance. It yields useful results without having to build and run complex building energy models. For example, about 19 different mechanical systems were modeled in-depth, which yielded a set of three systems that offer optimal performance for most buildings of a certain type. These three types of systems are then the choices offered in the on-line tool. In this way, a building owner or designer can quickly arrive at optimal choices for a building. The more sophisticated, time-consuming modeling already has been done to limit the choice set. The on-line tool also models the impacts of building geometry and site orientation. This on-line tool is an entry point into the program, a way for a building owner to engage with the program and express interest in further services for full design assistance. The tool features 12 relatively standard building types. It screens out those buildings that do not fit these standard types and would therefore require more customized modeling.

[75] This program is being initiated in the Fall of 2012; the tool and full program materials are not yet available..

A related approach, particularly well-suited for small, common building designs is simply to develop recommended building system "packages" for different types of buildings and applications. Modeling of different packages and designs is performed to develop specific systems shown to be cost-effective. These systems are then structured into program options classified according to energy savings tiers, such as "good, better and best." Incentive amounts vary accordingly, with the highest incentives paid for choosing the "best" package. This approach makes it simple for small business and building owners. It provides them clear choices for energy performance without the need for modeling and associated design time. Such modeling has already been done to develop the design "package." In this way programs are likely to affect more projects.

Incentives

Financial incentives are used within design assistance programs to: (1) support some of the extra costs incurred in the design phase caused by examining and analyzing a wider set of design choices for the building, (2) offset some of the additional costs of more energy efficiency equipment and systems, and (3) reward achieving high energy performance. An example of the first type of incentive would be to award a grant to a design team to enable them to spend additional time on developing and analyzing energy-efficient designs. Financial incentives that serve the other two functions are categorized as "prescriptive incentives" and "performance incentives." The distinction is that "prescriptive incentives" are typically paid for specific types of equipment and systems, such as high efficiency motors or lighting. "Performance incentives" are set and based on total energy performance, typically measured by energy use per square foot or similar measure of aggregate energy performance. The trend is to encourage developers and design teams to use performance incentives for high levels of savings but to also make available prescriptive incentives for small (and sometimes other) building for which modeling performance may be difficult. Finally, some programs are beginning to use financial incentives to encourage quality installation. To do so, programs may increase the amount of incentives for qualified measures if they are installed by certified contractors. Also, incentives for building commissioning are not uncommon.

Target Market

Commercial building design and construction markets have been hard hit by the economic downturn and continued sluggishness of the past few years. Construction activity overall has been way down, although this downturn varies by type of building and region. In turn, participation in design assistance programs has also been down. Programs are trying to get more savings out of fewer and smaller buildings (down to about 5,000 square feet). Typically, the target market for building design assistance programs has been medium to large projects (50,000 square feet and greater), with owners seeking high performance and corresponding low energy use and costs.

Generally the markets for smaller buildings have been largely missed by past and existing design assistance programs because the extra time and costs incurred were not typically acceptable to owners. Efforts are underway to address these underserved building markets in next generation building design assistance programs as was discussed earlier in the development of new tools and modeling approaches to meet the unique needs of smaller buildings and more "standard" designs. In this way, the programs seek to serve more types of buildings and reach a greater number of new building projects than they have historically.

There also are promising developments with private firms that work with franchises and national accounts to plan and manage energy for large numbers of similar facilities (e.g., chain stores, restaurants, etc.). Such companies include Ecova and RealWinWin. These businesses offer a variety of energy-related services, including administration of incentives for energy-efficient equipment purchases, which can occur with new construction. There may be opportunities to influence building design, which could have large potential impacts since national chains largely replicate the same design wherever they construct a new franchised building. However, this also raises questions about allocation of costs and benefits since such influences are likely to go well beyond a single utility service territory or state boundary. "Free ridership" could be a significant issue; to avoid this issue, some type of regional or national collaboration might be necessary among multiple program administrators.

Marketing

Overall the best commercial new construction programs are reaching 50% or more of new commercial floor area through a mixture of prescriptive and performance approaches. Typically, only a minority of participating square footage uses the performance path, but program implementers are working to increase this. One promising approach, especially for reaching owners involved with smaller, more standard building projects, is to use on-line tools to engage potential program participants as discussed earlier. This on-line tool has a marketing function as well. The tool and on-line materials are designed with the objective of generating a phone call from users as a follow-up to determine qualification for participation in the program with the full range of design assistance and associated financial incentives. Use of the on-line tool is designed to facilitate discussion with one of the program's energy design experts. From such an initial conversation about a potential building and the results shown from the on-line tool, the program staff then determines eligibility and get back to the applicant within 48 hours. The goal is to get commitments quickly from qualified customers. For large buildings, marketing generally emphasizes building an on-going relationship with key developers, architects and engineers through trade ally breakfasts, one-on-one meetings and other approaches.

Effective marketing is clearly a key to increasing program participation. Programs need to reach design and construction professionals to gain their interest and participation. As an example, Efficiency Vermont recently expanded its marketing efforts to attract more projects. Part of effective marketing is also to recognize and publicize successful projects relevant to target markets. Toward this end, Efficiency Vermont increased its recognition program for completed projects by providing plaques, certificates, public relations support and case studies to owners and design teams involved with completed projects. Such recognition efforts are designed to gain market awareness and encourage participation in Efficiency Vermont's program specifically but also to foster a broader market development for high-performance buildings.

Savings Potential

Design assistance programs generally set savings targets as performance significantly above the applicable building codes. For example, California's Savings By Design targets savings 30% better than code. Xcel Energy in Minnesota sets different savings targets for different versions of its Energy Design Assistance program. The basic target for participants in Xcel Energy's program is to achieve

5% better performance than code, while enhanced targets are for savings 30% better than code. Available services and incentives vary accordingly. Targeting smaller incremental savings is a strategy to increase the total number of projects affected since fewer owners are likely to be interested and willing to seek higher incremental savings.

While building codes are increasing the baseline performance expected to be achieved by new construction, the savings targets of commercial design assistance programs do not appear to be declining. By maintaining high targets, building designers will need to capture additional energy savings opportunities beyond even the best codes such as California's Title 24 and the ASHRAE Standard 90.1-2010. For example, ASHRAE is seeking 20% additional savings in its 2013 standard relative to 2010, and the 2010 standard reduces energy use about 25% relative to the 2004 standard. Based on these opportunities, many programs still seek the same level of savings above code, generally 25-30% lower energy use. This is stretching design teams but numerous examples illustrate that such levels of savings are possible.

Savings Potential

Commercial Retrofit	Electricity	Natural	Notes
	TWh	TBtu	
National energy use affected	112	251	For 2030 from AEO 2012; new commercial space estimated at 7% of total space (built since 2013).
Average percent savings	50%	50%	Savings possible from best practices
Ultimate net participation rate	75%	75%	
Potential long-term savings	42	94	

Examples

Savings By Design: California utilities

Savings By Design is a statewide program implemented by the four largest investor-owned utilities in California: Pacific Gas & Electric, Southern California Edison, San Diego Gas & Electric, and Southern California Gas Company. The program is about ten years old and is included in the utilities' next three-year program plans (2013-2015). Savings By Design offers up-front design assistance supported by financial incentives based on project performance. Participants receive services, including design assistance, owner incentives, design team incentives, and energy design resources. Design assistance ranges from simple plan review and efficiency upgrade recommendations to complete computer simulation analysis comparing a number of alternative systems and integrated building design options.

Savings By Design targets the primary decision-makers in new construction and renovation/remodel projects: building owners, developers, architects, engineers, designers, contractors, builders, and energy consultants. Savings By Design analyses provide detailed technical and financial assistance data that allows owners and design teams to make informed decisions regarding energy efficiency features. The program serves commercial, industrial, and agricultural customers and utilizes the 2012 California Building Energy Efficiency Standards (Title 24, Part 6) as a reference baseline for comparison.

Two performance-based design approaches, the Whole Building Approach and the Systems Approach, are available to identify and quantify energy-efficient design improvements. Design assistance and consulting is offered at no charge to the owner or the design team. The level of assistance provided for a project varies based on the program approach—Whole Building or Systems. Assistance may be as simple as providing plan review and recommendations or may be as involved as full energy modeling with financial analysis on multiple options for energy-efficient systems.

Incentives vary according to which approach is used. Systems approach incentives are calculated using a flat incentive rate ($/kW, $/therm). The incentive for the whole building approach is based on time-dependent valuation (TDV)[76] annual energy savings, which is calculated by a modeling tool to determine the percentage better energy performance than Title 24 energy codes. For projects falling between 10% and 30% better than Title 24, the kWh incentive rate is on a sliding scale.

For the program period 2006-2008, Savings by Design, had a total of 712 participating projects for the four investor-owned utilities implementing the program. Total electricity savings were 118,920 MWh and natural gas savings were 4.3 million therms.

This program also benefits other activities related to achieving high efficiency, low energy new buildings. The California utilities work to integrate their new construction and code development efforts. Measures and design elements that are popular in new construction programs are targeted for integration into code updates. Experience from new construction programs helps build understanding and market share of new approaches that can eventually be worked into codes.

Efficiency Vermont: New Construction and Major Renovation Program
National Grid: Advanced Buildings Program

Efficiency Vermont and National Grid are two of several organizations that offer new construction design assistance programs build around the Core Performance® platform created by the New Buildings Institute (NBI). Core Performance® is a design guide that addresses over 30 criteria for

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[76] "Time dependent valuation" is a methodology to determine criteria that consider cost variations related to seasonal and time of use energy consumption. TDV criteria place a higher value on energy savings during the high cost times of the day and year. The use of this methodology in building standards encourages the design and construction of buildings that reduce the peak demands on the energy system.

defining high performance, low energy buildings, including building envelope, lighting, HVAC, power systems and controls. The package of measures, when applied in an integrated process, can yield buildings that are up to 30% more energy-efficient than those built to minimum codes. Building Core Performance® is a national design platform designed for individual application by utility and other customer programs across the nation. About 15 utilities and related organizations have collaborated with NBI to develop Core Performance ®, which is updated periodically to reflect changes in codes and markets. The latest version being developed will reflect the 2012 International Energy Conservation Code as the baseline.

National Grid's Advanced Buildings program offers extensive training and support materials covering the best practices centered on cost effective, off-the-shelf, building technology. National Grid offers significant financial incentives for Advanced Buildings customers that offset added capital costs of advanced materials and equipment. The program targets commercial buildings that are from 20,000 square feet to 100,000 square feet or larger. National Grid offers a base incentive of $1.50 per square foot for electric measures.

Efficiency Vermont's New Construction and Major Renovation Program offers building owners and design teams technical support and financial incentives to meet the needs of all types of commercial projects. Participants can choose from standard rebates on efficient equipment, Advanced Buildings Core Performance® incentives or custom incentives. The program offers "Standard Rebates" for small (under 10,000 square feet) projects for qualifying energy-efficient equipment, including lighting, refrigeration, compressed air, and HVAC. Core Performance® incentives are available for larger projects (10,000–70,000 square feet) and are calculated by the square footage. An Efficiency Vermont energy consultant works with the project team to provide technical assistance. The objective is to achieve energy performance up to 30% better than would be achieved by building to the Vermont Energy Code. The base incentive is $0.50 per square foot, with an additional incentive of $0.10 per square foot for providing additional documentation of the design process and strategies. This yields typical incentive amounts from $15,000 to $25,000.

For projects 10,000 to 50,000 square feet, Efficiency Vermont also has streamlined its commercial new construction incentives to provide more information earlier in the design process and to develop incentive agreements based on a newly developed guide for interior lighting, lighting controls, exterior lighting, HVAC, and commercial refrigeration. For larger projects (greater than 50,000 square feet), Efficiency Vermont assigns an energy consultant who works with teams to develop a custom incentive package that addresses and incorporates the comprehensive measures common to larger scale or more complex projects.

Xcel's Design Assistance Program—Colorado

Xcel's Energy Design Assistance (EDA) program is a free, comprehensive energy and cost savings program for natural gas and/or electricity business customers who are considering new construction or major renovation projects. The program provides free consulting and incentives to owners and design teams for making buildings more energy efficient. The Energy Design Assistance program includes a Basic track and an Enhanced track.

The program offers:

- Energy consulting services and predictive energy modeling free to participants.
- Help toward a green building certification. Green building certification support, such as the Leadership in Energy and Environmental Design (LEED®) and Energy & Atmosphere, credit one point for projects registered with the U.S. Green Building Council and participating in EDA Enhanced.
- Early analyses in areas such as massing, daylighting, lighting and HVAC.
- Construction rebates for whole building energy opportunities, including envelope measures, lighting, controls and cooling, heat recovery and solar water heating.
- Energy measurement and verification, including construction document review, onsite walk-through and data logging.
- Design team reimbursement for participating in the EDA program. Incentives are based on the time spent gathering efficiency details and cost documentation, as well as participating in the EDA meetings.
- One-time rebate provided to the building owner at the end of construction verification.

The EDA Basic program track offers computer modeling results for energy efficiency strategies as selected by the owner and design team, review of the construction documents, site verification and monitoring of select installed strategies. Projects must be a minimum of 50,000 square feet and must enroll in the program in the schematic or early design development stages of construction or renovation. The energy savings requirement of the EDA Basic program is a minimum of 15% electric energy demand savings and 15% natural gas energy demand savings compared to ASHRAE 90.1-2007 Energy Standard or the local energy code. The EDA Basic program offers rebates of $400 per kW and $0.04 per kWh. $4 per Dth is also offered for Xcel Energy natural gas customers.

The EDA Enhanced program track starts earlier in the construction/renovation process than the Basic EDA program. Participants must enroll in the program in the pre-design or early schematic design stages of construction or renovation. As with the EDA Basic program, projects must be a minimum of 50,000 square feet. The EDA Enhanced program is for projects with at least 30% electric and 15% natural gas savings goals compared to the ASHRAE 90.1-2007 Energy Standard or the local energy code and achieving a third party verified green building certification, such as LEED. The EDA Enhanced program offers rebates of $400 per kW and $0.04 per kWh. $4 per Dth is also offered for Xcel Energy natural gas customers.

Recommendations

Designing and constructing buildings that are highly energy-efficient will continue to be a critical objective for utility-sector energy efficiency programs. Such programs push the envelope of building design to achieve the highest performing buildings beyond code. These buildings "lock in" long-term energy savings and also help to avoid "lost opportunities," as it is generally much less expensive to design a new building to be as efficient as possible than to have to retrofit the building later. Such programs can be very cost effective. Evaluation of a multi-state design assistance program in the Pacific Northwest, the Integrated Design Lab Network, over a ten-year period yielded a cost of saved energy of $0.0092/kWh (about 1/10 of retail electricity costs in the Northwest) using the most conservative valuation method. (Van Den Wymelenberg et al. 20120).[77]

The program approaches that have been used in these programs appear to be working well, although participation rates generally are low. The economic slow-down of the past few years has further reduced participation.

The basic approaches used by design assistance programs appear to be effective. While there are no major breakthroughs on the horizon to alter these approaches significantly, it appears they continue to evolve incrementally to provide better performance and improve the communications and interactions with participants.

The greatest need for next generation programs of this type is to reach much greater numbers and types of projects. New modeling tools and approaches are being developed and used to gain participation from owners and design teams involved in smaller, more standard building projects. These efforts appear promising and should be effective in expanding markets for high performance, low energy buildings. While design assistance programs clearly can continue to push the leading edge of building energy design to achieve high efficiency, support for the development of more stringent building energy codes is another promising area that has the impact of raising the entire baseline level of energy performance. Experience also shows that boosting compliance with such codes can yield significant savings. Consequently, program administrators are working with regulatory authorities to develop approaches to increase code compliance and credit programs involved with such efforts with corresponding energy savings. We recommend that this type of code development and support be continued and expanded. It clearly provides large savings opportunities. It does present rather unique program attribution and evaluation challenges, but the rewards in terms of market impacts and energy savings are large.

Another market development in some areas and building types is greater reliance on single design/build firms instead of using separate architect/engineering firms for building design and separate contractors for construction. This is being driven by efforts to achieve lower new building costs. Programs may need to develop and adapt marketing and services to reach and affect these new design/build firms.

Finally, it is clear that the market for green buildings is growing rapidly, independent of design assistance programs. This is a positive sign for programs, as it signals increased interest in high performance, energy-efficient buildings. Making energy efficiency visible and valued in buildings markets is important. We recommend enactment of energy disclosure requirements for commercial

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[77] Using the recommended analysis and assumptions yielded a much lower cost estimate; the range given is $0.0016 to 0.003 per kWh.

buildings so that owners and tenants can readily compare the energy performance of different buildings.

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SMALL BUSINESS

Synopsis

An overview of existing programs and emerging trends reveals that the best small business programs are slowly but steadily penetrating the small business market and achieving significant cost-effective savings. However, the vast bulk of savings have been in lighting, and these savings will decline as minimum efficiency standards and building codes improve the efficiency of baseline lighting systems. There is a need to add other measures to small business programs. Programs may be able to increase overall program savings by going "broad" and building the number of participating small commercial and industrial business. To do this will mean relaxing current budget constraints on these programs, offering generous financial incentives and free installation with easy loan financing for the remainder. To remain cost-effective, integrating demand response with efficiency for lower administrative cost per kWh saved, targeting marketing and outreach effectively, and optimizing financing terms are three possible strategies. Other enhancements that should be considered include enhanced marketing and outreach, with a customer-centered, local community-based strategy, and integrating demand response programs with small business efficiency programs.

Background

Many current and traditional small business programs rely on lighting measures for most if not all of their energy savings. Programs define eligible businesses by average electric demand use, usually with a threshold of 100 or 200 kW per month. Nonresidential customers under 500 kW of average demand are more likely to be classified as "small and medium-sized" businesses. This profile focuses on small business programs only.

Small business programs are often "direct install" programs, which keeps it simple and easy for the small business owner. "Direct install" means that contractors qualified and selected by the program do the energy audit and equipment installation, while the customers simply have to enroll in the program and approve specific measures. Typical measures installed in small business programs today include linear fluorescents, screw-in lighted electronic diode (LED) lamps and ballasts, LED display case lighting and open/closed signs, window film[78], occupancy sensors, and vending misers[79]. Historically, small business program participation rates have been modest, as many programs are budget constrained and have sought to gradually penetrate the small building stock at the rate of a few thousand customers per year.

Drivers for Change

As energy efficiency portfolio managers and program planners increasingly look for new sources of potential energy savings, the small business sector may hold significant resource acquisition opportunities for the future. There is a large and relatively untapped potential for energy savings available in the small business sector. Historically, small business programs have not been among the biggest contributors to energy efficiency program portfolio total savings. This is due at least in part to small businesses' status as "hard to reach" utility customers. Single-site, single facility enterprises are among the least cost-effective for programs to work with, as the administrative and marketing cost per unit of energy saved is higher. Most small businesses do not have building managers or operators to address energy use in their buildings, and owners are sometimes not available. Small businesses overall are less cost-effective than other energy efficiency opportunities, and program administrators would need to increase program budgets to maximize savings from the sector. It is also the case that smaller commercial buildings are more energy-intensive than larger buildings, using more electricity per square foot and more natural gas per square foot.

There are two primary external drivers of change for small business programs. First is the continuation and proliferation of energy efficiency resource standards (EERSs). In many of the states with the most extensive utility-sector energy efficiency programs, EERS have been in place for multiple years, and much of the low-hanging fruit has been harvested. A second force at work driving change is higher efficiency standards, such as those promulgated by the US Department of Energy, and those resulting from the Energy Independence and Security Act of 2007 (EISA). New, higher standards move commercial lighting programs–historically the largest contributor of inexpensive

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[78] Window film is a transparent film that adheres directly to the glass surface of windows and that saves energy by reducing solar heat gain in summer and retaining heat indoors during cold winter days.

[79] Vending misers are energy-saving control systems that shut off the refrigeration on soft drink machines when beverages do not need to be kept as cold, usually nights and weekends. They are not timers, but rather contain a combination of infrared sensors and temperature sensors that detect if anyone is within a set distance from the machine.

savings toward portfolio results–in the direction of being less cost-effective than they used to be. This is because only energy savings beyond the standard will count, and that number will be smaller because the baseline is higher. Small business programs which, in the past, relied on replacing T12 linear fluorescent lamps with standard ballast T8 lamps to provide most of their savings will not be able to do that anymore. Due to the higher national efficiency standards, utilities will not get the full savings attributed to them for T12 replacements even for program participants. Despite the fact that some businesses may stockpile T12s, or switch to compliant T12s, but these activities will not affect the overall impact on program administrator savings.

To tap into the savings potential of the small business sector, there are opportunities for "deeper" savings per business, greater percentage reductions in monthly energy use for each program participant, as well as "broader" savings from increases in the number of program participants.

Emerging Trends and Recommendations

The emerging trend for the next generation of small business programs will be to unlock more of the energy savings opportunities in the sector, not primarily through new technologies that save more energy per unit, but by enhanced marketing combined with financing and generous incentives to increase the number of program participants and through installing more measures per small business. Small business owners, perhaps more than other utility customers in different market segments, need to be actively "sold to" before they will buy into energy efficiency, or in some cases, even accept installation of efficient equipment for free. Among the end uses targeted for additional measures are refrigeration, which comprises a large share of small business energy use, and miscellaneous plug loads, particularly in small offices, where there are many low-cost and no-cost opportunities for energy savings.

Program Design

The small business sector comes with built-in barriers to achieving energy efficiency savings via utility-sector programs: the businesses are small, diverse, and short on time and capital. The barriers also tend to reinforce each other, so that overcoming one or two for a given customer or type of customer may not close the deal to result in a new program participant yielding cost-effective savings to the program.

Barriers include:

- Size---Small energy savings opportunities per location increases the administrative cost per unit of energy saved. This is compounded by the "siloed" nature of demand side management, which occurs through programs, regulation, and trade allies, each segmented by mass distribution of individual products and with efficiency program activities separated from demand response activities. This dynamic does not optimize energy savings per dollar of program delivery expense, and it means more time and effort on the part of the customer to access multiple services.
- Time/money constraints—Businesses require short payback times achieved with minimal time commitment from the business owners, who are busy running their operations. Also,

from the program administrator perspective, small business programs are not as cost-effective as most other energy efficiency programs; as a result, many small business programs are budget constrained.

- Diversity—There is a wide variety of industry subsectors and types of businesses. Diverse in energy uses, savings opportunities, financial needs, languages spoken, and culture, the small business sector represents a unique set of challenges for program management and design.
- Lack of awareness—The diversity of businesses makes it difficult to develop familiarity with the programs, understanding of what they are for, and how they work. Consequently, trust of the utility-sector programs is low. Many small business owners are not aware of the benefits of energy efficiency or lack sufficient knowledge of program benefits.

The utility-sector energy efficiency programs that successfully address each of these, and then design program services, marketing and financial incentives to get past these roadblocks, win increased energy savings.

Strategies for Cost-Effectiveness

As a result of the small size barrier, administrative overhead costs are high. The problem is, almost without exception, utility-sector energy efficiency programs must meet cost-effectiveness tests ordered by state regulators or required by state statute. Next generation small business programs will be designed to reduce administrative and marketing costs per unit of energy saved and demand reduced with comprehensive integrated approaches. Some strategies for making the programs efficient include:

1. Specialized software and data analytics. Leading programs use customer relationship management (CRM) software combined with their internal data for market segmentation, profiling, and modeling. This enables them to target communications and outreach to the best candidates for participation, and to match measures and incentives with different types of businesses.
2. Integrated demand-side management (IDSM). Most significantly in California, where the California Public Utilities Commission (CPUC) has directed the investor-owned utilities to do so, small business programs will be integrating energy efficiency with demand response at the program level.
3. Comprehensive approach. Incentivizing installation of multiple measures, such as refrigeration, HVAC, and insulation in addition to lighting, yields deeper savings per customer. Adding an additional "bonus" rebate or cash-back reward to installing measures for multiple end-uses can leverage deeper savings per program participant.

Making a Compelling Business Case, While Remaining Cost-effective

To attract those program participants in the first place, utilities and other program administrators have invested heavily in generous incentives and loan financing. Sometimes trade allies can be involved in providing the financing. Historically many small business energy efficiency programs, particularly direct install programs, have provided many if not all services for free: free energy audits or lighting consultations, free products and equipment, and free installation. Leading programs combine free and very low-cost options with low- or even zero-interest rate financing. To make the selling proposition even better, many offer on-bill financing. Combining these elements together in a package often results in an offering to the small business owner where they are getting new, high-efficiency products and equipment with neutral, or even positive, impacts on their cash flow. For types of businesses where cash flow management is critical to their success such as retail stores, this can be compelling.

Key to the cost-effectiveness of next generation small business programs is to spend enough—in incentives and interest subsidies—for the customer to meet their financial requirements for payback times and cash flow, but not so much that projects fail to remain cost-effective. Highly cost-effective lighting measures have been the foundation of small business programs, and while lighting savings opportunities will remain for many years to come, much of the cheapest savings will be captured in coming years by new federal minimum efficiency standards and remaining lighting measures will often be more expensive (this issue is discussed extensively in the Commercial Lighting section of this report). Adjusting how much the customer pays can change this equation. Designing flexible loan terms and interest rates for the bundle of installed measures, so that the loan term is long enough for the business customer to have neutral cash-flow impacts, but otherwise as short as possible, is another feature available for best practice program design.

Expanding the number of measures included for deeper savings per participant can spread the administrative costs for each business over more energy savings. Beyond lighting, two opportunity areas are refrigeration, which uses a large portion of the energy in many small businesses including restaurants, food service, and grocery stores, and plug loads and miscellaneous end-uses in small offices. Market segmentation has been used to identify additional measures specific to industry niches, such as variable speed drive pumps and motors for car washes.

Going to Where They Are: Customer-Focused Marketing and Outreach Key to Higher "Take Rates"

Integrated comprehensive program design and delivery, even combined with a great financial case, may not be sufficient if small business decision makers are not aware of the program and its benefits to them, or if they lack confidence and trust in the program. The established programs that have continued to increase program participation, and to raise "take rates"[80], are those that increased their outreach, used multiple marketing communications channels, and most important, geared their marketing to the unique perspectives of each business owner. They explicitly take a sales approach and customize how the message is delivered to the small business owner's industry sector,

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[80] "Take rate" refers here to the percentage of those small businesses receiving an energy audit that become program participants with energy efficiency measures installed.

community, culture, and even the owner's neighborhood. Partnering an energy advisor with a trade ally while performing energy assessments can help build trust and participation.

Some outreach and marketing strategies program managers have found success with include:

1. Hiring auditors primarily based on sales ability, even above outstanding technical skills.
2. Partnering with community-based organizations to offer job training, which offers the additional benefit of hiring a diverse workforce that is a match for community small businesses in language, culture, and ethnicity.
3. Developing and maintaining an extensive network of qualified, local vendors and contractors. Trade allies play a vital role in managing community strategy, and they provide additional community intelligence to assist with business district targeting.
4. Conducting door-to-door outreach, neighborhood by neighborhood, and getting in communication with businesses in advance of when energy service representatives visit, further builds awareness and trust.
5. Providing educational seminars in multiple languages in conjunction with local non-profit organizations, including local business associations and faith-based groups, about energy efficiency and the programs offered.

Savings Potential

The combination of all of the above areas can achieve and sustain greater total savings over time. Managers of leading programs and their implementation contractors estimate that current electric energy savings range from 7 to 15%, which is lower than in the past when there was more low-hanging fruit available. As more utilities across the country implement small business energy efficiency programs in "virgin territory", and as established programs incentivize multiple measures and go beyond lighting, we estimate that average savings will be at the high end of this range. Through improved target marketing and customer-centered outreach, we believe that participation rates of 3% per year or more can be maintained. Experience in the 1980s with geographically-focused programs indicated that ultimately cumulative participation rates of 60% or more can be obtained. (Nadel, Pye & Jordan 1994).

Small Business Programs	Electricity	Notes
	TWh	
National energy use affected	154	AEO 2012 reference case 2030, selected energy uses of all commercial space use 2.63 quadrillion Btus. Buildings from 1,000 to 10,000 s.f. are targeted for the program.
Average percent savings	12%	Electric savings estimated by program managers
Ultimate net participation rate	60%	Estimate approx. 3% participation rate per year
Potential long-term savings	12	Estimated annual savings in the year 2030.

Notes: selected energy uses are electric: lighting, cooking, AC, refrigeration, office equipment; CBECS estimates buildings of this size constitute 20% of commercial floor space for electricity usage. Assumes average electric energy intensity per sf.

Examples

Three leading examples of next generation small business programs are all well-established programs that have been refined and evolved to include the designs and strategies we recommend.

Connecticut Small Business Energy Advantage (SBEA)

Originally created over 10 years ago, the SBEA program is funded by the Connecticut Energy Efficiency Fund (CEEF). SBEA is offered by the Connecticut investor-owned utilities, United Illuminating Company (UI), Connecticut Light and Power (CL&P), Connecticut Natural Gas and Southern Connecticut Gas. Three key financial program characteristics include financial bonuses for multiple measure types, 0% interest on-bill loan financing, and customizable loan terms. Most important, however, is the combination of those financial aspects with an entire marketing and communications structure designed to garner the trust of the diverse small business customer base and reach out to them. This includes training programs that create a pool of knowledgeable energy auditors who are a match for the varied industries and demographics of small businesses across the state.

UI, for example, has used SBEA to acquire both deeper savings per small business and broader participation. The UI SBEA program is designed and managed to incent small business owners to do comprehensive efficiency projects. Customers are given financial "bonus" incentives—beyond what they would be paid for a lighting-only project -- for accepting and implementing project proposals comprised of multiple energy saving measures. While lighting remains the source of most of the savings, UI also includes adding controls, refrigeration, compressors, and HVAC roof top units in the program. No single end-use category may account for more than 85% of estimated project energy savings. Savings of up to 40% of gross energy use become possible with this approach. For even deeper energy savings per project, in 2012 UI added natural gas savings measures to the SBEA program.

By bundling relatively less cost-effective measures such as new compressors or modifying existing roof top HVAC units, which might have a simple payback period of eight years, with lighting measures that pay back in less than two years, the project as a whole becomes cost effective, with a total resource cost test (TRC) above 1.0, the minimum allowed. What is most exciting about the program design, however, is that the "blended" simple payback drops below 48 months. The loan term may then be adjusted so that the small business saves more on their monthly utility bill than the amount of the monthly loan payment so the energy savings is totally free and no money down. When the load is paid off, the energy savings represent pure positive cash flow for the business. With a longer loan term, and corresponding lower monthly payments, a comprehensive EE project is providing a positive cash flow from Day 1. This is very attractive to small business owners and has resulted in a participation rate above 40% of those getting energy audits.

To increase program participation, UI has been going to where the small business customers are and reaching out in ways that build trust in the program. The program has intentionally targeted underserved areas, such as economically distressed areas of the larger cities, including Empowerment Zones; worked with the Spanish American Merchants Association; been to job fairs with the Veterans Association and the Department of Labor; and has coordinated with the community college network.

Less direct, but potentially more impactful overall, UI has collaborated with the Step Up program, which subsidizes the salaries of candidates who complete the small business energy auditor training program for the first six months of employment. Subsidies begin at 100% and step down to 25%. The vendors get a well-trained new auditor and they are not bound to keep them on the payroll. Critical to the successful expansion of participation in the SBEA, the utility customers are now contacted by energy auditors that they perceive as more trustworthy, coming from a diversity of backgrounds and cultures often literally speaking their language.

http://www.ctenergyinfo.com/dpuc_small_business_energy_advantage.htm

http://www.uinet.com/wps/portal/uinet/business/!ut/p/c5/

National Grid Small Business Program

National Grid's Small Business Program was established 23 years ago. Turn-key programs at very low cost to the business owner have been the essential elements to the program's success. The program makes it easy for the small business owners who are resource-constrained in terms of time and money. They offer generous financial incentives of 70% of project cost, and 0% interest on-bill loan financing for the remaining 30% for a term of up to 24 months. Most of the savings, approximately 90%, are the result of lighting measures. They are increasingly looking to refrigeration measures, as this represents a large part of small business energy use. Energy-efficient time clocks, photo cells for outdoor lighting, occupancy sensors, programmable thermostats and walk-in cooler measures are covered.

National Grid has structured its programs to involve many local vendors to be the contractors serving the small businesses across its utility service territory, and this approach tends to build local support for and acceptance of the program; relying on a single vendor may lead to resistance. National Grid has also coordinated efforts with natural gas utilities.

Energy savings per program participant overall is in the range of 7% to 15%. When new territory with many previously underserved small businesses is reached by the National Grid Small Business Program, savings are on the high end of the range. Attribution is favorable for small business programs because participants would not install high-efficiency equipment and products without program financial incentives, audits, and loans. Net-to-gross ratios can be above 0.95.

http://www.nationalgridus.com/masselectric/business/energyeff/3_small.asp

Southern California Edison Direct Install Program

One of the largest utilities in the nation, with well-established and extensive energy efficiency programs, Southern California Edison (SCE) has been running small business programs for many years. SCE faces two of the main barriers to achieving high savings via their small business program. The first is size, with more than half of the 282,000 small business customers being very small, below 20 kW of peak demand. Second, savings are almost all from lighting efficiency measures. Approximately 90% of program savings comes from linear fluorescents, 95% from lighting overall, and program managers do not anticipate this changing in the next two years.

SCE exemplifies the approach of going "broader" rather than deeper to obtain more energy savings. SCE identified that two major barriers were low awareness of the program and the benefits of energy efficiency and lack of trust in the program and the utility. 2009 program evaluators observed that customer program participation had growth potential. In response, in the last couple of years, SCE started to do heavy outreach to small businesses below 100 kW. Outreach included mailers, media events, account representatives going door-to-door systematically in a geo-targeted approach, seminar presentations to Chambers of Commerce and other Community-Based Organizations (CBOs), such as Korean Grocers Associations, and outreach to more ethnic groups in various languages to break through the cultural and language barriers to having the program be widely available.

Important to program success is that it generates not only energy savings, but also jobs. The CBOs and faith groups work closely with the small business direct install program to create community partnerships that result in employment in the communities where they operate, through the Green Job Skills Training component of the program. In a pilot initiative of the increased outreach and communication effort, the take rate increased from 36% to more than 55%. More than 10,000 customers participated, saving 45 GWh and reducing demand 9.6 MW. Later, the program was able to double the take rate compared to the historical rate. It also created over 30 skilled job positions in installation, energy auditing, and clerical areas.

Possibly beginning in late 2012, SCE will be moving in the direction of delivering its energy efficiency program combined with demand response, enabling the program to offer the small business more options in managing energy use and cost.

http://www.sce.com/b-rs/small-medium/direct-install/direct-install.htm?from=directinstall

Recommendations

To obtain higher energy savings from small business programs, we recommend that small business programs organize themselves to overcome the barriers described above. Each must be addressed in administrative structure, program services and delivery, and marketing—but marketing is the crucial piece for high participation.

Size/expense Barrier

In order to develop a small business program that acquires the maximum energy savings per dollar of incentives and administration expense, we recommend adapting three strategic approaches to the unique context of the program administrator:

1. Targeting potential participants using internal data from customer relationship management (CRM) software to identify those participants with the greatest potential for cost-effective savings;
2. Integrating demand response programs with energy efficiency programs to break down the "silos" between programs and eliminate redundancies; and
3. Incentivizing the installation of multiple measures, in multiple end use areas (not just lighting), to avoid "cream skimming" and prevent the creation of "lost opportunities" for savings.

Time/money Constraints Barrier

Programs should continue to offer generous incentives, attractive loan financing, and turn-key, direct-install programs that make it easy and profitable for small business owners to participate. To maintain cost-effectiveness, we recommend including some co-pays from business owners and minimizing loan terms within the constraint of cash-flow neutrality.

Diversity/Lack of Awareness

The third, and critical, element of next generation small business programs needed to achieve and sustain high energy savings is extensive marketing and outreach centered on the business owner. We recommend what has worked for leading programs profiled in examples above:

- take an explicitly sales-oriented approach,
- target sales to the industry, culture, and language of each small business,
- use multiple communication channels,
- hire auditors and contractors from the local community, and
- collaborate with community-based organizations to build trust.

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Industrial, Agriculture, CHP, and Distribution Systems Program Profiles

Industrial: Custom, Strategic Energy Management and Market Channels

Synopsis

The majority of industrial-sector energy efficiency opportunities exist in improvements and optimization of *processes*, which is where the majority of the energy is used. The predominant industrial program strategy, however, has been to offer prescriptive rebates for energy-efficient equipment such has motors, HVAC and lighting. Prescriptive improvements do not realize the system opportunities that would be achieved through improvements in facility-wide processes, performance, operations, or behavior-based changes. Another past challenge is that programs have been incorporated into overall commercial & industrial (C&I) portfolios, which tends to overlook the unique need of individual industrial customers. Next generation industrial energy efficiency programs must evolve beyond equipment replacement programs toward whole-system and customized approaches, while also taking into consideration the size of the customers.

There are several broad categories of program approaches to consider. First, custom programs offer targeted support, generally for larger customers, through both financial incentives and engineering expertise tailored to specific industrial processes. Second, Strategic Energy Management (SEM) programs are a major new program trend that focuses on integrating energy management practices into a company's culture, standard operating procedures, and profitability. Only a handful of program administrators have yet to explore the savings potential from SEM, so these customers represent another promising target for savings. Third, an important approach to working with small and medium enterprises/businesses (SME) is to work with them through market channels such as regional trade associations or supplier networks for larger companies. All of these strategies offer significant new energy savings opportunities for next generation energy efficiency programs.

Background

The industrial sector accounts for approximately 31% of total U.S. energy consumption (EIA 2011). Untapped energy savings in this sector remain large for both electricity and natural gas, and some estimates suggest there is approximately 14-22% of cost-effective savings available in this sector by 2020 (National Academy of Sciences 2010). The industrial sector also offers some of the most cost-effective energy efficiency opportunities. As energy savings targets increase and more stringent equipment standards are enacted, energy efficiency program managers are increasingly interested in expanding their industrial energy efficiency opportunities. The industrial sector generally comprises four subsectors: manufacturing, mining, construction, and agriculture. Some program administrators, such as NYSERDA, also address data center and information technology infrastructure through industrial programs. For the purposes of this report, the industrial sector is largely composed of manufacturing facilities, and some mining in certain areas. The agricultural subsector is discussed separately in this report. Due to the transient nature of construction, it is a difficult subsector to target, and we are unaware of applicable successful program models.

Efficiency program administrators are not the only stakeholders interested in expanding industrial-sector energy efficiency. Industrial companies in the U.S. are facing dramatic changes in production costs, global competition, regulation and consolidation. These changes are creating pressure on companies to reduce costs and risks through better management of resources, including energy. In addition, outsourced industrial activity has begun to return to the US, meaning that substantial investments in capacity are likely to be made in coming years to support expanding production. Improving energy efficiency can reduce facilities' long-term costs; increase productivity, quality, and profit margins; and thereby increase competitiveness.

Barriers

There are a number of barriers to securing the participation of industrial customers in energy efficiency programs. These barriers must be addressed prior to approaching industrial customers with program options:

1. One program will not fit all customers. Industrial operations vary widely by size, product, process, annual budget, equipment replacement cycles, staff technical sophistication, etc.

2. Although most industries would like to reduce energy waste, it is not their primary focus and they choose to put their time and effort into their primary business product. Those making decisions about capital investments are often not familiar with energy efficiency opportunities and their cost-effectiveness.

3. Industrial customers are often charged lower energy rates compared to other sectors, which makes energy efficiency seem a less attractive investment. Often, however, the industrial sector offers some of the most cost-effective energy efficiency opportunities.

4. Some larger industries have on-site experts who feel that they already invest in all necessary and cost-effective energy efficiency opportunities.

5. Many industrial customers are sensitive to sharing information they feel is proprietary, making it difficult to ascertain the distinct opportunities available in certain facilities.

These barriers present substantial challenges to emphasizing the benefits of energy efficiency to a company. Companies will often respond well to innovative outreach approaches, such as leveraging the relationships of an existing trade association. Because of the heterogeneous nature of industry, programs must be flexible in order to be customized to individual industry types.

Historically, utilities and other program administrators have offered industrial customers prescriptive equipment replacement programs, as well as some custom programs. Prescriptive programs typically offer a predefined rebate amount for predefined products like energy-efficient lighting, motors and variable speed drives. Equipment replacement programs can play a role in improving overall processes through the use of more efficient compressed air systems, motors, pump and aeration technologies, and even snow-making machines. But prescriptive approaches alone miss the largest potential for savings, which is the use of a system-based approach. Custom energy efficiency programs, on the other hand, offer targeted technical expertise and rebates for more complex energy efficiency improvements tailored to a specific industrial process or site. Because the energy use required for industrial processes can far exceed the energy use and demand associated with building and lighting systems, industrial processes offer great savings opportunities.

Drivers for Change

A number of issues are driving evolution in industrial energy efficiency process and operations programs.

"Reshoring" of Manufacturing

The last few years have seen a return of manufacturing to the United States, as our country has again become a low-cost manufacturing country due to cheap energy and world-leading productivity. The Boston Consulting Group has coined the word "reshoring" to reflect this market phenomenon (Boston Consulting Group 2012). This return of manufacturing will require significant investments in capacity to meet the expanding domestic and export demand. This new investment presents an opportunity to lock in energy efficiency for the future.

Advances in Metering and Control Technologies

Significant energy efficiency gains depend less on devices and more on how we use the things and services we demand (Trombley et al. 2012). Metering, monitoring and control have been demonstrated to be key elements of improving industrial process efficiency (Shipley and Elliott 2006). Reduced sensor and control costs, combined with the emergence of viable wireless communications technologies are making collection of data from multiple points feasible, allowing sub-metering of processes and even individual pieces of equipment.

The ability to collect large volumes of data have made understanding the details of processes and the ability to run near-real-time simulations of critical processes possible, allowing these processes to be better optimized.

"Intelligent efficiency" is a "systems-based, holistic approach to energy savings, enabled by information and communication technologies (ICT), and user access to real-time information." Smart sensing and control technology help companies understand how the complex systems in a plant interact and provide real-time information about what the systems are doing at any given moment. An example of "intelligent efficiency" in the industrial sector is provided below. But with increased focus on practices and behavior rather than devices, this also raises questions of how to account for savings, as discussed below.

Continuous Improvement Movement

Principals of continuous improvement have dominated the industrial sector for the past three decades, with focuses on product quality, pollution prevention and safety being internalized in the corporate culture. Concepts such as *lean*, *quality circles*, *six sigma* and *kaizen*[81] have become part of the language of business, providing a foundation for the impressive productivity improvements seen over the past decades. These principles have been formalized in the International Organization for Standardization (ISO) 9000 quality and 14000 environmental standards. The ISO's more recent 50001 standard (discussed below) goes further, establishing guidelines for the development and implementation of an energy management system. Concurrently with the development of ISO 50001, several utilities and organizations have expanded their programs designed to encourage more robust energy management in targeted facilities. These programs go by many names, but are most frequently called continuous energy improvement or strategic energy management.

ISO-50001 Standards for Energy Management

In July 2011 the ISO released their final standard for energy management, called ISO-50001. The goal is to provide organizations with a systematic approach for managing energy use based on a data-driven approach to measurement, planning, operational control evaluation, and management review processes. As a data-driven *Strategic Energy Management* (SEM) certification process, ISO-50001 is "intended to provide organizations with a recognized framework for integrating energy performance into their management practices" (ISO 2011). The standard requires an energy planning process to be initiated by top management, which will drive data collection and analysis of energy usage and a demonstration of continual improvement of energy performance.

The voluntary standard applies to any organization that uses energy, but will likely be primarily used by companies seeking an internationally recognized response for sustainability, energy cost or emissions reductions along the manufacturing supply chain, future or current carbon regulations, or increasing market value of "green manufacturing" (Goldstein et al. 2011). Improved efficiency of operations and processes may also motivate companies to adopt the standard. For industrial facilities, the goal is to introduce continual improvement of energy performance into their management

[81] *Lean*: or Lean Manufacturing is a term that refers to the practice of continuous improvement in which any activity that does not add value for the customer is considered waste and is targeted for elimination from the manufacturing process.
Quality Circles: groups of workers and supervisors that are trained to identify, analyze and solve work-related problems and then present solutions to management.
Six Sigma: A practice of continual improvement that uses quality management problem solving strategies and statistical analysis tools to improve the quality of products and services through identification and elimination of defects by minimizing the variability in manufacturing and business processes.
Kaizen: Japanese term for improvement, or change for the better. In contemporary continuous improvement programs, it can refer to the process of continuous improvement or an event in which improvements are made.

practices, such as by optimizing production processes and improving the efficiency of industrial systems and facilities.

Depending on the interest by industrial companies to comply with this new voluntary standard, this new tool has the potential to complement existing policy and program efforts by utilities, other program administrators, and state and federal governments.

For example, DOE's Office of Energy Efficient and Renewable Energy incorporated ISO-50001 into its *Superior Energy Performance* (SEP), which is a voluntary certification program that will be launched in Fall 2012. Industrial and commercial facilities can earn the certification by: (1) conforming to the ISO-50001 energy management standard; and by (2) demonstrating continual improvement in energy efficiency through achievement of specific energy performance targets (at least 5%) over a 3-year period[82]

Emerging Trends and Recommendations

Although energy efficiency improvements are continually being made to industrial technologies (superior motors, pumps, fans, variable speed drives, etc.), and equipment programs should continue to target these opportunities, next generation advancements in industrial energy efficiency are primarily focusing on industrial process and operations improvements, largely through custom program offerings, behavioral approaches through strategic energy management, and marketing channel strategies.

Equipment programs, which have primarily offered perspective incentives, have had to evolve in recent years as minimum efficiency standards and market changes have made older program designs less effective. In particular motor rebate programs have been made less attractive as motor standards have approached limits of currently available product (Elliott 2007). ACEEE has recently been involved with preliminary discussions with industry trade associations about developing labeling of motor driven equipment and *extended product*, which combines the motor with driven equipment such as fans and pumps, and with other components such as variable speed drives, sensors and controls. The labeling of efficient extended-products could represent an evolutionary direction for more prescriptive program approaches.

Custom Programs

For large customers, custom incentive programs are the standard for incenting energy efficiency projects. Obtaining both internal and external funding for energy efficiency investments remains a major barrier to implementation of these projects (Elliott, Shipley and McKenney 2008), something that became even more challenging during the economic downturn. The presence of an incentive or financing can provide additional support to move a project forward.

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[82]See http://www1.eere.energy.gov/manufacturing/tech_deployment/sep.html and http://www.superiorenergyperformance.net/MandV.html

In an ideal custom program, the customer works with the program staff to identify a project, analyze energy savings and estimate a project budget. The program administrator agrees to an incentive amount, often based on the projected energy savings and capped as a portion of eligible project costs. Many of them involve optimization of electric motor systems, including fan, pump or compressed air systems. These projects frequently make use of advanced sensors and controls to dynamically optimize the system to respond to variations in the needs of process that they serve (Laitner et al. 2012). This application of technology is sometimes referred to as "intelligent efficiency" or "smart manufacturing" (Elliott, Molina and Trombley 2012).

These custom programs have increased among more mature industrial program portfolios (Chittum, Elliott and Kaufman 2009). These programs can be responsive to very specific customer needs in ways that prescriptive programs cannot. As program portfolios mature and the programs familiarize themselves with their customers; further opportunities for customized approaches can appear. These more flexible services take several forms and seem to exist primarily in well-established and mature programs that possess an intimate understanding of their customer base. Nearly all established industrial programs have some form of custom industrial incentive program available to their customers.

Custom programs are generally the best way to reach the industrial sector and help industrial customers meet their most complex needs and achieve larger volumes of savings. These facility and process specific opportunities can however be a challenge because programs can have difficulty identifying industry specific expertise to meet customers' unique technical needs, as is seen in the National Grid example below. Building these networks can be an important role that a regional energy efficiency program can play, and the Electric Power Research Institute is a source of referrals for member utilities (Howe 2012).

Custom programs tend to be more program staff and resource intensive than are prescriptive programs, the savings can be very cost effective for the program portfolio. The levelized program administrator's cost for these customer program can frequently be well below 2.5 cents per kWh saved (Laitner et al. 2012). Because the acquisition costs for custom programs tend to be too high to offer to most SMEs , custom programs tend to be restricted to larger customers where there are large savings available to offset the program costs.

Industrial facilities can be in a variety of positions within their capital investment cycle so may not be ready to make a major investment for several years. These firms may also need a significant amount of time to approve the investment internally, which, added to the time a complicated capital investment takes just to plan, purchase, and install, can well exceed one year. As a result, the most advanced custom programs increasingly allow for longer timeframes between when a customer becomes eligible for a program and when the eligible project is actually completed. It is critical to send the correct market signals of long term program availability to develop trust between the program administrator and the industrial customer. Southern California Edison is one program that features a codified three-year funding cycle in its industrial program (Chittum, Elliott and Kaufman 2009).

Project savings from custom programs can be significant, often exceeding 20% (Laitner et al. 2012). In addition, these projects typically have significant non-energy benefits making them compelling to the manufacturing facility. These non-energy benefits include improved productivity and product quality, and reduced emissions and lost-work injuries. Investigations of the total benefits of implemented industrial energy efficiency project suggest the total benefits are three to five times direct energy savings (Elliott, Laitner & Pye 1997; Worrell et al. 2003; Lung et al. 2005).

Strategic Energy Management (SEM)

Next generation industrial trends in process and operations programs are anticipated to largely focus on strategic energy management (SEM) programs, which typically involve a review of how a company manages its energy use, engages executive-level leadership from the company, and suggests the implementation of (or improvements to) an energy management strategy. Strategic Energy Management (SEM) is a system of *practices* that create reliable and persistent energy savings and is currently demonstrating potential to add significant energy savings to industrial processes. Some overarching trends to improve SEM include: standardizing savings protocols/accounting; and leveraging information and data systems. Energy savings from SEM programs come from multiple sources: 1) direct behavior changes such as O&M improvements; 2) indirect savings from incremental increases in capital energy efficiency projects, e.g., improved lighting efficiency; 3) indirect savings from additional capital projects that would not have otherwise been pursued, e.g., process changes; and 4) improved persistence of energy savings due to better management. One of the challenges with SEM programs is the allocating of energy savings between SEM and other incentive programs utilized to offset the cost of implementation.

Only a handful of utilities and energy efficiency program administrators, including the Energy Trust of Oregon, NEEA, Bonneville Power Administration, BC Hydro, Ontario Power Authority, Enbridge Gas, ComEd/Exelon, the New York State Energy Research and Development Authority, Wisconsin's Focus on Energy and National Grid/NStar in Massachusetts, offer exemplary SEM programs. BC Hydro's program, for example, offers industrial customers SEM assistance through its Energy Manager for BC Manufacturers and Energy Manager for BC Food Processors programs. BC Hydro's customers register for these programs through the BC manufacturing and food processing associations. After they register, they are assigned an energy manager who works with them to create a customized Sustainable Energy Management Plan (SEMP) for their company. After outlining practical recommendations for saving energy, the energy manager assists with project implementation and helps them apply for incentives from BC Hydro's Power Smart program.

Market Channels

The transaction cost of custom program approaches makes them impractical for individual small and medium enterprise/business(SME) customers. To address this sector requires approaches that allow the program to work with multiple facilities together. Two approaches have shown success: working with regional trade associations to leverage their existing member relationships to deliver energy efficiency offerings; and working with large manufacturers to work with their suppliers to adopt energy efficiency measures.

The Northwest Industrial Alliance provides an example of working with a regional trade association. To form this alliance, NEEA partnered with the Northwest Food Processors Association (NWFPA) to develop a comprehensive energy efficiency program that was delivered to NWFPA members. The program offering included awareness, education and training, and research targeted at addressing energy efficiency challenges facing food processors in the region. This collaboration lead to the development in 2011 of a Members Roadmap to guide efforts at member plants and an Association Roadmap to guide member and staff activities at the association level (NWFPA 2011). Wisconsin Focus on Energy has used similar approaches to work with water and wastewater treatment plant operators and dairy and food processors (Shipley, Elliott and Kaufman 2009).

Many years ago, automobile manufacturers realized that the majority of energy use embedded in a car was input by suppliers and that these firms, predominately SMBs, were far less energy efficient than the large companies. These automakers have worked with energy efficiency programs to jointly develop and deliver energy efficiency to their supply network. This approach has been successfully used by DTE Energy for many years in conjunction with its automotive customers (Elliott et al. 1996). Similarly, the federal government's *ENERGY STAR for Industry*[83] program and the *Green Suppliers Network*[84] work to encourage internal energy managers to look beyond their own facilities to those of the rest of the firm, supplier companies, and even customer companies. These kinds of supply chain-wide efficiency efforts are in line with other types of non-energy partnerships entered into by industrial firms looking to maximize economies of scale in distribution and purchasing (NAM 2005).

Complementary Programs and Policies

In addition to these three emerging program trends, there are two complementary program and policy elements that are emerging in the marketplace—combined heat and power and self-direct programs.

Combined Heat & Power

Combined heat and power (CHP) systems, or cogeneration, are another energy saving option in which industries can invest. CHP is a method of using waste heat from electrical generation to offset traditional process or space heating. This option is discussed in detail in a separate section in this report.

Self-Direct Programs

While this approach is not always a program per se, it is a response to a growing trend by some industrial firms to seek to be exempted from paying for or participating in industrial energy efficiency programs. Some large industrial customers may not see the benefits of participating in a program offering if they have sufficient and steady on-site expertise and resources to implement their own

[83] See http://www.energystar.gov/index.cfm?c=networking.bus_networking_supply_chain for more on the ENERGY STAR program's Supply Chain Working Group.

[84] See https://www.greensuppliers.gov/gsn/home.gsn for more about the Green Suppliers Network.

energy efficiency projects. Still, the energy efficiency gains from these customers are a valuable energy efficiency resource to the system at large and should be measured, verified, and accounted for. In these situations, utilities may give industrial customers an option to "self-direct" the energy efficiency program costs and instead make investments in on-site energy efficiency programs in lieu of participating in one of the program administrator's existing programs. For more information, see Chittum et al. 2011, which reviews numerous self-direct programs and documents best practices and a list of specific recommendations for program administrators regarding self-direct programs (Chittum 2011).

Program Design

Program design may vary according to geographic differences or sector-specific characteristics due to the heterogeneous nature of industry customers and the site specific nature of industrial energy efficiency opportunities. In general, we have seen two approaches to program design: a technology-focused approach that looks at a specific support system technology (e.g., motor systems or process heating); and an industry-focused approach that looks at a specific customer processes (e.g., food processing or chemicals manufacturing). In recent years, the latter approach appears to be gaining favor as more of the focus shifts to understanding the unique processes and market conditions of the industry-group clusters that exist in individual program service territories. This approach also encourages developing stable, trusting relationships with customers, which has been demonstrated to be key to successful programs (Chittum, Elliott and Kaufman 2009).

Accounting for Savings

Measurement and evaluation of industrial programs continues to prove particularly challenging, as a recent ACEEE report documents (Chittum 2012a). Among the challenges that industrial programs face are:

- The long lead time that industrial energy efficiency projects require, resulting in loss of corporate memory among those involved on the history of the program engagement. Program participants may be interviewed about their motivation to make investments several years after the investment was made, reducing the accuracy with which they can recall their motivation.
- Complexity of the industrial investment decision process, which can make determining whether a project is a free-rider difficult.
- The complex nature of process savings and variations in both the level of output from a process and the mix of products that are produced, making quantification of actual energy savings difficult.
- Lack of industrial management practice baselines, which makes assessing the impacts of SEM programs difficult.

As the ACEEE report found, there is a need for further development of EM&V practices for industrial programs. As these next generation programs are implemented and evaluated, new procedures and policies for EM&V will be developed. The confidence and ability to push these boundaries are the hallmark of the more mature program portfolios.

Savings Potential

Some estimates suggest that a comprehensive industrial process program that incorporates incentives and voluntary agreements and complements ISO 50001 could achieve *annual* facility energy savings of 2.4% (Goldstein et al. 2011). Customers participating in the Energy Trust of Oregon's Strategic Energy Management (SEM) program have experienced annual savings levels ranging from about 2% to 18%, and averaging about 8% (Crossman 2012; Jones et al. 2011). The savings that result from customer programs that focus on processes vary significantly, but project savings far in excess of 20% are not uncommon (Chittum, Elliott and Kaufman 2009). For SME customers, savings vary widely as well, depending upon the nature of the measures considered. DOE's Industrial Assessment Center program, which has been run since the 1970s, has consistently identified 10-15% savings focusing on a fairly limited range of measures (Trombley 2009). Some more process focused programs can produce savings above that level.

Table 5. Summary of Savings Potential from Industrial Programs

Industrial Programs	Electricity	Gas	Notes
	TWh	TBtu	
National energy use affected	1009	1590	For 2030 from AEO 2012 industrial sector; For natural gas, industrial plant and lease fuel only
Custom Programs			
Average percent savings per project	20%	20%	Assumes 20% project savings (see text)
Ultimate net participation rate	9%	9%	Assumes 75% energy used by non-SME, 60% use eligible for efficiency measures, with 20% of usage participating
Potential long-term savings	18.2	28.6	
Strategic Energy Management			
Average percent savings per project	8%	8%	Average savings from Energy Trust of Oregon program (Crossman 2012)
Ultimate net participation rate	50%	50%	Assumes 50% of usage affected
Potential long-term savings	40.4	63.6	
Market Channel Programs			
Average percent savings per project	15%	15%	Assumes 15% plant savings
Ultimate net participation rate	12.5%	12.5%	Assumes 25% of SMBs and 50% usage participates
Potential long-term savings	9.5	14.9	
Total Industrial Program Savings	7%	7%	

Examples

The Northwest Energy Efficiency Alliance—Continuous Energy Improvement

The Northwest Energy Efficiency Alliance (NEEA), which is a regional energy efficiency market transformation organization, developed a Strategic Energy Management (SEM) product called Continuous Energy Improvement (CEI). CEI helps industrial facilities permanently integrate energy management into their business and manufacturing operations, leading to reduced costs, increased profitability, and persistent energy savings from operational and other behavioral changes. Executive sponsorship, goal setting, and a tracking system are the three core components of CEI. After three years of implementation the CEI program, NEEA and its partners demonstrated actual and persistent energy savings that were distinct from capital improvement investments (Jones et al. 2011). Independent evaluation of food processors that participated in the program identified 3% annual behavior-related energy savings (NEEA 2011).

Energy Trust of Oregon (ETO), Industrial Energy Management

The Energy Trust of Oregon's Production Efficiency program built on lessons learned from NEEA's CEI efforts to develop its own SEM offering called Industrial Energy Improvement (IEI). Participating firms in the IEI are from a wide range of industries and are very diverse in size—from multiple building campuses of many hundreds of thousands of square feet to a small manufacturing plant. The IEI incorporates a peer support network approach to deliver training and motivate participation among non-competing companies. It offers several "service" or technical assistance incentives, such as energy team training sessions with the IEI cohort and one on one, at the plant consultation and coaching on employee and executive engagement, energy mapping and opportunity analysis, and development of energy intensity models and tracking systems. Energy Trust also provides financial incentives of $.02/kWh and $0.20/therm for energy intensity savings achieved at the end of the 12 month IEI engagement.

Since launching IEI in 2009, Energy Trust has accelerated the development of baseline and energy tracking systems earlier in the process and throughout the IEI to support resource acquisition goals. The Energy Trust has brought 57 large industrial plants into the IEI over four years, and annual energy savings reductions in the studied facilities averaged 7-9% from operational and behavioral measures alone (Crossman 2012).

Southern California Edison —Innovative Designs for Energy Efficiency Activities

Southern California Edison's (SCE) Innovative Designs for Energy Efficiency Activities (IDEEA) Program is an example of a process energy efficiency program. Phase 1 of this program began with the creation of a Value Stream Map (VSM) which included energy usage information (i.e., a value and energy stream map). VSM is a flow chart of each process step at each machine or workstation with a table of manufacturing performance statistics gathered about each process step as well as summarizing performance tables about selected groups of process steps working together. When factory processes demonstrated significant quality yield and rework issues, statistical analysis tools or root cause discovery and investigation techniques were used to help identify causes of scrap and rework as well as identify projects that would eliminate or reduce the causes of scrap. After process improvement projects that meet minimum energy savings levels are identified in Phase 1, the findings are reviewed with the client, including what the client must contribute to implement the process improvement as well as the expected benefits. After the client commits to support the proposed improvement project, one or more "Kaizen" (quick improvement) teams were formed to implement the VSM Phase 2 improvement projects. The teams were provided an expert trainer, project manager and facilitator to help the teams investigate, problem solve and implement the selected process improvement.

For one food products manufacturer, for example, two Kaizen team improvement projects were conducted one for equipment changeover time reduction and one to focus on increasing equipment run time with better equipment maintenance, faster equipment repair/recovery, better start-up procedure checks to reduce the risk of an unexpected line shutdown, etc. The combined project results increased actual equipment run time as a percent of shift hours worked (actual line capacity) from an average of just under 50% to about 80% for a 60% increase of available plant capacity per work shift. Even though equipment runs longer, these projects produced about 240,000 kWh per year in gross savings. The 60% gain in plant capacity enabled the company to significantly increase plant production and sales for a very large financial company benefit. (Prather et al. 2011)

NYSERDA

The New York State Public Service Commission recognized that the industrial sector would be a key component to achieving the goals of its Energy Efficiency Portfolio Standard (EEPS) and authorized the New York State Energy and Research Development Authority (NYSERDA) to administer the Industrial and Process Efficiency (IPE) Program with $180 million from 2012 to 2015. IPE recognizes the need for flexibility and site/sector-specific approaches to ensure that the best energy efficiency opportunities are identified and addressed. And as a performance-based custom program, IPE works to ensure credibility of results for the customer site and the ratepayer investment is delivered.

A core program goal of the IPE program is to enable process improvements for manufacturers and data centers; while including traditional industrial upgrades. NYSERDA looks at productivity projects, scrap reduction and throughput improvements at industrial and data center sites as potential ways to increase energy efficiency. NYSERDA now provides incentives for process improvements that reduce the energy use per unit of production as an innovative approach to engaging facilities in energy efficiency.

Data centers and telecommunications facilities are included under the industrial umbrella as their process energy consumption is similar to manufacturing consumption in its load shape, process oriented characteristics, economic development impact, power quality requirements, mission critical nature and load growth potential. NYSERDA is collaborating with industry experts and stakeholders to develop approaches and metrics to measure computing efficiency. This includes baselines for server virtualization projects and increased computational loads.

In order to fully support the complex needs of large industrial and data center customers, NYSERDA has implemented a "Key Account Manager" strategy that assigns a dedicated project manager to be the main point of contact and develop a long term relationship with the customer. These relationships allow the NYSERDA project manager to work with the industrial site to identify the energy efficiency component of a process improvement project when funding for the next cycle is being considered.

The program has stringent technical analysis and measurement and verification requirements, to ensure credibility of results for the project sites and for ratepayer investment. Further, the program only provides performance-based incentive payments on a verified kWh or mmBtu energy-saved basis.

Xcel Energy

Xcel Energy, Inc. is a public electric and natural gas utility based in Minneapolis that serves customers in Colorado, Michigan, Minnesota, New Mexico, North Dakota, South Dakota, Texas, and Wisconsin. The utility has industrial energy efficiency programs in Minnesota, Colorado, Wisconsin, North Dakota, and New Mexico. All are governed differently with different regulatory nuances, have different markets, and are at different points in their lifecycle. A demand-side management program was started in Minnesota in the 1980s and in New Mexico in 2009. Funding mechanisms, efficiency mandates, investment timeframes, and incentives vary from state to state.

Xcel Energy uses prescriptive and custom programs fairly evenly. Programs are both technology- and sector-based. Programs generally look to drive customers to the next level of efficiency, as opposed to what is currently standard in the marketplace. There is some focus on the demonstration of emerging technologies. Xcel Energy offers both technical assistance and energy audits, and offers training to energy managers, though there is no specific energy manager program.

The industrial sector varies from state to state, but it is generally around 30% of Xcel Energy's total load. Xcel Energy currently has about 12 people working on industrial marketing, and they are supported by a number of employees in the regulatory, communications, and sales fields. However, there is still a deficiency of staffing for the needs of the programs. Xcel Energy has Business Solution Center phone agents for small customers and assigned account managers for large customers. To promote their programs, they use state energy offices, nonprofit organizations, economic development agencies, real estate entities, trade associations, mass marketing advertising, training sessions, direct mail, and a web site. In 2007 Xcel Energy launched a program targeted specifically at the large industrial market. It is a more holistic approach to energy management that provides customers with additional resources to develop and implement a sustainable energy management plan that incorporates both their technical opportunities and energy savings that can be achieved by modifying their business practices.

Conservation goals will be growing aggressively over the next few years and Xcel Energy is thus in the process of redefining how it does business. This includes implementing a more aggressive approach to finding opportunities for natural gas conservation.

National Grid

In Massachusetts, National Grid, an electric and natural gas utility in the Northeast, offers industrial-focused efficiency efforts to address process efficiency improvements with prescriptive and custom incentives. It offers prescriptive incentives for elements of production processes such as motors, compressed air, and variable speed drives. It does not address each industrial sub-sector by market but instead uses its in-house engineering staff and customer service representatives to serve its customers. Service is, however, divided geographically. In general, National Grid reports a challenge finding enough experts with particular expertise to serve its customers.

Recommendations

No single approach will work for industrial programs because of the diversity of the customers' size and energy use. Thus it is important for industrial programs to develop a portfolio of offerings to address different customer needs. The persistence of the program engagement has been consistently among the most critical factors in program success (Elliott, Pye & Nadel 1996 and Chittum, Elliott & Kaufman 2009). This persistence allows trust relationships to develop between customers and program staff, while also positioning each program to take advantage of changes in the facility or market conditions that allow the program to realize greater savings when plant modernization and expansion occur (Elliott, Shipley & McKinney 2008). The three emerging program trends discussed here are complementary. The SEM engagement helps make energy efficiency part of the corporate culture and makes customers more receptive to making major energy efficiency investments. Similarly, working with a large company on management issues will likely make them more sensitive to the opportunities for energy savings among their suppliers (and the cost savings that result), and the more that the program fosters the development of a network of energy mangers that provide a mutual-support community that shares ideas and promotes creativity in energy saving approaches.

It is not critical to start with a fully developed portfolio of program offering. Even the most successful programs started with basic engagement and prescriptive program offerings. As these programs develop and mature, they can expand their portfolios to include some of these emerging ideas allowing the savings to grow with their developing relationship with their customers.

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Agriculture

Synopsis

Energy efficiency in the agricultural sector can be increased in two ways—increasing awareness about established techniques that increase energy efficiency, and implementing recently-developed high-tech solutions where appropriate. Actively educating and marketing to farmers through local or regional networks is essential. Additionally, the agricultural sector is extremely diverse, so it is important to market to farmers a variety of different options for increasing energy efficiency, so they can make use of the techniques and technologies that are most applicable to their individual situation. Financing is also a barrier for farmers to improve their energy efficiency, so programs that connect farmers with available state and federal funding and assist them through the application process are also important.

Background

Energy efficiency in agriculture has largely been overlooked in recent years for a variety of reasons. Of course, all farmers want to save money on their utility bills and fuel expenses, but energy efficiency specifically is generally not a top priority. From a policy perspective, this is partially due to the incredible diversity of the farming sector: what works for a farmer in Indiana with 1,500 acres of corn and soybeans may be entirely inappropriate for a farmer in Alabama who grows 35 different kinds of vegetables on 80 acres of family land, or a farmer in Maryland who operates 6 poultry houses, each containing 20,000 birds or more. Additionally, it can be challenging to get information to farmers. A large percentage of American farmers rely on cooperative extension services for information and assistance. Cooperative extension services are administered through the United States Department of Agriculture (USDA) in partnership with state land-grant universities and state and local governments. Each county has its own extension office (though in recent years some county offices have been consolidated into regional offices). The goal of extension is community-building and rural development as well as disseminating the latest agricultural research from land-grant institutions. Individual extension offices have a fair amount of autonomy so that they can best serve local needs. Energy efficiency is not always a priority for extension agents, who often spend time answering farmers' questions about the use of a new chemical or treatment for a particular plant disease.

USDA administers several programs that provide funding for energy efficiency. The Rural Energy for America Program, or REAP, is one of the main federal sources of energy efficiency funding. This program is authorized in the Energy Title of the Farm Bill. Through REAP, farmers can apply for grants or loan guarantees to install energy-efficient equipment or renewable energy systems, or make other energy efficiency improvements. However, many farmers have had difficulty with the REAP application process or do not meet the requirements and must look elsewhere for funding. Simplifications to the REAP application process for small projects have been proposed in the next Farm Bill, but it is unclear if these changes will be reflected in the final version of the law, or if they will reduce the barrier to accessing funding in a meaningful way.

USDA also administers the Environmental Quality Incentives Program (EQIP), which also addresses efficiency though it is authorized under the Conservation Title of the Farm Bill, not the Energy Title. EQIP provides financial assistance for on-farm energy audits, as well as funding for implementing any efficiency improvements identified during the audits. Several programs have been using EQIP funding as a more-accessible alternative to REAP funding. Currently, the 2008 Farm Bill is in effect, but it is set to expire this year. The 2012 Farm Bill is currently being debated in Congress, and the level of funding for these programs for the next four years is not yet determined. As of this writing, it appears that mandatory funding for energy and conservation programs will be dramatically reduced.

Drivers for Change

Lack of education on program offerings is the primary driver for change in agricultural energy efficiency programs. Program managers have found that most farmers are not aware of existing options for on-farm energy efficiency improvements. In some cases, program managers have had difficulty finding enough farmers to make use of all available funds. Many programs focus on simply reaching out to farmers, making them aware of their options, and often assisting them with the process of applying for federal funding. In a way, thinking about "next generation" energy efficiency projects for agriculture is somewhat premature; many programs focus on what might be considered the first generation.

However, recent technological improvements have increased the potential energy savings on the farm. Technologies like compact fluorescent lighting, tractors guided by GPS, or even simple efficiency upgrades to equipment like coolers or motors all can dramatically decrease energy consumption. Farming techniques for tilling or pest management that save energy have also been developed in the past several decades—perhaps not "recent," but within the farming career of the average American farmer. Even if farmers are aware of the existence of these technologies, the cost of implementing them or seeing how they can be applicable on a particular farm can be barriers.

Farmers do see a need for energy efficiency, even if there is a lack of awareness about the many ways they can decrease energy consumption. A large percentage of farm revenue is dedicated to fuel expenses, particularly for more energy-intensive types of farming. Farmers feel the rising fuel prices acutely. The cost of agricultural chemicals has also been rising. This is partly due to the fact that many kinds of chemicals are particularly energy-intensive to manufacture—for example, the price of natural gas accounts for as much as 90% of the production cost of ammonia fertilizer (GAO 2003). Additionally, environmental regulations have required farmers to replace cheap, persistent pesticides with newer chemicals that tend to degrade relatively quickly. Though such regulations are important in protecting the local ecosystem, they tend to be more expensive and require more frequent applications.

Emerging Trends and Recommendations

Technologies

There is a wide variety of available technologies that can increase on-farm energy efficiency. Not all technologies are appropriate for all types or sizes of farm. Additionally, many of these technologies require a significant capital outlay and technical expertise. A priority for many programs is ensuring farmers are aware of these technologies and how to acquire adequate funding and knowledge to implement them.

Precision Agriculture

Precision agriculture is the use of GPS and/or satellite remote sensing in farming. At its more basic level, GPS can guide a tractor or combine along extremely precise rows. The benefit of such a system is that it allows farmers to minimize chemical application overlap and maximize harvest. Depending on the equipment, accuracy can be within a quarter of an inch or less. More advanced precision agriculture techniques use satellite imagery to map individual fields. The farmer can then identify which sections of the fields require more or less water, fertilizer, or pest control, with a resolution as high as one square meter. With GIS software, the farmer can automate spraying. Since crops receive an optimum level of chemicals, the farmer can minimize waste and trips into the field, and thus energy use.

Lighting

Confined livestock operations (particularly poultry) make heavy use of lighting. One poultry house, which would generally contain a flock of 20,000-30,000 birds, could have fifty light bulbs that burn all day—conventional poultry houses have no natural lighting so that the grower can keep the light levels at the optimum for maximum growth. Farmers have begun to switch from all-incandescent lighting to all-compact fluorescent lighting, with energy savings of up to 80%. Using CFLs in farming is catching on slowly. Light color is a concern, since it can have important impacts on feed conversion and egg production. Expense is also an important consideration, especially since farmers may be reluctant to spend significant amounts of money to transition from a "tried and true" method to a newer method that may affect yield.

Tilling

Conventional agricultural practices require farmers to till or plow fields before planting. This process churns and loosens the top layer of soil, shaping it into rows for planting and destroying weeds. However, conventional tilling can increase erosion and decrease the quality of the soil and requires labor and energy as farmers take tractors into the fields to plow. No-till farming is an alternative system that minimizes the disturbance to the field. Leftover organic material from previous crops (such as corn stalks) remain in the field to decompose and increase soil quality, and planting is done by drilling small holes or digging narrow trenches. Energy savings come primarily from diesel fuel that would otherwise have been used for machinery to till fields. However, since plowing is no longer an option for weed control, herbicide use can increase. No-till agriculture is not a "new" practice; it was developed over 50 years ago. However, farmers have been slow to adopt the technique. Today, slightly over 35% of US cropland is farmed using no-till practices, and that number is slowly increasing (Horowitz et al. 2010).

Other Trends

There are a host of energy-saving techniques and technologies that are available to farmers. What may be appropriate for one farmer may not work at all for another. Not all of these technologies are recently developed, but they are new to many farmers. These may include:

- Switching from diesel fuel to electric or natural gas
- Drip or micro-irrigation
- Planting cover crops or practicing crop rotation to increase soil nitrogen
- Raising animals for longer on pasture instead of in confined animal feeding operations
- Use of plastic mulch for weed and evaporation control
- Use of variable speed drives for milking machines on dairy farms

Program Design

Programs can take several approaches to agricultural energy efficiency:

- Assessing on-farm energy use and potential for energy efficiency improvements,

- Assisting with the federal or state funding application process, and
- Helping farmers implement new, high-tech methods (i.e., precision agriculture).

Many farm energy efficiency programs use energy audits as a primary tool. Traditionally, the focus has been on "headquarters" energy use, e.g., lighting and fuel use. A new type of energy audit is beginning to take a more holistic look at on-farm energy use, taking into account practices like tilling and irrigation. This includes the landscape AgEMPs (Agricultural Energy Management Plans), developed by EQIP. Since many farmers are unaware of the options for energy efficiency or what their potential savings are, the audits help fill in those gaps. They also provide a basis upon which to make recommendations for which options would be most cost-effective and provide the greatest energy savings.

Managers mention the necessity of marketing to farmers *as farmers*, rather than more broadly as utility customers or small business owners. Farmers are a close-knit community, and can be difficult to reach. Relationships are important. Many programs operate so that farmers deal with an agent or technical service provider who is based locally, a member of the community. Word of mouth is also an essential mechanism for making farmers aware of the existence of a particular program. Farmers generally have a great deal of latitude in making their own decisions, even when operating under contract with a large corporation. Program managers have found success in reaching farmers through cooperative extension offices and trade organizations.

Target Market

Many programs target the largest farmers. Due to the economies of scale involved in farming thousands of acres or raising hundreds of thousands of animals, dramatic reductions in energy consumption are possible from even small changes. These farmers also tend to have a greater ability to make changes that require a large upfront cost and to hire workers or acquire the expertise necessary to operate the new equipment.

Savings Potential

Because of the diversity of the agricultural sector, it is difficult to estimate the potential for on-farm energy savings. Anecdotal evidence suggests that at least for some farmers, the potential savings are quite high. In one case, a farmer was able to achieve a 35% reduction in nitrogen fertilizer use after using satellite imagery to map soil type within field (UMAC n.d.).

Small Business Programs	Electricity	Natural Gas	Notes
	TWh	TBtu	
National energy use affected	43	165	
Average percent savings	30%	15%	
Ultimate net participation rate	60%	50%	
Potential long-term savings	6	12	

Examples

Agriculture Energy Efficiency Program (NY)

The Agriculture Energy Efficiency Program (AEEP), run through NYSERDA, offers incentives for implementing energy efficiency improvements on farms. This program has been used mainly by dairy farms, generally for upgrades to equipment used in milking such as variable speed drives and plate coolers. However, other types of agricultural operations are also eligible to receive assistance through AEEP, from greenhouses and orchards to grain dryers and poultry houses. AEEP will fund up to 75% of a project's total cost, up to $250,000. Farmers are expected to contribute at least 25% of the final project cost in cash. Funding is also available for farm energy audits up to $1,500. Average incentives for this program have been around $18,000, with savings of about 44,000 kWh per project. Additionally, NYSERDA contracted with EnSave, a Vermont-based farm energy efficiency implementation organization, to assist farmers through the application process. AEEP is funded by systems benefit charges. Funding for AEEP is granted on a first-come, first-served basis. This program has been closed since March 2011, but is expected to re-open by the end of 2012, with funding approved until 2015.

California Dairy Energy Program

The California Dairy Energy Program (DEEP) is available to customers of Pacific Gas and Electric (PG&E), and is administered by EnSave. DEEP provides incentives for energy efficiency improvements to dairy farms. Incentives can be either fixed for specific pieces of equipment (i.e., motors) or can be calculated based on the volume of milk produced (for example, most dairy equipment is eligible for an incentive of 9 cents per gallon of milk produced). An incentive of $1.00 per therm of gas saved is also available. To date, there have been 129 participants in the program, with average electric savings of just under 13,000 kWh.

Recommendations

Increasing awareness of options for on-farm energy savings is essential for increasing energy efficiency in the agricultural sector. Most farmers want to do all they can to save energy, though their primary motivation is cost savings. The most effective programs will utilize existing locally-based networks. In other words, farmers are most likely to take the advice of someone they already know and trust, or who is known and trusted by a friend. Cooperative extension offices, and in some cases agricultural equipment vendors, are natural choices for being at the center of efforts to increase on-farm energy efficiency. Some extension agents already do make energy efficiency a priority, but this is by no means universal. Unfortunately, funding for extension has dropped significantly in recent years, and some extension agents may find it difficult to spend significant amounts of time working on energy efficiency in addition to their existing duties. Extension agents do have the ability to refer farmers to organizations, such as EnSave, who *do* have the time and inclination to help farmers with energy efficiency.

There are significant potential savings from some fairly low-hanging fruit. Some practices that are now considered fairly conventional, such as no-till farming or drip irrigation, have been adopted by only a fraction of farmers. These practices are applicable to many types and sizes of farms, and can be relatively low-cost to implement. Dramatic reductions are possible from precision agriculture, particularly for farmers who have already made significant changes to reduce on-farm energy use. As existing programs expand and the technology becomes less expensive, more farmers should be able to benefit. The expertise necessary for implementing a precision agriculture system is certainly a barrier for many farmers, so programs that focus on giving farmers the necessary technical skills is important.

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Combined Heat and Power

Synopsis

Combined heat and power (CHP) systems save energy and reduce emissions compared to separate grid-provided power and onsite thermal energy, and therefore provide an opportunity to help states meet energy efficiency or carbon emissions targets. Only a few states, including Massachusetts, Texas, and Ohio, allow CHP to count as an eligible efficiency measure toward their electricity program targets. Most of these states are just beginning to address the critical issue of how to account for energy efficiency gains from CHP systems because CHP does not necessarily reduce electricity load but rather displaces grid electricity with onsite electricity generation and captured thermal energy. Other states, such as New York, New Jersey, and California, administer CHP programs as part of their overall portfolio of clean energy programs. These programs can offers insight into best practices for next generation CHP program development, such as the important of right-sizing CHP; however currently the energy savings from CHP are not attributed toward energy efficiency targets. States could consider allowing CHP to count toward energy efficiency goals, but only if targets are set with CHP potential in mind and appropriate accounting methods are considered. Alternatively, states could set a separate target for annual CHP output and emissions reductions, which is more consistent with the nature of CHP as a generation resource.

Background

Combined heat and power (CHP) systems produce both electricity and thermal energy from one fuel source such as natural gas. CHP systems capture heat that is normally wasted in a conventional power plant to produce steam or hot water for onsite space heating, hot water, or manufacturing processes in a building or facility. The result is that CHP systems have a higher efficiency (up to 80%) compared to separate generation of electricity (typically 30-40% electric efficiency) and thermal energy, which can lead to substantial benefits for customers such as lower energy bills, and societal benefits such as lower fuel consumption and lower emissions compared to centralized fossil fuel generation.85 CHP can also benefit utilities in the form of lower transmission and distribution losses, freeing up delivery capability for other loads. Such reduction in grid stress can also help defer distribution upgrades.

The upfront costs of CHP systems, utility regulatory barriers, and non-supportive air quality regulations are some of the major barriers that prevent cost-effective CHP projects from being implemented. States have pursued several policy and regulatory measures to break down these and other barriers. Lack of rules for interconnection of a system to the grid, for example, can slow or hinder CHP installation, while good interconnection standards make explicit and transparent the parameters for CHP systems to interconnect with the grid. Some air quality permitting rules have also hindered CHP development, while output-based emissions standards more fairly calculate the emissions savings from CHP systems. See Chittum et al. (2012) for a review of state policies to encourage CHP and their relative impacts.

Recent CHP program models and policy successes in some states have started to overcome these barriers by providing financial incentives to customers, streamlining interconnection standards, and

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[85] A natural gas-fired CHP system emits about 0.28 metric tons of greenhouse gases (GHG) per MWh, compared to a natural gas combined cycle or conventional coal plant, which emit about 0.37 and 0.82 metric tons/ MWh, respectively (IDEA 2010).

opting for output-based emissions permitting, while other states continue to lag. This lack of supportive CHP policies and programs, along with recent economic conditions, has yielded slow growth in the installation of CHP systems. Substantial energy savings potential remains.

Drivers for Change

Policy

At the federal level, President Obama signed an Executive Order[86] in August 2012 to support industrial energy efficiency and CHP. Toward this end, the administration calls on several agencies to "coordinate and strongly encourage efforts to achieve a national goal of deploying 40 gWs of new, cost effective industrial CHP in the United States by the end of 2020." This goal builds upon the largely successful 1999 CHP Challenge to double installed capacity by 2010 set forth by DOE and EPA. The goal provided focus for a national road-mapping effort that results in the goal being largely met by the time the recession hit in 2007 (USCHPA 2001). This new policy goal for CHP installation, while aggressive, should help to enable state-, utility-, customer-and energy efficiency program-level efforts to implement cost-effective CHP systems.

At the state level, one major recent policy driver for CHP development is whether and how CHP projects can contribute to EERS and RPS goals. Currently only a few states allow CHP to count as an eligible efficiency measure toward its EERS, and several more states allow CHP to count toward its RPS if the systems use renewable fuels (Sciortino et al. 2011). As utilities face increasing energy efficiency targets, they are looking for a broader portfolio of efficiency options, and CHP could be a good candidate. Recent developments in both Massachusetts and Ohio allow CHP to qualify as an eligible energy efficiency measure. In Massachusetts, CHP has accounted for more than 9% of commercial and industrial (C&I) energy efficiency program electricity savings from 2009 to 2011 (Ballam 2012). Other recent state policy and program developments include a change to the California utilities' long-standing Self-Generation Incentive Program (SGIP) to allow non-renewable-fueled CHP systems to participate in the program, and new R&D programs offered by NYSERDA geared toward market transformation. These latter examples create a more favorable environment for CHP, but in both states efficiency gains from CHP do not count toward their state's EERS targets.

Economics

The economics of CHP systems is another important driver of CHP development. Low natural gas prices are currently making gas-powered CHP systems more economically favorable in their annual variable fuel costs to potential installers. To a lesser extent, lower natural gas prices can also lower utility electric costs, which can lengthen the payback of CHP systems. But while the energy savings from CHP projects offer significant benefits to customers in certain situations, the upfront capital requirements are still a significant barrier to overcome. CHP systems can cost anywhere from $700 to $3,000/kW (Chittum and Kaufman 2011). Program incentives in the form of rebates or production

[86] Accelerating Investment in Industrial Energy Efficiency: http://www.whitehouse.gov/the-press-office/2012/08/30/executive-order-accelerating-investment-industrial-energy-efficiency

incentives can help, however these do not overcome a lack of available capital. Customer financing may also be needed to further stimulate market development. Finally, providing engineering or feasibility studies is also highly beneficial to improve customer economics. Studies are otherwise considered a risky undertaking because it is unknown whether the results will find that CHP is an advisable investment.

The costs to program administrators in some cases may also be too high and unduly burdensome, especially for incentivizing one-off custom installations. NYSERDA, which has longstanding and successful CHP programs, is moving toward a market transformation approach as a next step to replace its CHP demonstration program. Site-specific demonstrations can be time-intensive and costly, and a more streamlined approach for pre-packaged and pre-approved CHP systems could bring down costs and the length of time to implementation.

Emerging Trends and Recommendations

Policy

Recent developments in states such as Massachusetts and Ohio point to a trend of increasing opportunities for CHP eligibility as an energy efficiency measure, however some important issues remain, especially the need to determine appropriate and administrable methods to account for a CHP system's energy savings and costs.

Calculating energy savings and emissions reductions from CHP is a complex task, because reductions in metered electric loads are offset by increased consumption of onsite fuel to generate the power. CHP systems can improve overall efficiency, but the electric fuel savings do not occur at the point of use like other efficiency measures, but rather at the point of the electricity generation that is displaced. And while many utilities or statewide efficiency program implementers face electricity efficiency targets, the savings from CHP are the resulting net reduction in fuel while meeting the same onsite electric and thermal energy needs that would be required without the CHP system. In general, ACEEE recommends comparing the efficiency with which a CHP system generates power with the efficiency of generation of the local electric grid. The net savings need to be properly attributed to either the displaced thermal or power consumption. There are significant issues with program administration that will need to be worked through to insure fair and equitable accounting for CHP savings because of the complexities associated with CHP systems producing two usable outputs. Several years ago, ACEEE developed some recommendations for an accounting methodology (see Elliott, Chittum and Trombley 2009), and an active discussion of appropriate approaches that will meet each state's unique needs is underway (Chittum 2012b).

Technologies

CHP systems can use a wide range of technologies to generate power on-site and use recovered heat for space heating, hot water, absorption chillers or manufacturing processes. Generation technologies include turbines, microturbines, fuel cells, and reciprocating engines. While these technologies are not new, each customer's project typically requires custom, site-specific applications and additional equipment, which can lead to a lengthy and costly process for project development and implementation. Small, pre-engineered and modular systems have been identified as a target for faster market transformation opportunities in some applications such as multifamily buildings and hotels. NYSERDA, for example, is launching a new R&D program that specifically targets these systems, as discussed in the examples.

Customer electric and thermal metering is another important technology opportunity for programs, because better metering is needed to demonstrate the useful thermal and power output of CHP systems for verification of savings. To encourage greater usage of meters, program managers can provide guidelines for customers with the details of metering and a list of qualified meters, as the Massachusetts program does.

Program Design

CHP programs typically offer financial and/or technical assistance such as an initial scoping and technical feasibility studies, and financial rebates to help lower upfront capital costs or reduce operating expenses. There is much untapped CHP potential, in part because CHP is challenging to execute, and CHP is not universally a good fit for all facilities. Innovative program designs are addressing the challenges and barriers to expedite development of more good CHP opportunities and to address regulator and customer site concerns of effective, persistent performance. Programs should provide credible and objective information and guidance to help customer decision making, while also executing verification measures to ensure delivery of cost-effective resources.

Program design examples include:

- NYSERDA is piloting some rules of thumb for small to medium CHP systems to help the marketplace streamline project installations and program participation. Projects that fit the rules of thumb will not need to go through a full technical feasibility study process.
- NYSERDA has proposed to the NYS Public Service Commission a deployment program for medium to large CHP using performance based payments based on rigorous, multiyear measurement and verification (M&V) of electricity, demand, fuel conversion and environmental performance to protect ratepayer and customer investment.
- In Massachusetts, the program requires that all thermal energy efficiency measures must be installed before doing a CHP installation. Second, the system should be "right-sized" to the improved, i.e., lower, facility energy demand. If a system is sized too large, it will not be able to run at its maximum capacity, resulting in less than ideal system performance and cost-effectiveness.

Executing verification and program evaluations are an important aspect of CHP program design, as it is with all energy efficiency programs. The benefit of CHP systems only accrue when the system produces power and thermal energy, whereas typical energy efficiency measures tend to accrue savings passively on a regular basis compared to the baseline technology. When CHP systems are shut down due to operational changes or shifts in fuel prices, for example, the efficiency gains no longer accrue. In this respect, CHP systems are similar to behavior-based energy efficiency such as strategic energy management and control measures which require some ongoing attention by facility managers or building owners. Regular verification, which can be enabled by metering technology as discussed above, is a critical element to program design.

Target Market

CHP systems are typically best suited and most cost-effective for commercial, industrial, governmental and institutional customers with year-round and steady thermal usage, such as universities and hospitals. These types of customers are also good targets because they have multiple types of buildings and loads, which allows for optimization of the CHP system across multiple buildings. In Massachusetts, typical sectors participating in the CHP incentive program include nursing homes, large apartment complexes, hotels, universities, hospitals, and multi-shift industrial operations that use hot water or steam (Harnett 2011). In New York, 50% of projects over the last 5 years occurred in New York City, especially multifamily buildings and hotels (Kear 2012). As a result of these past successes, NYSERDA's forthcoming R&D program on pre-engineered systems will focus largely on this target market.

Marketing

Market characterization studies can help program managers by estimating CHP opportunities by key market segment, which arms program administrators with a list of potential candidates for CHP. For large customers, program administrators could then directly identify and reach out through key account managers. For smaller commercial and industrial customers, program administrators can tap into their existing marketing channels for other energy efficiency program offerings and encourage trade allies such as CHP developers to market to the customer base. Customer education and communication are also important to increase implementation because many would-be CHP customers are unfamiliar with CHP.

Savings Potential

Market potential for CHP installations varies by state, depending in part on the economics of electricity rates versus natural gas prices, the available financial incentives, and the policy and regulatory context. In Massachusetts, the state estimated for its 2010-2012 electricity efficiency plan that the CHP programs could achieve annual incremental electricity savings of about 0.3- 0.5% each year relative to total load, and its other electric efficiency programs could achieve at least 2.5% per year from a suite of other program offering (EEAC 2009). In 2010, fifteen CHP projects were approved for incentives, ranging from 60 kW to 5.55 MW in size (National Grid 2011). The state also completed a quantitative CHP market assessment, which identified 4 different market segments by size category (e.g., 60 to 150kW or > 1 MW), and estimated nearly 1,500 "high-value" customer account opportunities in the utility service territories with a potential of about 475 MW and generation of 3,318 GWh (KEMA 2011). In New York, over the 5-program cycle from 2007 to 2011, 83 projects were funded with a cumulative capacity of 115.3 MW (NYSERDA 2012a).

Estimating the potential for energy efficiency program savings from CHP is difficult, because a significant portion of the capacity will be implemented outside of these programs by large industrials who implement CHP when they make capacity additions. Nationally, one estimate of existing potential considering just on-site thermal and electricity needs of existing facilities suggests a CHP market penetration of 3,157 MW over 8 years (2010 through 2017) (ICF 2010). We use this range to determine savings estimates for 2030 in the table below.

Combined Heat and Power	Elec.	Notes
National energy use affected	2616 TWh	Total commercial and industrial electricity sales projections for 2030
Participation (MW of CHP systems installed)	7103 MW	Estimated installations by 2030 based on annual rate of market potential identified in ICF 2010 (10% Industrial Tax Credit (ITC) scenario).
Potential long-term savings	44 TWh*	Onsite electricity output displaces grid electricity; Assume 70% capacity factor.
	1.7%	Displaced grid electricity relative to all commercial and industrial electricity demand in 2030

*Note: This represents electrical output from CHP systems, which displaces grid electricity. Appropriate energy efficiency savings accounting methodology would need to be determined; Estimated incremental onsite gas or other fuel usage for generation (222 TBtu) is based on analysis by ICF for ACEEE's state CHP potential assessments

Some national efforts are aiming for much higher potential, on the order of 40 GW of new CHP installed by 2020 (SEEAction 2012, Obama Executive Order). These aggressive goals consider substantial policy and regulatory business model changes that would greatly expand the scope of CHP deployment, but are outside the scope of what is considered in this report. As a result, we have chosen to use the a conservative value to estimate the saving that could be realized from energy efficiency programs focusing on CHP deployment.

Examples

Massachusetts

Two recent policy elements in Massachusetts are encouraging the development of CHP. First, the Green Communities Act of 2008 made Combined Heat and Power (CHP) eligible as an electric energy efficiency measure for under the MassSAVE utility-administered programs.[87] Also, CHP is prioritized and qualifies in the state's CHP-dedicated Alternative Energy Portfolio Standard (APS): By 2020, 20% of electricity must come from renewable energy and another 5% from CHP.[88] The two programs provide complementary benefits for CHP customers. The energy efficiency programs provide rebates toward technical feasibility studies and capital expense reductions ($ per kW rebates), while the APS eligibility enables an incremental annual operating benefit in the form of alternative energy credits (AECs).

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[87] MassSAVE is an initiative sponsored by Massachusetts' gas and electric utilities and energy efficiency services providers, working closely with the MA Department of Energy Resources, to promote energy efficiency that help residents and businesses manage energy use.

[88] See 225 CMR 16.00, enacted in 2009. Flywheel storage and gasification with carbon capture and sequestration (IGCC) can also comply, but given that CHP is the only commercially viable technology of these three, it will likely make up nearly the entire 5%.

Alternative Energy Portfolio Standard (APS)

CHP systems are eligible for AECs due to efficiency gains, and one of the innovations of this program is the clearly delineated calculation for counting savings. AECs are calculated as the energy savings of a CHP system compared with grid-provided electricity and a separate thermal unit (boiler), to meet the same load. The calculation assumes the average efficiency of the grid is 33% and the efficiency of the boiler averages 80% (Breger and Ballam 2012). An AEC Estimating Tool is available on the state website, which provides a template for the developer or vendor to estimate their annual AECs. Both electric and thermal metering is required to verify performance of the system. The program has determined a rule-of-thumb outcome that the value of AECs generated by a representative CHP system is usually sufficient to cover O&M costs.

MassSAVE Energy Efficiency Programs

CHP systems are also eligible measures for utility-sector energy efficiency programs, which provide financial incentives of $750 per kW for systems with an electrical capacity of 150 kW or less, and up to $750 per kW for systems over 150 kW, with a cap at 50% of the installed cost (Breger and Ballam 2012). Overall building energy efficiency measures are also implemented as part of this program to ensure proper sizing of the system. Projects must pass the benefit/cost test, accounting for installed and ongoing maintenance costs, CHP system electric and thermal efficiencies, run hours with full utilization of thermal output, and timing of electric generation (e.g., winter/summer and peak/off-peak). The systems must be at least 60% efficient (combined electric and thermal efficiency), and the best applications fully utilize electric and thermal energy outputs with sufficient run hours to meet the cost-effectiveness criteria. Three of the state's program administrators have implemented CHP projects from 2010-2012 (EEAC 2012). About 20-25 MW of CHP projects have been approved through the program, and the electricity savings from these projects have accounted for more than 9% of total C&I program savings over the last three years, and at only 2% of the costs (Ballam 2012).

Ohio

In 2012, SB 315 was enacted, allowing utilities to count CHP as an eligible energy efficiency measure toward their EERS goals. The state's annual efficiency targets will take a big jump to 2% per year in 2019, which utilities see as a major obstacle. American Electric Power (AEP), one of the largest electricity utilities in the state, anticipates this new eligibility of CHP will be helpful toward meeting efficiency targets in the long term. However, AEP notes that many questions remain, such as whether CHP can compete with other demand-side options; the value of energy and capacity from CHP in the PJM market, whether systems are dispatchable; and the capacity value to the utility (Williams 2012). AEP has identified one of their pending industrial efficiency programs, the EE Auction program, as a potential avenue to encourage CHP projects going forward. In this reverse-auction approach, customers come to the table with their project and time frame, and the utility will provide support for the lowest-cost projects. To AEP, their current custom incentive program is not an appropriate avenue for CHP projects because that program offers a one-time payment for measures with known lifetime savings. Large CHP systems, however, are viewed by the utility more as an ongoing stream of savings that may vary over time and should thus be evaluated on an annual performance basis.

New York

The New York State Energy Research and Development Authority (NYSERDA) has a long and successful history of CHP research, development and deployment. Since 2000, NYSERDA's CHP programs have resulted in the installation of about 180 projects at over 190 sites. In 2011, NYSERDA completed its 5-year program cycle for its CHP demonstration R&D program and a performance-based CHP deployment program.

A new technology and market development effort for small to medium systems called the CHP Acceleration Program was recently approved with a budget of $5 million per year for 2012–2016 (NYSERDA 2012). A separate CHP Performance Program designed as a resource acquisition program for medium to large systems has been proposed for $10 million per year, and a decision by the New York Public Service Commission is expected during the fourth quarter of 2012 (Kear 2012).

The new CHP Acceleration Program shifts emphasis from CHP demonstrations to market transformation, promoting the market for pre-engineered, modular CHP systems that are ready to deploy and have lower transaction costs than custom systems. Participating customers must install pre-packaged systems that will be pre-approved by a technical evaluation panel, which consists of utilities, the New York City Department of Buildings, the NY Department of Public Service (DPS), NYSERDA, and others. The goal is to support CHP systems that customers, utilities and building officials are highly familiar with. Customers are offered fixed incentives for these pre-packaged systems which range in size from 50 kW up to 1.3 MW. Multifamily buildings, for example, are a prime candidate for CHP systems in the 100-600kW size range. To further simplify the process, NYSERDA and the technical panel will develop "rules of thumb" to determine whether a customer can go through a streamlined application process. Otherwise the customer would complete a full technical feasibility study process, which takes longer and increases program administration costs (Kear 2012).

The proposed CHP Performance Program will support efficient, persistent installations of CHP systems larger than 1.3 MW and will utilize energy, demand, efficiency, and environmental performance-based payments. The program will initially focus on clean, efficient, cost effective gas fired systems and emphasize system operation during summer peak demand periods. To quantify the performance-based payments, the program will apply rigorous, multiyear system measurement and verification (M&V). The program requirements and performance-based payments is a state-of-the-art approach for energy efficiency program administrators.

Recommendations

- To encourage market penetration of cost-effective CHP, programs should offer financial incentives, including upfront incentives for installation of systems, "pay for performance" annual production credits, credits in carbon markets, financing support, and loan guarantees to help reduce the cost of purchasing and operating cost-effective.
- Programs can also offer feasibility studies and other technical support to help identify projects and determine their feasibility early on. Programs can also offer the services of internal staff or contracted third-party vendors who act as intermediaries between vendors and customers.

- To adequately identify target markets, programs should conduct market potential assessments to characterize market segments and high-value customer opportunities; Programs should also cater their education and outreach services to the targeted market segment to help potential participants learn about the benefits of CHP systems.
- Programs should expect different project implementation timelines for projects in different market segments, and work to streamline paperwork and incentive agreements when possible and create a pipeline approach as a way to track potential projects., Pre-engineered or pre-qualified systems may also help streamline the market and programs.
- Due to the long time frame of project implementation for many CHP systems, regulators and legislative funding sources should account for the need for long-term funding security to induce market advancement and reduce free-ridership.
- Both electric and thermal projects should be required to monitor electricity and thermal output on an ongoing basis that may be needed to evaluate production financial incentives;
- States should consider the eligibility of CHP as a component of meeting efficiency targets or for energy efficiency program funding. Another option is to count CHP as a separate category or tier of an EERS, or separate standard altogether.
- State targets should account for CHP market potential. Also, policies should clarify how CHP system savings will be counted and credited within the given scheme.

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Distribution System Efficiency Improvements

Synopsis

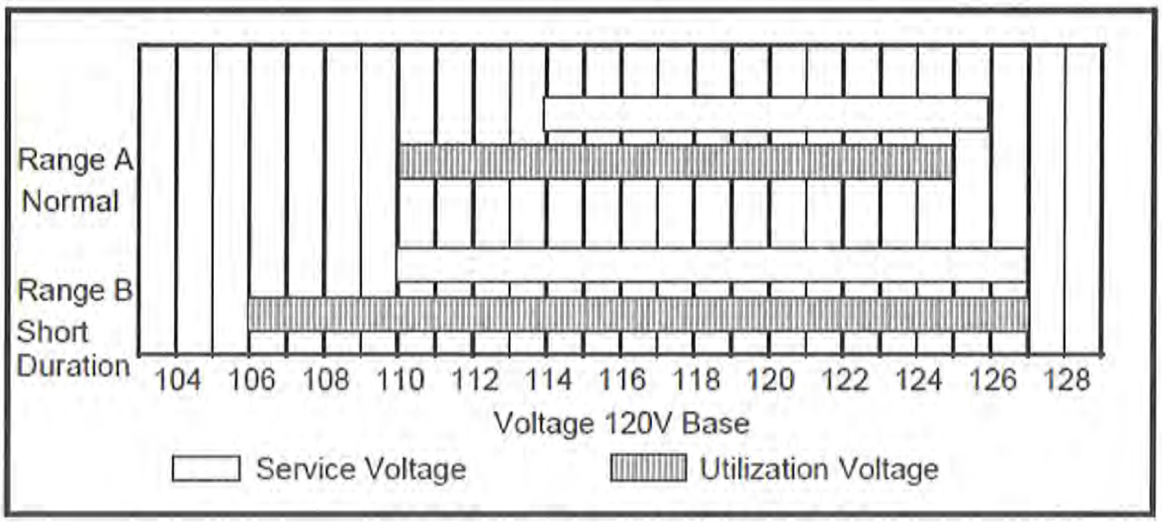
There are significant opportunities to improve the efficiency of distribution systems. In this section we focus on two such opportunities—voltage optimization and amorphous core transformers. A variety of studies find average savings from voltage optimization of just over 2% on appropriate circuits. Amorphous core transformers can reduce transformer losses by 25-40% relative to proposed new federal minimum efficiency standards and will often be cost-effective when transformers need to be purchased. Examples of utilities pursuing these opportunities are provided.

Background

In the United States, roughly 7% of electricity generated is lost in the transmission and distribution system[89] (EIA 2012), although this is lower in some areas and higher in others (e.g., most rural areas). This section concentrates on ways to reduce distribution system losses, which are roughly two-thirds[90] of these losses. We discuss two opportunities for improving distribution system efficiency—voltage optimization and high-efficiency transformers.

In the United States, electricity is supplied to residential and small commercial users at 120 volts nominal. However, under American National Standards Institute (ANSI) standards, voltage at the meter can range between 114 and 125 volts at all times and between 106 and 127 volts for brief periods (see Figure 2). The minimum ANSI voltage for some industrial uses is slightly higher—117 volts (RW Beck 2008).

Figure 2. ANSI Voltage Ranges



Source: ANSI C84.1 standard as excerpted in RW Beck 2008.

Voltage Optimization (VO) involves carefully analyzing voltages on distribution feeders in order to find ways to reduce voltages while still maintaining service requirements (including voltage levels and phase balance) at levels that allows equipment to operate without problems. Voltage Optimization is sometimes called Conservation Voltage Reduction (CVR). Lower voltages can improve end-use equipment efficiency and reduce line losses on both the customer and utility side of the meter. Voltage optimization can also improve the effective capacity (kW and help with reactive power management (NWPCC 2009). Voltage can be regulated using either voltage regulators or Load Tap Changers at the substation. Controlling the distribution voltage level from the transmission system or

[89] Losses during critical times such as on hot days when systems peak can be twice average losses

[90] ACEEE estimate based on a review of data at http://www.ercot.com/mktinfo/metering/dlfmethodology/ .

using switched capacitors are less common methods. Voltage control needs to be automatic and can be done via Line Drop Compensation settings, switched capacitor banks, excitation on the generator, or voltage feedback signals from the extremities of the distribution system (RW Beck 2008). At times, distribution system improvements will be needed on some circuits in order to optimize voltages across the circuit. Best methods for voltage control will often vary from circuit to circuit—there is not a one size fits all approach. Additional plain English information on this opportunity can be found in a Regulatory Assistance Project report (Schwartz 2010).

Distribution transformers are ubiquitous on distribution systems and are used to step-down voltage from primary to secondary to the voltages used by customers. The U.S. Department of Energy estimates that more than 700,000 liquid-immersed distribution transformers (the type that are primarily used by utilities) are sold each year and that these transformers have an average service life of 32 years. This implies that there are more than 20 million transformers in utility distribution systems (DOE 2012a). New federal minimum efficiency standards took effect for these transformers in 2010 that result in more than a 20% reduction in losses relative to typical transformers being sold when the standard was set in 2007 (Sampat 2012).

Drivers for Change

Recent work on VO began in the Pacific Northwest with a major project by the Northwest Energy Efficiency Alliance (NEEA). The NEEA project involved pilot demonstrations involving six utilities, 10 substations and 31 feeders (NWPCC 2009). Voltage was controlled one day, off the next day, controlled the following day, etc. for multi-month [check] periods. In this way the impacts of voltage control could be separated from non-control under a wide range of operating conditions. The NEEA project found average energy savings from voltage control of 2.07% of the consumption on the circuit, with savings higher in summer and lower in winter (seasonal variation is discussed further below) (NWPCC 2009). As long as voltage is being carefully controlled to be above minimum thresholds, pilot programs have found that most customers will not notice any difference.

Interest in Voltage Optimization is growing. VO can save energy in ways that are fully under utility control, unlike some other approaches that have major unknowns such as customer response. VO can lead to known savings that can help meet resource needs and meet energy-saving goals. VO can also have other benefits such as reactive power management (specific data are discussed below). And one company markets its voltage optimization tools by saying they help to prevent under-voltage that can violate service quality requirements.

Building on the initial pilot in the Northwest, the Bonneville Power Administration is now implementing a full-scale Voltage Optimization program, providing a possible template for others. Some information on this program is provided below. Furthermore, the Electric Power Research Institute (EPRI) sponsored a major project, called Green Circuits, which working with more than 24 utilities to characterize 85 circuits across 33 states and four countries, identify existing circuit losses and prioritize potential options for efficiency improvement.[91] This project is exposing the 24 participating utilities to distribution efficiency opportunities and also is helping to validate these opportunities across many different applications.

In addition, new software and new technologies are making voltage optimization easier. Some of these developments are discussed in the next section.

Regarding distribution transformers, DOE will publish a new standard in late 2012, to take effect in 2016, that is likely to result in modest further reductions in losses (e.g., a 4-10% average reduction in losses for the draft 2016 standard relative to the 2010 standard). DOE has indicated that this standard will be set at levels that can be met with silicon steel cores (DOE 2012b). Utilities can avoid more losses by upgrading to amorphous core transformers. For example, relative to the draft standard DOE published in early 2012, amorphous core transformers that result in minimum lifecycle costs will reduce transformer losses by 25-40% (DOE 2012a). Specific numbers are provided later in this description under Savings Potential.

Emerging Trends and Recommendations

In this section we review emerging trends regarding distribution system efficiency and then discuss potential elements of a distribution efficiency program and potential savings from such a program.

Technologies

Several recent technology developments can contribute to distribution system efficiency. There are improved ways to optimize voltage. For example, several companies (General Electric, Cooper, Utilidata) are now marketing Integrated Volt-VAR Controls (IVVC) that provide automated adjustment of substation-level voltage based on end-of-line voltage and predictive algorithms. And some of these products can also control switchable capacitor banks to regulate reactive power compensation.

Second, smart meters with two-way communication being installed in many areas can provide utilities with a way to measure service voltage at each home. These data can provide aid in voltage control. For example, Dominion Voltage (a subsidiary of the utility Dominion Energy) has a set of three software products that use this smart meter data for customer voltage control as well as grid-planning, and energy savings validation.[92]

Third, as discussed above, amorphous core transformers reduce core losses relative to silicon steel transformers, even transformers with low-loss steel. Amorphous steel is a solid metallic material with a disordered atomic-scale structure. Amorphous metals are non-crystalline, and thus are classified as

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[91] http://tdworld.com/overhead_distribution/epri-green-circuits-project/ .

[92] https://www.dom.com/business/dominion-voltage/edge-overview.jsp .

glasses. But unlike the usual glasses, such as window-glass, which are insulators, amorphous metals have very good electrical conductivity, reducing losses in transformer cores. Amorphous steel was first developed by Allied Signal in the 1980s which was bought by Honeywell and ultimately MetGlas, a subsidiary of Hitachi. They have a plant in Conway, SC that produces the amorphous material for transformer manufacturers such as Howard and General Electric. Amorphous metal is also produced in China and Posco in Korea recently announced they will start production.

Interestingly, China and India have been quicker to embrace amorphous core transformers than American utilities. China requires that utilities purchase a certain percentage of their transformers at efficiency levels which can only be met by amorphous metal. A forthcoming specification will increase this percentage. In India, utility specifications require amorphous level performance. As a result, China is installing roughly five times the volume of amorphous transformers and India twice the volume as the U.S. (Millure 2012).

Program Design

For the most part this is an effort that utilities would implement themselves for their own systems. A plan for voltage optimization would need to be developed identifying which circuits to address first and specifying the period for overall implementation. Voltage optimization experts suggest that circuits that are primarily residential tend to be the easiest, followed by circuits with many small commercial customers. For circuits with very large commercial and industrial customers, more detailed circuit analysis will be needed to make sure that any changes do not have adverse impacts for these key large customers. Large customers may also have opportunities to optimize voltages on their side of the utility meter but we are not aware of any utilities offering programs in this area.

For transformers, the likely approach is to change purchasing practices so that when new transformers are purchased, generally these purchases are amorphous. We suggest "generally" because most utilities conduct a simple economic analysis on each transformer purchase and there will be some applications where amorphous transformers have higher lifecycle costs. Typically utilities examine transformer economics using so-called A and B values. These should be set to minimize lifecycle costs over the entire life of a transformer. "Bands of equivalence" should not be used as these override long-term life-cycle cost savings in favor of minimizing initial costs. As a rough approximation, Table 6 provides DOE's estimates of the mean lifecycle savings and median simple payback for use of amorphous core liquid immersed transformers relative to transformers meeting today's federal minimum efficiency standards.

Table 6. DOE Estimates of the Economics for Representative Amophous Core Transformers

Transformer Size and Type	Mean Lifecycle Cost Savings	Median Simple Payback Period (years)
50 kVA, single phase, rectangular tank	$641	7.9
25 kVA, single phase, round tank	$338	8.0
500 kVA, single phase	$5591	4.7
150 kVA, three phase	$3356	4.1
1500 kVA, three phase	$12,513	6.3

Source: DOE 2012b. Values shown are for Trial Standard Level 4

Target Market

This program would generally be operated by distribution utilities working on their own circuits. In the case of small utilities, a wholesale power provider could offer a program, just as the Bonneville Power Authority is offering a program for their utility customers (discussed further under Examples).

Marketing

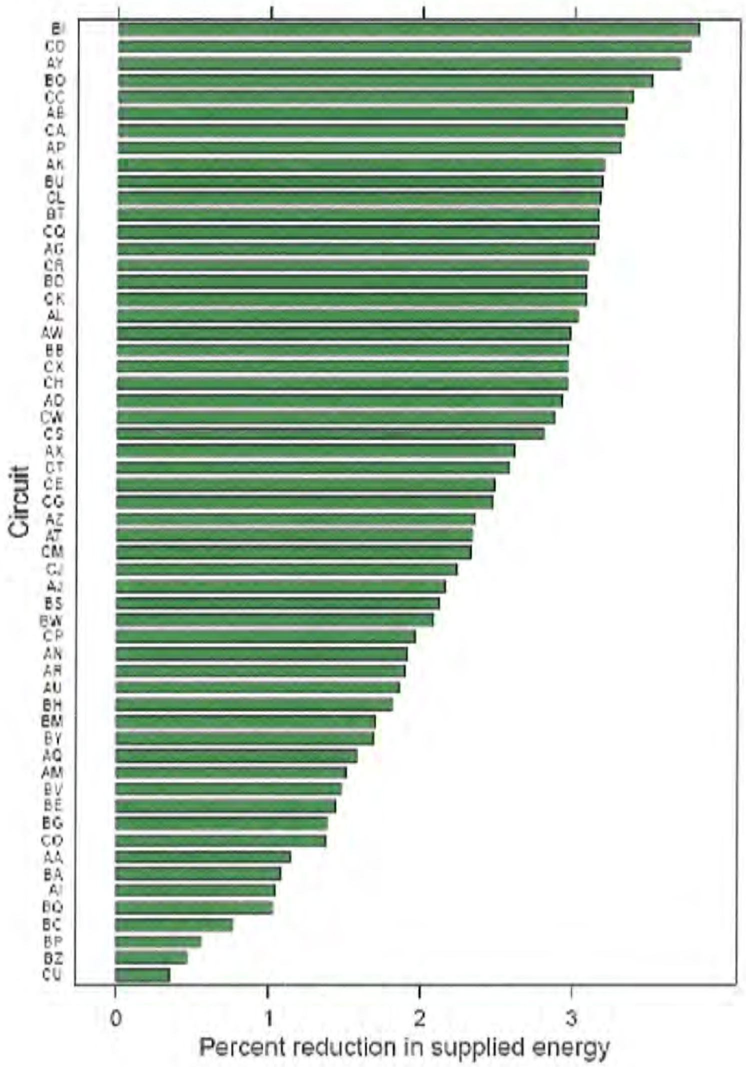
Unlike other energy efficiency programs the primary "marketing" is for a utility to decide internally to proceed. Utility management needs to be convinced that the savings are real and that there will not be adverse impacts on customers. All of the benefits should be examined together—customer energy savings, line loss reductions on the utility side of the meter, and reactive power management. One utility representative we talked to also suggested that decoupling or lost revenue recovery can be important, as voltage optimization clearly reduces sales, and utility management can be concerned about the lost revenue.

Utility commissions also have a role. They need to approve expenditures for distribution system improvements and they can encourage utilities to undertake any such improvements that reduce customer lifecycle costs. Voltage optimization in particular can reduce customer cost, because, as discussed below, most of the savings are on the customer side of the meter.

Savings Potential

Voltage Optimization. As discussed above, the NEEA project in the northwest found average savings of 2.07% across the 31 feeders that were included in their pilot study. Results from the EPRI green circuits program have found similar savings. For example, computer modeling of 66 circuits across multiple participating utilities found average kWh savings of 2.3%. These circuits were not randomly selected but instead were selected by participating utilities for a wide variety of reasons. Savings ranged significantly from circuit to circuit, as shown in Figure 3 (Arritt, Short and Brooks 2012). Tom Short (2012) of the EPRI green circuits team reports that achieving savings is generally easier and more cost-effective on shorter circuits, as on long circuits, voltage drops over the entire length of the line are greater and therefore, to avoid violating voltage limits, either voltage can be reduced less or more monitoring points and regulator banks must be installed, which increases costs.

Figure 3. Modeled Saving from Voltage Optimization of 66 Circuits



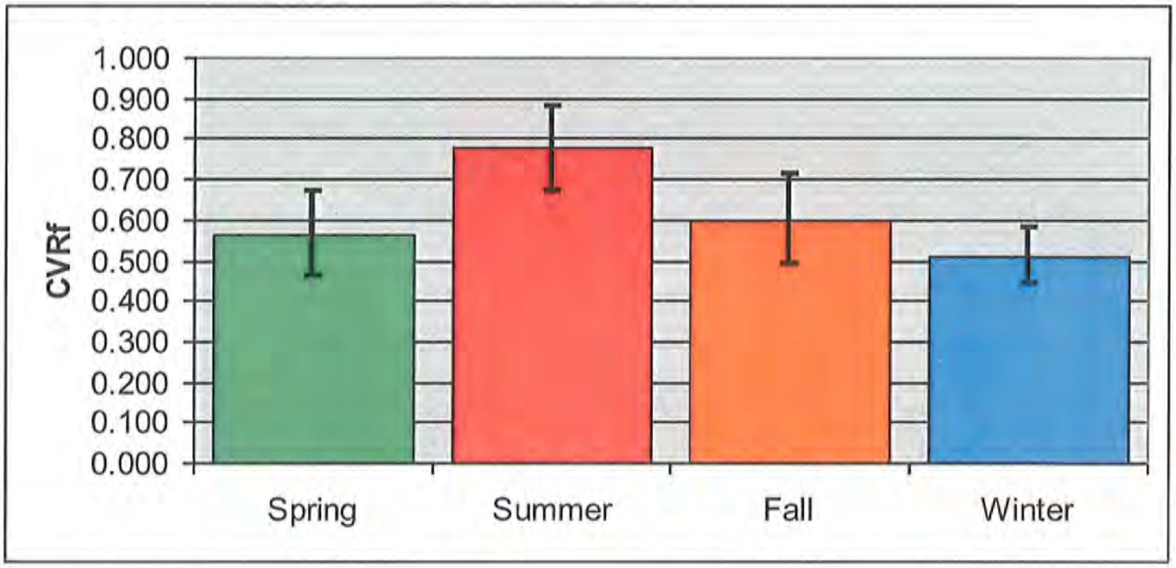
Source: Arritt, Short and Brooks. 2012.

Actual field measurements for nine circuits that were optimized as part of green circuits found savings ranging from 0.23-2.40% with a median of 2.01% energy savings. Reasons for the outlier are unclear but instrumentation accuracy may be involved (Short and Mee 2012). Reactive power was also measured on two of these circuits and very positive improvements in reactive power were obtained. Among these nine circuits for the most part, there were no complaints on circuits operating at reduced voltage. There were initial complaints on two circuits, but these were resolved by less aggressive voltage reduction.

Schwartz (2010), based on her review of data available as of 2010, estimates that voltage optimization can reduce energy consumption by 1-3%, peak demand by 1-4%, and reduce reactive power requirements by 5-10%.

There are two other interesting findings regarding energy savings First, savings tend to be higher in the summer when air conditioners are running and lower in the winter on circuits with substantial electric resistance heat. With electric resistance heat, when voltage is reduced, the amount of heat is also reduced and equipment needs to run a little longer. This is illustrated in Figure 4, which shows results from the NEEA study.

Figure 4. Energy Savings per Percent Voltage Reduction by Season in Northwest Pilot



Note: CVRf is the conservation voltage reduction factor. It is the percent reduction in energy use divided by the percent reduction in voltage.
Source: NWPCC 2009

Second, the majority of savings from customer optimization are on the customer side of the meter. Schwartz (2010) suggests "perhaps 80%." One utility we talked to suggested it might be as high as 95%.

In addition, it is not yet clear what proportion of circuits these savings apply to. The most work has been done on circuits that are primarily residential and secondarily on circuits with significant commercial loads. But little work has been done on circuits with large commercial and industrial customers. Experts we consulted expect lower savings on these circuits.

Amorphous core transformers. DOE, as part of their draft standard for distribution transformers estimates that on a national basis, by 2035, use of transformers that minimize lifecycle costs (primarily but not exclusively amorphous core) will reduce national electricity use by about 7,300 GWh. Savings will gradually ramp-in starting when the standard takes effect in 2015 and will gradually increase until all transformers are upgraded by about 2048 (2015 + 32 year average transformer life). Extrapolating, the savings in 2048 will be approximately 11,700 GWh. The 2035 savings amount to an estimated 0.2% of national electricity use in that year.

Potential Energy Savings Summary

Distribution Efficiency System Improvements	Electricity	Notes
	TWh	
National energy use affected	4514	Total electric use from AEO 2012
Average percent savings	2.2%	2.07% for voltage optimization from NW plus 0.15% for transformers
Ultimate participation rate	75%	Estimate of appropriate percentage of circuits and transformers
Potential long-term savings	75	

Examples

Voltage Optimization

Bonneville Power Administration (BPA). Based on the results of the northwest pilot project, BPA decided to go to full-scale implementation of voltage optimization and supporting system improvements. BPA is a wholesale power provider and utilities that purchase power from them can receive incentives for VO projects. BPA requires that a study estimating savings be conducted and BPA pays incentives based on the estimated savings achieved. Details can be found in their Implementation Manual (BPA 2012). The Northwest Regional Technical Forum has adopted two measurement and verification protocols for savings verification—one for simple approaches, one for sophisticated systems.[93]

PacifiCorp. PacifiCorp serves portions of six states and has begun to pursue voltage optimization in three of these. Work began in Washington where the utility commission has explicitly authorized cost recovery for voltage optimization.[94] In Washington PacifiCorp conducted a "tier 1" study of its circuits which identified some circuits for immediate work and other circuits for a further "tier 2" study. Some of the immediate projects are now being implemented and the tier 2 study is underway. In Oregon, an initial high-level tier 1 study is planned for 2012. In Utah, PacifiCorp originally proposed a similar process but the utility commission instead asked them to incorporate voltage optimization as part of their normal transmission and distribution business. PacifiCorp conducts a planning exercise on each circuit every five years, with about 20% of circuits reviewed each year. Voltage optimization is now being incorporated into this process. In Idaho and Wyoming, PacifiCorp serves extensive industrial loads and is not pursuing voltage optimization at this time (Jones 2012).

[93] http://www.nwcouncil.org/energy/rtf/protocols/Default.asp .

[94] http://apps.leg.wa.gov/wac/default.aspx?cite=194-37-090 .

Amorphous Core Transformers

Green Mountain Power (GMP). Like most utilities, GMP conducts an economic analysis on each transformer purchase. GMP uses criteria that emphasizes life-cycle cost effectiveness with the result that since 2011, about half of their transformer purchases are now amorphous. The change happened in 2011 when their main supplier began providing amorphous core transformers at competitive prices. GMP notes that their economic analyses indicate they should purchase amorphous cores in more than half the cases, but lead times for amorphous transformers from their current supplier are long and sometimes they cannot wait (Litkovitz 2012).

Recommendations

Based on these findings, we recommend that utilities conduct voltage optimization studies on their circuits, beginning with primarily residential circuits and proceeding over time to circuits with substantial commercial and industrial loads. Such studies can occur in blocks, as PacifiCorp is doing in Washington, or as part of regular planning processes, as PacifiCorp is doing in Utah. In addition, utilities should review their transformer purchase policies to make sure they minimize life-cycle costs at the utility's cost of capital. Using such criteria, utilities should consider amorphous core transformers whenever new transformers are purchased. For both of these savings opportunities, we recommend that utilities receive credit for the savings as part of efforts to reach savings goals and to earn incentives if they meet their goals.

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Additional Program Concepts

In addition to the full program write-ups in the previous chapters, there are several other promising program concepts where field experience is still limited. In this chapter, we discuss two of them with a briefer write-up than for programs with substantial experience; these are for *Miscellaneous Energy Use in Commercial Buildings* and for *Commercial-Sector Behavior Programs*.

MISCELLANEOUS ENERGY USE IN COMMERCIAL BUILDINGS

Synopsis

Projections show that miscellaneous energy use will account for nearly half of commercial sector energy use by 2035. Available data and programs are limited and there is a need for continued data collection and program experimentation. The New Buildings Institute has just issued a guide to reducing plug loads in offices, which might provide enough information to support pilot programs.

Many program operators already address data centers in their programs but these efforts generally target large dedicated data centers. Program implementers should consider expanding this work to servers that are not in data center. Further work is needed to understand miscellaneous energy use and program strategies for addressing this use. This program area has larger potential energy savings than any other program area profiled in this report.

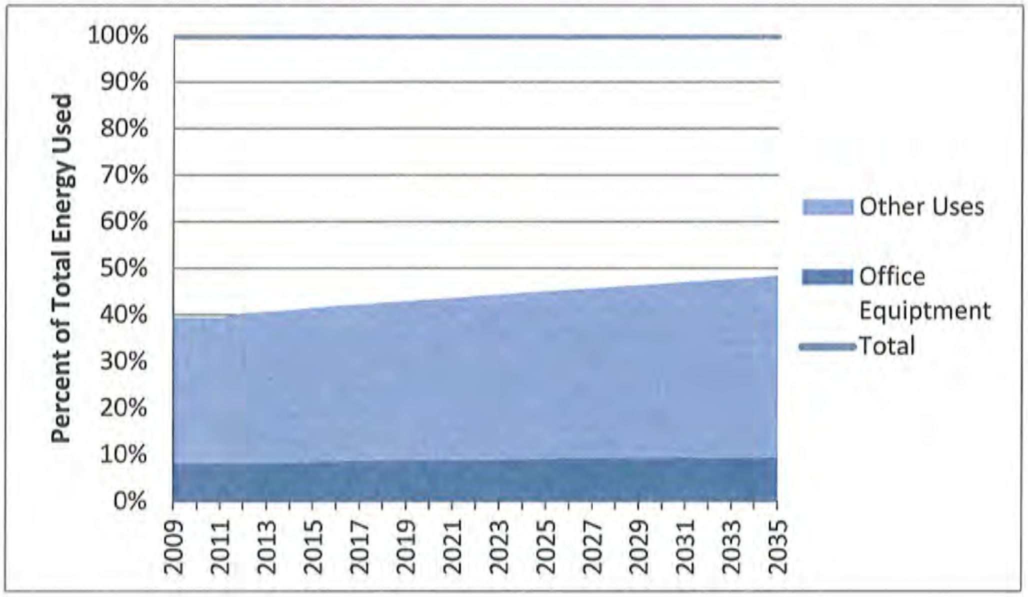
Background and Drivers for Change

Historically the vast majority of energy used in commercial buildings has been for space and water heating, cooling, ventilation, lighting and refrigeration. In recent decades, efficiency in these major end uses has improved yet simultaneously the number of "other" energy uses has grown (computers, peripherals, servers, data centers), increasing their proportion of the total load. The Energy Information Administration is now projecting that by 2035, almost half of energy use in commercial buildings will be for office equipment, and "other" energy uses (see Figure 5). In absolute terms, EIA projects this use will grow from about 7 to about 11 quadrillion Btus per year (see Figure 6). Other estimates of miscellaneous energy use are somewhat smaller,[95] but all agree that these loads account for a steadily growing share of commercial building energy use.

The range of end-uses in buildings and their contribution to total energy use is illustrated by metered data from a single building, as shown in Figure 3.

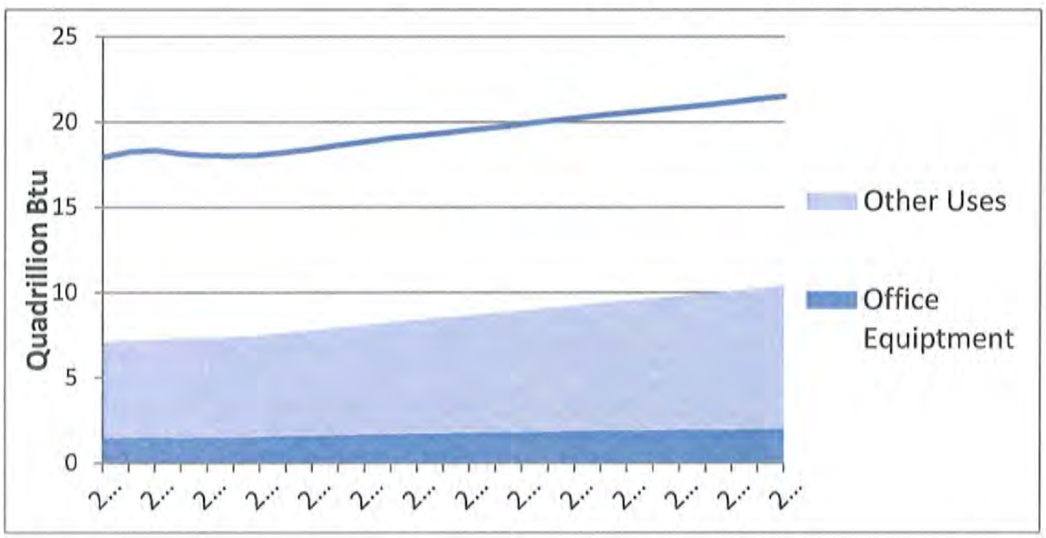
[95] ACEEE will be releasing a report summarizing available data in early 2013.

Figure 5. Projected Energy Use for Office Equipment and "Other" Uses in the Commercial Sector as a Percent of Total Commercial Energy Use



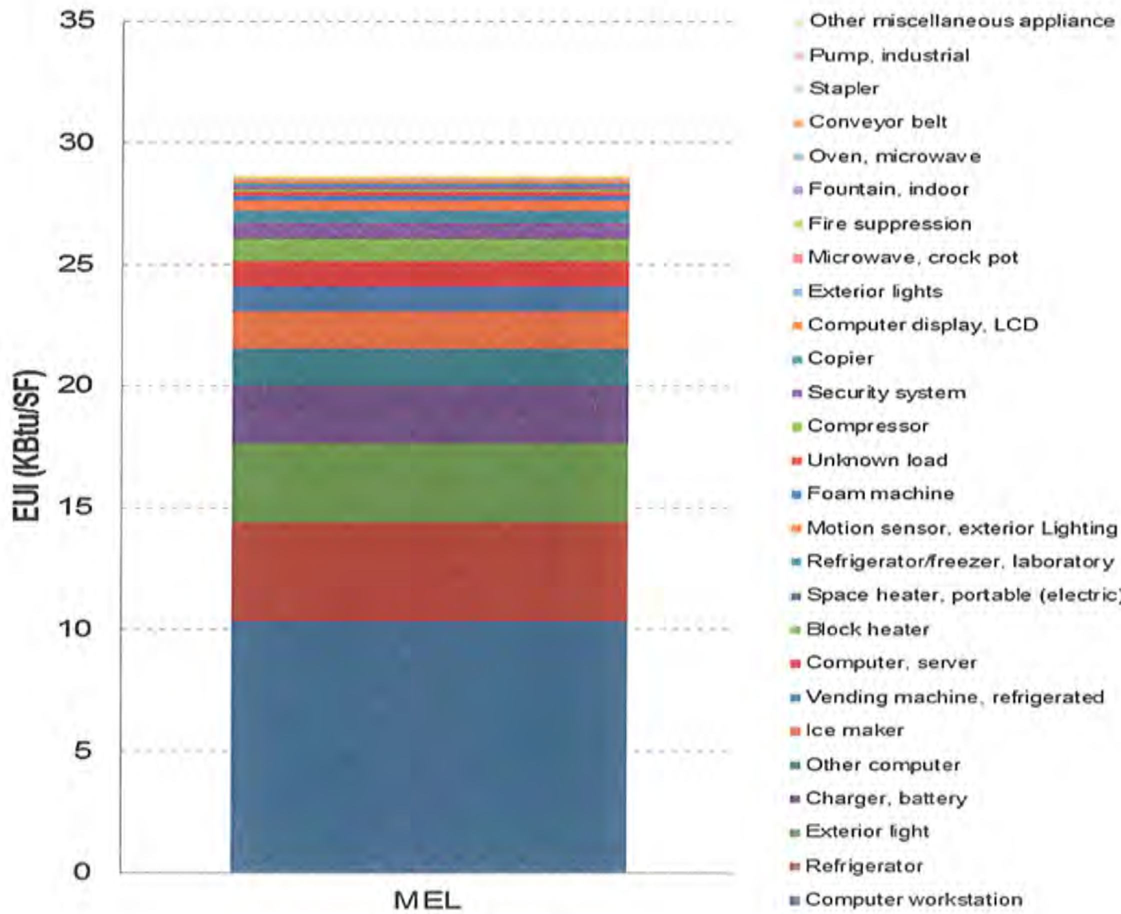
Source: EIA AEO 2012

Figure 6. Projected Electricity Use for Office Equipment and "Other" Uses in the Commercial Sector in GWh



Source: EIA AEO 2012

Figure 7. Metered Miscellaneous Electric Loads in a Warehouse



Source: Dirks and Rauch 2012

Emerging Trends

Given the trends discussed above, researchers and program administrators are paying more attention to miscellaneous energy uses in the commercial sector, with a primary focus on office equipment, servers and data centers. While this work is not as advanced as is comparable work on miscellaneous uses in the residential sector, the savings opportunities may ultimately be greater.

For these end-uses, energy savings opportunities fall into two general categories:

1. Promote more efficient technologies such as improved personal computers, monitors, printers, copiers and servers.
2. Promote management and control of these devices power management of personal computers, virtualization of data centers that allow computing to be accomplished with fewer actual computers (hardware) running, and improving distribution of heated air and light distribution in buildings so fewer personal space heaters and lamps are needed.

In addition, there are major energy users in the commercial sector that might merit attention. For example, a report by TIAX (2006) for the Energy Information Administration finds significant electricity use for water distribution, water treatment, elevators, X-ray machines, non-road electric vehicles and coffee makers. Some program administrators have targeted water distribution and treatment for many years, but others have not. And few utility-sector programs have addressed these other end-uses.

Examples

New Buildings Institute (NBI) has recently (August 2012) released a *Plug Loads Best Practices Guide* that outlines steps that an office can take to examine and reduce plug load energy use. Previous research by NBI (Mercier and Moorefield 2011) that examined plug loads in an office and a library, collecting baseline data and then instituting a variety of operational improvements as well as replacing some old equipment. These changes resulted in 48% plug load savings in the office and 17% in the library.

Data Centers. According to McDonald (2011), many utilities have offered custom incentives to data centers to help improve cooling system performance, for more efficient equipment, for virtualization/consolidation, airflow control systems, high efficiency uninterrupted power supply systems, efficient distribution systems and efficient power supplies and monitors. Leaders including Pacific Gas & Electric, Austin Energy, and BC Hydro, are also incenting efficient data storage technology, thin and zero client systems, PC management software, and remote monitoring. Some of these measures apply beyond data centers, for example, many of these can apply to server systems outside of data centers.

Savings Potential

More systematic work to estimate the savings potential is needed, however here we provide a rough initial estimate.

Miscellaneous Energy Use in Commercial Buildings	Electricity	Natural Gas	Notes
	TWh	TBtu	
National energy use affected	782	1360	From AEO 2012 for "other, office equipment & cooking" in 2030
Average percent savings	30%	10%	Based on midpoint of NBI study for electric; ACEEE estimates 10% for natural gas savings
Ultimate participation rate	75%	50%	
Potential long-term savings	176	68	

Recommendations

This area requires significantly more research and program development, and therefore program implementers should monitor and contribute work in this area. In the interim, programs should continue to target data centers, should consider expanding these offerings to servers outside of data centers, and should consider pilot programs building on the new NBI Plug-Load guide.

COMMERCIAL SECTOR BEHAVIOR PROGRAMS

Synopsis

Behavioral programs are proliferating across the residential sector, yet workplace engagement efforts remain scattershot and under-developed. A recent study examined five commercial sector programs and found savings of at least 4% from programs that combine visible support from upper management and that use multiple channels to send a range of messages (addressing comfort, productivity, morale, savings, and profitability) via a variety of media. Successful efforts had teams consisting of peer champions selected from building occupants, often formed into committees representing various stakeholders. The best programs used engagement techniques including feedback, peer pressure, competition, and rewards.

There is a need for additional pilot programs that develop these examples for a broader assortment of workplace types. Such pilots will help refine behavioral techniques and their specific application to the commercial sector; define benefits for business owners (such as savings that contribute to increased profit margins), and provide solid data on the energy savings that can be achieved, the persistence of savings rates over time, and the presence of non-energy benefits such as increased morale and productivity.

Background and Drivers for Change

While programs to influence behavior are becoming widespread in the residential sector, much less work has taken place on influencing behavior in the workplace. Nevertheless, just as behavior change can have a substantial impact on how much energy homes use, the same applies to the workplace. Individual behavior affects energy use for lighting, office equipment, refrigeration, cooking equipment, and even space conditioning (e.g., efforts to override thermostats or use of portable space heaters). As program implementers look for new savings opportunities in order to meet longer-term targets, capturing some of the savings available from influencing behavior in the workplace will become increasingly attractive.

Emerging Trends

Many employers have urged workers to conserve energy in the past, yet very few efforts have used modern behavioral techniques like combined messaging, 'nudges', social norming, prompts, and gamification. A recent ACEEE study (Shui 2012) examined a few recent such programs, finding savings of 4% or more from programs that used best practice techniques including:

- *Channels*: Need to be top-down, bottom-up, and peer-to-peer.
- *Media*: posters, mailers, social media
- *Message*: savings, corporate values, and social norms.

- *Messenger*: They need to be both authoritative and trusted and should be selected from among sets of stakeholders to drive process forward.
- *Incentives*: Game-based, providing recognition and a chance to boost social capital. Monetary rewards need to be small, concrete, and immediate.

Interest in this area is growing rapidly, and therefore more pilot programs should be deployed as soon as possible, to expand the information we currently possess from the relatively isolated and mostly short-term efforts we currently have data from.

Examples

Shui (2011) discussed five case studies, summarized below.

"Green the Capitol" was a successful top-down energy program implemented by the U.S. House of Representatives. A key component of the project was the development and application of the "Green My Office" Web site to help educate workers on what they could do and to track their results. Other research from the residential sector has shown that such social forums enhance savings and persistence.

The Empire State Building is in the middle of a highly publicized retrofit program (2008–2013) which incorporates a behavioral component. Individual tenants have in-office monitors that both tells them their real-time energy use, and also how they are comparing to other offices in the building (social norms). The overall project is estimated to reduce energy use by 38% from the combination of capital measures and tenant engagement.

Three programs from Canada were profiled, including programs at BC Hydro, the Ministry of Energy, Mines and Petroleum Resource (MEMPR) of British Columbia, and the University Health Network in Toronto. BC Hydro integrated the results of energy reduction into employees' and management's annual performance management structures, which in turn determined their annual bonuses, thus creating a potent incentive mechanism for participation. At MEMPR, the program used 'green teams', public pledges, and real-time feedback to reduce electricity use by 5% the first year. Meanwhile, the TLC-Care to Conserve" program at the University Health Network of the University of Toronto is an excellent example of the principles outlined above; multi-modal, multi-channel, multi-message. TLC's attention-getting banners and posters used both humor and historical association (WWII era poster styles) to engage participants and deliver the program's messages. Over two years the behavior program reduced energy use by approximately 4%.

Savings Potential

Potential Energy Savings Summary

Commercial Sector Behavior Programs	Electricity	Natural Gas	Notes
	TWh	TBtu	
National energy use affected	1607	3600	Total Commercial sector use for 2030 from AEO 2012
Average percent savings	5%	5%	Based on case studies from Shui 2012
Ultimate participation rate	50%	50%	
Potential long-term savings	**40**	**90**	

Recommendations

There is an urgent need for more pilot programs that use the experience we have gained and expand our knowledge across a wider variety of workplaces. Such programs provide savings while simultaneously giving us more data on how specific behavioral techniques perform in the commercial sector, which information can in turn be used to refine recommendations, saving employers and building management energy and money, thus boosting the bottom-line.

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